
Proceedings of the CSNI Specialist Meeting on Training of Nuclear Reactor Personnel

Held at Orlando, Florida
April 21-24, 1987

Sponsored by
U.S. Nuclear Regulatory Commission
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CSNI Specialist Meeting
on
Training of Nuclear Reactor Personnel

Orlando, Florida, United States
21-24 April, 1987

Co-Sponsored by the
UNITED STATES NUCLEAR REGULATORY COMMISSION
and the
NATIONAL ACADEMY FOR NUCLEAR TRAINING

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PROCEEDINGS

Committee on the Safety of Nuclear Installations
OECD Nuclear Energy Agency

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Nuclear Energy Agency
of the
Organisation for Economic Co-operation and Development

The Nuclear Energy Agency (NEA) is a specialized agency of the Organisation for Economic Co-operation and Development (OECD) in Paris. The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers who have responsibilities for nuclear safety research and nuclear licensing. The Committee was set up in 1973 to develop and coordinate the Nuclear Energy Agency's work in nuclear safety matters, replacing the former Committee on Reactor Safety Technology (CREST) with its more limited scope.

The Committee's purpose is to foster international cooperation in nuclear safety amongst the OECD member countries. This is done essentially by:

1. Exchanging information about progress in safety research and regulatory matters in the different countries, and maintaining banks of specific data (these arrangements are of specific benefit to the countries concerned).

2. Setting up working groups of task forces and arranging specialist meetings in order to implement cooperation on specific subjects and establishing international projects. The output of the study groups and meetings goes to enrich the data base available to national regulatory authorities and to the scientific community at large. If it reveals substantial gaps in knowledge or differences between national practices, the Committee may recommend that a unified approach be adopted to the problems involved. The aim here is to minimize differences and to achieve an international consensus wherever possible.

The main CSNI activities cover particular aspects of safety research relative to water reactors and fast reactors; probability assessment and reliability analysis, especially with regard to rare events; siting research; fuel cycle safety research; various safety aspects of steel components in nuclear installations; and a number of specific exchanges of information.

The National Academy for Nuclear Training

The National Academy for Nuclear Training was established in September 1985 to strengthen and unify the training efforts of the U.S. nuclear industry. The 55 U.S. electric utilities that own, operate or are building nuclear power plants make up the Academy's membership. The Academy is a framework for the nationwide effort to continue upgrading the quality of training and qualification programs and to promote pride and professionalism of nuclear plant personnel. The impetus behind the formation of the Academy is the recognition that training is a key to nuclear plant safety and reliability.

The Academy is comprised of three elements:

- o the training activities, resources and facilities of the nuclear utility industry
- o the National Nuclear Accrediting Board
- o the training and accreditation activities of the Institute of Nuclear Power Operations

The nuclear plant becomes a branch of the Academy when its first training programs are accredited by the National Nuclear Accrediting Board. All utilities are provisional members of the Academy. A utility becomes a member of the Academy when all of its key training programs at all of its nuclear plants are accredited.

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SESSION 1

OPENING REMARKS

Dr. W. Haussermann
Nuclear Energy Agency
OECD

I am very pleased to welcome you on behalf of the OECD Nuclear Energy Agency to the CSNI Specialist Meeting on Training of Nuclear Reactor Personnel. We at the Nuclear Energy Agency are very grateful to the United States Nuclear Regulatory Commission and notably to Dr. Persensky for the excellent preparation and organization of the meeting here in Orlando. At the same time I want to thank Mr. Al Mangin and the National Academy for Nuclear Training for the equally very substantial support in the preparation of the meeting. Dr. Persensky, as chairman of the NEA Task Force on Training Programs for Plant Personnel, will in this capacity present to you first results of an international survey of training programs in OECD countries. I am sure that with these thorough preparations and the very beautiful surroundings here, all the conditions are there for a very fruitful and lively meeting.

Let me say a few words about our activities in the OECD Nuclear Energy Agency for those who are not familiar with our program. All our safety work is carried out under the supervision of the Committee on the Safety of Nuclear Installations (CSNI), which is composed of government officials from OECD countries who are scientists and engineers responsible for safety and licensing in their respective countries. Five Principal Working Groups and several ad hoc groups operate under this Committee. The Principal Working Group No. 1 is responsible for feedback from operating experience and work in the human factors area.

One important way to learn from operating experience is the collection, analysis and exchange of information on reactor incidents and accidents. Since 1980 the Nuclear Energy Agency operates an international Incident Reporting System (NEA-IPS) which is probably familiar to most of you. This system was established in a formal way as a result of the Three Mile Island accident and has up to now led to the world-wide exchange of information on some 800 reactor incidents. At present the system is undergoing important changes and improvements in order to enhance the possibilities of thorough and speedy analysis of all safety-significant incidents. I should also like to mention that the IAEA incident reporting system is complementary to our system and our two agencies are cooperating very closely in this area.

Our past and present work in the human factors area comprises the following activities amongst others:

- Assessing Human Reliability in Nuclear Plants,
- Identifying Significant Human Actions in Reactor Incidents,
- Comparing National Approaches to Training Programs in OECD Member Countries.

More recently work was started on:

- The Analysis of Incidents Involving Human Factors,
- The Use of Digital Computers in Control Rooms, and
- The Misinterpretation of Plant Status by Operators and Possible Remedies.

Because of the significant role which operator error played in the Chernobyl accident, one area of continuing strong interest is the role and training of operators and other reactor personnel. Much attention has already been paid to this issue, particularly after the Three Mile Island accident in 1979, and extensive activities were carried out at both the national and international level. Following Chernobyl, the NEA has reinforced its activities in this area, particularly in the use of simulators and operator training programs.

The remainder of the CSNI cooperative program is concerned with reactor system response during abnormal transients, various aspects of primary circuit integrity, the phenomenology of radioactive releases in reactor accidents, containment performance, risk assessment, and severe accidents. The Committee also studies the safety of the fuel cycle and conducts periodic surveys of reactor safety research programs in OECD member countries.

The CSNI Subcommittee on Licensing, consisting of those CSNI delegates who have particular responsibilities for the licensing of nuclear installations, examines a variety of nuclear regulatory problems and provides a forum for the review of regulatory questions, the aim being to develop consensus positions in specific areas.

The present Specialist Meeting on Operator Training fits very well into the CSNI work program and the great number of papers (more than 45) from 12 different countries demonstrates the interest for this subject. I can assure you that the outcome of your meeting and the results of your discussions will be closely analyzed by experts in our Principal Working Group No. 1 and will thus contribute to further improve the safe operation of power reactors in OECD Member Countries.

I wish you a very successful meeting.

REMARKS BY COMMISSIONER KENNETH CARR

U.S. Nuclear Regulatory Commission
Washington, D.C.

I am pleased to be here this morning, and I welcome the opportunity to provide a few remarks at the opening of this important conference. In my thinking, this conference underscores the importance of three fundamental principles I consider vital to ensuring that nuclear technology remains an option for the future. First, the importance of training of nuclear power plant staffs. Second, the importance of learning from the experience of others and integrating that experience into the training program. Finally, the importance of minimizing human errors which, in effect, turn out to be training's "report card" in cases like Chernobyl, Three Mile Island, Davis Besse, Rancho Seco and the like.

Such a fine turnout for this conference, with representatives here this morning from 15 countries, attests to the importance you place on these same principles. I will briefly offer a few comments on the value of what I consider to be a team approach to training. Later in the conference you will undoubtedly hear one or more presentations describing the more conventional use of the term "team training". Those presentations will touch on generic team skills and the basic team skills training approach with which most of you are familiar. What I intend to discuss is a somewhat broader use of the term "team training."

I came to my present job following 42 years of experience in the United States Navy. If there is one important concept that I carried away from those 42 years, it was the importance of training in general, and team training in particular. A majority of my service in the Navy was spent associated with the nuclear submarine program and the training of the crews that served on these ships. For many years I worked for a man of whom I am sure many of you have heard, at least by reputation, Admiral Hyman G. Rickover. The success of the Navy's nuclear program is due in large part to the emphasis that Admiral Rickover placed on training -- team training -- for everyone who served aboard his submarines.

Each person assigned to operate or maintain these Navy plants spent a year of intensive training prior to reporting to the ship. This included approximately six months of classroom training in the design and theory of operation of these plants, followed by six months of training at a land-based prototype. There the student was required to demonstrate that he could operate the plant under normal and casualty conditions, in strict compliance with detailed operating and casualty procedures.

Admiral Rickover also placed a great deal of emphasis on the value of sharing operating experience. We were constantly reading of and training to handle the errors and near-misses of other operating crews.

Finally, team training played a major role in the Admiral's overall training scheme. Much of our time, both at sea and in port, was spent running drills and exercising the crews in a wide variety of situations. This training involved maintenance technicians and engineering disciplines, as well as the plant operators, and was truly a team approach to training.

I mention these points only to illustrate that I bring to this job a firm belief in the vital importance of training.

Let me mention now some of the players in this team approach to training, as I use the term. First, utility management must believe that training is necessary and foster a company-wide attitude that it is a valuable, important part of everyday activities. Properly running a complex technical program requires a fundamental understanding of the technical aspects of the job and a willingness to pay infinite attention to the details. This can only be done by one who understands the details.

We have seen some impressive accomplishments in the training area in our industry over the past several years. A large number of plant-specific simulators have been built and placed into operation; the utilities in this country have put their support behind an aggressive training accreditation program managed by the Institute of Nuclear Power Operations to upgrade training programs across the industry; and many fine training facilities have been constructed and staffed with instructional technologists and subject matter specialists to train both operators and technicians. These are all valid indicators of utility management support for training. But what I refer to here is an attitude that needs to exist and permeate the organization from the top down -- an attitude that training is a fundamental aspect of everyday nuclear plant operation. That it cannot be compromised or limited to just the operations staff, and that it is a continuing process. Since joining the Commission in August 1986, I have had the opportunity to visit to date 26 nuclear plants in this country. I'm pleased to say that this support for training has been evident at all levels of the organization at the vast majority of the stations I have visited. That was not the case very many years ago.

The second group of players on this team that I am describing are represented by you here today -- the people responsible for developing, implementing, and overseeing the training programs at nuclear stations. It goes without saying that thorough, sound training programs need to be provided -- that the operators and

technicians need to be provided the information they need to do their job and do it well.

Simulators, I think, provide one of the best tools for the team training of operators. In this country alone, the use of these simulators has grown from about 11 in operation in 1980 to over 40 currently in operation, with a number more either on the drawing board or soon to be placed in operation. The availability of training tools such as these will go a long way towards upgrading the job skills of our operators and technicians.

These tools by themselves, however, do not ensure effective training. The responsibility to ensure that these are used well, and are used to provide meaningful training, falls on your shoulders. In this regard, I have observed that often too little effort is placed in planning the simulator exercises and critiquing the training after the fact. In my thinking planning and critiquing are as important, if not more so, than the conduct of the exercise itself.

With all the emphasis on job skills training and simulators, it is important that we not lose sight of the value of what I call basic foundation training, such as reactor theory and the fundamentals of heat transfer. If the Chernobyl accident taught us anything, it was the need for operators to clearly understand the design bases for certain protective features and procedural limitations. At the risk of oversimplifying what is a very complex sequence of events, a group of operators, who by every account were well trained and enjoyed one of the best operating records among all the reactor plants of that type operating in the Soviet Union, clearly did not fully comprehend the impact on reactor safety of many of their actions that evening. This was a breakdown in training in these foundation subjects.

We all have the responsibility to ensure that sound, well-balanced programs are provided to train our operators and technicians in those areas in which they need to do their jobs. In this country, these training programs have come a long way. The emphasis, however, has been on developing and improving the operator training programs. More work is still needed on the training programs in other areas, particularly maintenance training.

The final team player I want to mention, and the one whose role is often underestimated, is the recipient of the training -- operator or technician. Regardless of the utility-wide attitude in support of training that exists, and regardless of the quality of the training programs and facilities, unless the recipient has a desire to learn, and sees the need for the training, there is very little chance that the training will be effective. This is the old concept of "You can lead a horse to water but you can't make him drink." The key here, I think, is that the trainee must be able to see the link

between the training he is receiving and the job he is being called on to perform on a day-to-day basis. With on-the-job training this association is obvious to the trainee. The results of the survey that many of you completed prior to this conference reflect that heavy dependence is placed on on-the-job training. The reason is the ease with which this link between the training and the tasks which the operator or technician must perform can be made. The challenge comes in providing this link to those training elements other than on-the-job training. Based on the plants I have visited in this country, there is a soft spot or weakness on the team, at this point. The recipient of the training may not always see the tie between basic education training and his day-to-day responsibilities and, as a result, the training falls on less than responsive ears.

These, then, are the three players on the team - utility management, the training staff, and the recipient of the training. All have to be in the game for there to be a winning team.

Let me make just a few more comments concerning this team approach to training. First I am a firm believer in the importance of learning from the experience of others and factoring this experience into our training programs. A number of presentations are planned over the next day or so concerning training programs in the countries represented here at the conference, and that exchange of information will be valuable. I am also pleased to see a presentation scheduled for later in the conference on the use of case studies to share operating experiences with plant operators. In reviewing the results of the survey you participated in, it was gratifying to note that all respondents had some form of operating experience feedback mechanism at their utilities. We should capitalize on every opportunity to exchange and learn from the experience of others.

Second, the concept of team training applies to all utility staff and not just the operators. From my observations, the technicians and engineers who maintain the plant seldom train together as a team. The shift rotations are such that joint training is, in most cases, precluded. I recognize the problems associated with bringing all disciplines together to train and work as a team, but the benefits justify exploring it further.

One such benefit is competition -- the natural and healthy desire to be the best shift, to have the fewest personnel errors, to have the cleanest plant. We don't give this important motivation the credit it deserves and we often don't do enough to plant the seed and watch it grow. Whether between shifts at one unit, between units at a multi-unit site, or even between different stations, competition can be a powerful force in bringing about improved performance.

Let me say again, that I am pleased to be here. I think this is a very important conference, and I am eager to hear some of

the presentations planned over the next day or so. As a representative of one of the host organizations for this conference, I welcome you to the CSNI Specialist Meeting (and to Disney World) and I hope your stay is a pleasant one. I applaud your efforts to share experiences in this extremely important area - training.

Discussion

QUESTION FROM THE FLOOR: In the last several years, since Three Mile Island, there has been an emphasis in the nuclear industry in the United States on additional academic training -- on the foundation training, as you called it. A question I am often plagued with is how much is enough, and does an operator, a licensed operator, need a college degree to satisfy that requirement. Can the requirement somehow be satisfied by just basic training, and to what extent?

COMMISSIONER CARR: As you may or may not know, the question is before the Commission now as to whether to require senior operators to hold a degree. In my travels around the country, talking to operators, I would say there is an overwhelming opinion on the part of the current operators that they do not need college training. The Chairman of the Commission, Chairman Zech, is of the opinion that we should require future entrants into the operator cycle to be college graduates. There is an ongoing discussion on this topic.

My personal opinion is that if you give two people the same amount of practical training, the college graduate, in the long run, will be a better operator, and you probably would want that. I realize that we have a lot of people operating in this country who do not have degrees. Some of them are working towards a degree.

I do not think there is ever enough training. I personally think continuing training is very important to the operator. You never stop learning. It seems like the more we operate these plants, the more there is to learn about them. When we first started operating the Nautilus' reactor plant, the total engineering procedure stack was about four inches high -- a very simple set of instructions that said, when you are ready to start up, light off the engine room. That was the procedure. Now most nuclear submarines have a stack of operating procedures three feet high. We know more about the plants than we did in the beginning. So I think that continuing education is very important. I do not believe that you can get to the point where there is "enough" training. You have to have continuing education for operators, even for the qualified, licensed shift supervisors.

As you will hear later on, we have put out a policy paper on qualifications of operators in this country. You will get a description of that later.

My personal opinion about operator training, and I have argued this with some of the utilities, is that our operators are comparable to airline pilots. They are the people with the public health and safety on their shoulders in the middle of the night when there is nobody else around. It is very important that they be recognized as key players, that they be paid appropriately, and that they be educated to handle the job in the best way they can.

JAMES JAMISON (PNL): Do you have a comment on the general effect of including a licensed shift technical advisor on shift at each plant, regarding enhancement of the overall level of education of the team?

COMMISSIONER CARR: I think it is valuable. I do not have any basis to measure whether we have seen improved performance as a result of an STA being on rotation with a shift. As you know, it was a fallout of Three Mile Island that we added that watch. It is very hard to measure the value of having that person around. I do believe it is valuable to have another educated operator on site in case you need another opinion. But I don't have a direct measure of the benefit -- someone may have, but I don't.

REMARKS BY PIERRE TANGUY

Inspecteur Général pour la Sûreté
et la Sécurité Nucléaire
Electricité de France

Introduction

On April 26, 1986, at 1:23 in the morning, an accident occurred at the fourth unit of Chernobyl nuclear power station in the Ukraine, Soviet Union, which resulted in the destruction of the reactor core and part of the building in which it was housed. Large amounts of the radioactive materials in the reactor core were released into the surrounding environment.

At a meeting held in Vienna over the period 25-29 August, 1986, leading Soviet scientists and nuclear engineers presented an account of the causes of the accident, the accident sequence, and its consequences and the countermeasures taken. The International Nuclear Safety Advisory Group (INSAG), at the request of the IAEA Director General, presented a summary report of the meeting(1). It concludes that the accident was caused by a remarkable range of errors and violations of operating rules in combination with specific reactor features which compounded and amplified the effects of the errors and led to a reactivity excursion. Consequently, INSAG stated that there was a need for a "nuclear safety culture" in all operating nuclear power plants. It identified several lines of action. One of them was:

- o "Training, with special emphasis on the need to acquire a good understanding of the reactor and its operation, and the use of simulators giving a realistic representation of severe accident sequences."

This can be hardly considered as a new finding. After Three Mile Island, I had the opportunity to present a paper on the lessons learned from important nuclear power plant accidents at the International Conference on "Current Nuclear Power Plant Safety Issues" sponsored by the IAEA in the fall of 1980 in Stockholm (2). I selected, more or less arbitrarily, six events: Windscale (1957), Enrico Fermi (1966), Lucens (1969), Browns Ferry (1975), TMI (1979) and Saint-Laurent-des-Eaux (1980). In most cases, the analysis showed that the operators were relying mainly upon the experience they had acquired by working "on the job," and that an appropriate training program was needed to revive their awareness of infrequent accidental situations.

In this paper, I will deal only with nuclear plant operator training. (By operator, I do not mean only the personnel in the control room, but I include all personnel involved in maintenance,

repairs, et cetera.) In a previous paper (3), I discussed the specific problems raised by other categories of personnel, in design, construction, surveillance and evaluation. For operating personnel, the concern for safety can be only one aspect of training. The overall objective has to be much larger since it must include all operating aspects. Therefore, in my presentation I will try to cover two main points:

- o In the course of all training activities, how should the safety point of view be taken into account?
- o Is there a need to include in a training, or recycling, program some supplementary activities solely devoted to plant safety?

At first, it seems useful to briefly review some characteristics related to the human behavior, especially when plant safety can be seriously challenged.

The Safety Implications of Human Performance

Man is fallible. But the designers have taken it into account. In nuclear power plants, safety does not rest ultimately upon man, but upon the actions of automatic safety systems. An efficient quality assurance program should be able to detect various human failures, in design, construction, control and operation, and to initiate the corresponding corrective actions. It must therefore be emphasized that no "superman" performance is required from operating personnel. They do not have to rush for immediate action; they have a right to commit errors, thanks to the design. But they have also a fundamental duty, that is to report all abnormal events, and especially "near-misses," because experience feedback is the only sure way to verify the overall validity of the safety approach. This is certainly an essential part of the "safety culture" mentioned earlier. Experience demonstrates that spontaneous error reporting is not easy to implement, and the correct mind-sets must be established as part of the training approach.

If the various redundancies built into the design can cope with most failures in human performance, it must be realized nevertheless that the prevention of all types of abnormal occurrences is an important safety goal. There are many examples of accidents in nuclear reactors which originated from degraded states. Safety analyses could not cover all possible cases and the repetition of minor discrepancies from the normal operating conditions increases the risk of a serious accident. That is why the search for "excellence" must be a safety requirement. Strict application of all rules is also a fundamental aspect of the safety culture.

Research performed during the past year has given important results related to the behavior of operators when they have to face

unexpected sequences of events. The operator response is mainly determined by the image of the machine he has in mind. It is therefore essential that a technically correct image be constructed in the operator's mind during training, and be periodically revived. There are many examples of serious distortions which cannot be identified in the course of daily plant operation, but could be very harmful in face of some accidental sequences. We must realize that the use of simulators, where the control panel arrangement is identical to those in the plant control room, can hide false perceptions. Nuclear power plants are complicated machines, and the information given to the operators is sometimes remotely connected to the physical reality of the phenomena. One of the important objectives of training should be to fill this gap.

It has been recognized that there is one type of operator error which could jeopardize the nuclear safety approach; some call them "strategic errors;" we prefer to use in France "erreurs de representation," which means that the operator is reasoning well, but on a plant which is not the real one. One well known example is the case of a valve, assumed to be closed by the operator, but actually open. There are several lines of actions which are being followed in order to prevent this type of error: improvement of man-machine interface, computerized assistance on special safety panels, et cetera. The role of training may also be very important if it helps to set up the proper attitude in the operating personnel. One aspect looks to me essential: the operating team should not be used to follow blindly the line defined by the team's leader, but each member, with his specific knowledge, should attempt to keep a good understanding of the plant behavior. I will come back later to this special aspect of safety training.

Finally, one should always keep in mind that the operator's experience could contradict the first safety priority, the prevention of severe accidents. Operators may have some difficulty in realizing what a low probability event means, compared to their daily experience. When a test has been successful one hundred times in a row, without any simple failure, there is a general tendency to conclude that it will always be successful. Only statisticians know that the only conclusion is that the failure probability is probably less than one in fifty. Operators must be kept aware of that, at every level, including top management. This can probably be best done by analyzing with the operators some sequences they have met themselves, and explaining what could have happened if? Training on the job is certainly an essential part of any training program, but it must go beyond the actual facts.

The Role of Safety in the Definition of Training Objectives

I do not intend to present the general EDF training policy; it has been done already several times, and there are some papers on

this topic in this meeting. If one defines "training" as the action which makes a person able to fulfill a given task under the most favorable conditions, one can identify the following process, schematically:

- o definition of the tasks
- o characterization of the personnel available for the job
- o selection of training tools, material and human
- o habilitation procedure, as a judgment on training adequacy

Two aspects of the EDF training deserve mentioning: the principle of individual training programs, even if standard modules are required for specific positions; the habilitation decision by the plant manager taking into account professional experience of the trainee outside the training program itself.

This corresponds to a general philosophy: the plant manager must take responsibility for the operating personnel in a similar manner to components and systems; they have to fulfill predetermined criteria, but they are deemed acceptable after individual qualification. Safety authorities should establish the minimum requirements and the relevant criteria. They may also verify that the habilitation procedure is done according to precise rules and does not lead to inappropriate decisions. But they should not get directly involved in the process itself, since the responsibility of the man in charge of plant operation would become meaningless, if it does not include the decision on operators.

I will now attempt to define some objectives which must be pursued if one wants to keep a proper perspective in the training program:

- o implementation of a safety culture
- o enhancement of quality in operation
- o build-up of a correct mental representation
- o awareness through use of experience feedback.

Let me review briefly each of these objectives:

Implementation of a Safety Culture

The need for a "nuclear safety culture" in all operating nuclear power plants was considered as one of the most important safety lessons learned after the post-accident review meeting on the Chernobyl accident. In this respect, training will play an essential role if it is primarily based on the basic aspects of plant behavior and safety features, covering the range appropriate to the task to be performed. This must extend from the shift manager, who should have broadly-based knowledge, to the plant operator and maintenance craftsmen, who should have a competent understanding of the safety consequence of error in their immediate tasks. It is not so much the

actual stringency of measures which must be emphasized, but rather the fact that everybody realizes the underlying justification of the safety regulations.

During the training period, operators must get directly acquainted with the type of extreme conditions which have been taken into account in the design of safeguards systems, and explain safety requirements which could look unnecessary from current operational experience. One must realize that the nuclear safety approach may appear as contradictory to direct operating experience, since its purpose is to cope with rare events. Training provides a unique opportunity to make clear to all personnel that safety regulations are technically appropriate to face a wide spectrum of operating conditions which may happen in nuclear power plants.

Quality in Operation

The achievement of a high level of quality in operation is a vital safety requirement. In a way very similar to what can be seen in the construction stage, quality assurance in operation should not be viewed as supplementary procedures put on top of the actions needed to operate the plant, but as an integral part of these actions themselves. I will give one example: communication between various members of the operating team. There have been many cases where an incident was initiated by a misunderstanding between operators; either because the proper word was not used, or even because it was not correctly heard.

We realized in EDF that most of these errors could be avoided if all operators were using standardized phrases, as in air transport activities. A special manual was prepared and listed on one of our plants. It was not a success, probably because it was considered as an external constraint. Its use during the training, and retraining periods, will make it an integral part of the normal operating system. Many other examples could be listed, such as the necessary formalism between successive shifts, the steps to be followed for work orders, et cetera.

Mental Representation

As mentioned earlier, safety could be seriously challenged if operator action in case of accident was to be based on a technically incorrect image of the plant's behavior. It is therefore essential that training succeeds in building up in the operator's mind a correct image. One of the main obstacles to overcome is the "distance" between the physical phenomena which take place in a nuclear plant and their representation on control room's panels. In this respect, the use of full-scope simulators absolutely necessary for many reasons, could well be detrimental, since the abstract interface between the man and the machine will be unchanged when the

operator passes from the training center to the plant control room. This is why I am very much in favor of the use of "dedicated" simulators during the training and re-training periods, which break up the usual representation and force the operator to have a different look at the operating systems.

Experience Feedback

It is now widely recognized that training must make a systematic use of incidents which have been recorded and analyzed. All simulator programs include such exercises, and theoretical education refers to operational experience as realistic examples for the knowledge acquired in text books.

Two aspects may be pointed out. First, there is a considerable benefit in the exchange of experience between different plants, even if the designs are also different, but on the condition that the trainers are able to draw attention to the common safety lessons. This is easy for the widely publicized large accidents, such as TMI; it is more difficult for other incidents, or accidents, unless there has been a preliminary work done by specialist teams. This point should be kept in mind by the international organizations, such as IAEA or NEA, which collect incident reports and distribute the information. I think it could be very useful if such organizations would publish a number of typical accidents for training purposes, in a form similar to the benchmark exercises used in reactor design or safety evaluation.

The second point is associated with retraining of operating personnel. It is essential that it makes the widest possible use of the abnormal events which have happened to the retrained teams. Here, an in-depth analysis of the event, with reference to the safety analysis report and the regulatory requirements, complemented by a series of parametric studies, covering hypothetical accident sequences which could have been initiated by the events, looks to me a very efficient way to make operators fully aware of the potential safety significance of minor incidents. It will help to close the gap between the accident evaluations performed in the safety report, which is often considered by the operators as highly theoretical, and their experience on the job.

Special Training for Accidents

It is evident that the development of an appropriate behavior of operators during normal operation and anticipated transients will be a very important factor in preventing the occurrence of abnormal operating situations. But it will not necessarily guarantee an adequate behavior if these situations do occur in the plants. Therefore, all training programs include specific parts with the objective to prepare operators to face

accidental situations, and particularly hypothetical severe accidents. These programs cannot possibly cover all types of accidents. On the other hand, exaggerated importance given to that part of training could well create in an operator's mind a feeling prejudicial to normal operation, and therefore to safety. I think several aspects must be taken into account:

Minimizing Operator Stress

I mentioned earlier that operators must realize fully that their plants are designed for safety even if several systems, components or operators do fail. The various operating procedures they have been instructed to strictly follow, take into account practically all types of failures. That is why they are often complicated and not always easy to apply. Operators can develop stress, if they think they are not entirely up to their tasks, and this stress can initiate in turn inappropriate operator actions.

For the last few years, EDF has set up special retraining sessions for operator teams on simulators. They are called "Stages de Mise en Situation Recréée - MSR", which means that the team, consisting of the shift supervisor, the senior operator, the operator and the safety engineer, has to operate the simulator in extreme accidental situations under the surveillance of observers. These sessions are a good tool to validate the special accidental procedures (beyond design). They are also very useful to make operators realize that they are expected to maintain the same general behavior in case of unforeseen events or in normal transient operation, and it is hoped that their experience will minimize the stressing effects of such unforeseen events if they do occur in their plants.

Operator's Aids

This type of simulator session is also used to measure the effectiveness of the assistance which is presently available to the operators through the safety panels and the associated computer programs. The implementation of these safety panels in all nuclear power plants was decided as a consequence of the TMI lessons learned. Even if their design is the result of a close cooperation between designers and operators, it remained to be seen if, in practice, they would be used by operators as intended.

The simulator tests demonstrated that operators were greatly helped in their diagnosis of the accident sequence by the information displayed on the safety panel. Consequently, it was decided to "replay" these tests in each nuclear plant; adapted to the safety panel which is used on each site for training purposes, the recording of the test was used to teach operators how they could get assistance from the panel in case of a serious accident. This was done in an

interactive manner, the operators keeping the freedom of choice between the various programs of the safety panel.

Prevention of "Mental Representation Errors"

I have already discussed the potential risk related to this special type of operator error. The operational aids, and more generally the improvement of man-machine interface, play an important role in preventing them. EDF relies also on the "human redundancy" provided in the control room by the safety engineer, who is called in for any abnormal occurrence. It should help create a critical mind within the team, but it has first to be part of the training and retraining programs.

Complementary Remarks

The presentation above left out some other important aspects that I will briefly review.

Training on the job is important, in general, and also for safety. It is our experience in EDF that operators which have been associated with the commissioning tests have got a direct knowledge of many examples of failures and errors which help them to recognize quickly similar situations in commercial operation. All requalification tests performed after maintenance or repair works, or after periodic inspections may play a similar role.

A strong motivation of the trainees is certainly important for a good training efficiency. In this respect it is probably important to give training responsibilities to ex-operators, preferably the best ones. Their past experience will undoubtedly help to convey the right message to the trainees.

Finally, it is well known that safety in plant operation requires a general awareness at all levels of the electrical utility. Therefore not only plant managers, but also the highest hierarchy of the company should be directly associated with the safety aspects of the training programs. Simulated crises give good opportunities for that objective.

Conclusion

Among the large modern industrial outfits, the nuclear power plants are probably those which mostly call upon automatic protection systems to provide against the risk of accidents. The ultimate safety never rests upon man's correct behavior. On the contrary, plants are designed to accommodate human failures, as far as possible. Nevertheless, there are many examples of accidents which originated in an operator insufficiently trained in the tasks he was entrusted with. On an other side, there are also many examples when

man had to act to successfully correct a failure not properly covered by design safety features. At the end of this paper, I want to emphasize this last point. Training, with an appropriate safety content, should allow man to play a positive safety role, and definitely obliterate the image of man as "the weakest element in nuclear safety."

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Discussion

QUESTION: There was one panel in one of your early slides of the simulator that had a profile that looked like the power temperature in the core -- was that an actual panel? Or was that a principles trainer? It showed a CRT with a trace on it that looked like a power profile or a flux profile.

M. TANGUY: I don't know about the flux profile, but you certainly can have, with the CRT and the computer program, a lot of information on the plant which has not normally been presented in the control room. I don't think you can get core profile in the reactor. Someone from EDF might know that.

The slide you mention is a simulator devoted to training where you get information on the plant which is different from the one you get in the full scope one. You can obtain a power profile.

QUESTION: Could you briefly review the educational background of your shift supervisors?

M. TANGUY: There are two possibilities. The first one is a young engineer with a college degree. Most of the time the first job is to enter EDF and he has a special training of two years on the general knowledge of the company, of course, but mainly oriented on safety aspects of nuclear reactor operation. During the two years, part of the training is also in nuclear power plants. I think these college-educated engineers represent about two-thirds of the safety engineers. One-third is ex-shift supervisors who are about forty years old and who have at least 10-15 years experience in plants and in nuclear power plants. They have a special training period which is different, of course, since their backgrounds are different, with a special emphasis on safety.

SESSION 2: APPROACHES TO TRAINING
AND REGULATORY PRACTICES (I)

Chairman: Dr. J. J. Persensky
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This first session is on approaches to training and regulatory practices. My comments are on the survey that Dr. Haussermann discussed, prepared by Principal Working Group No. 1, Task Force 5. The purpose of the survey was to provide a basis for the exchange of information concerning the analysis, design, development, implementation and evaluation of training for nuclear power plant personnel in CSNI member countries. It was also the vehicle which served as the impetus for this Training Specialist meeting.

The respondents to the survey were as listed in the report on Section 3.1. I would like to thank the respondents and the Task Force members who assisted in the development and analysis and reporting on this survey. Messrs. Vandewalle, Grandame, Wahlstrom, Gomolinski, Hada, Magnusson, and Morimoto, the former secretary of PWG-I.

The entire report, published in December of 1986, has been distributed to you. One of the major observations from this survey is the concept of standardization, i.e., how standardized are training programs in various countries? In fact, there is some standardization in all countries, but the focus is primarily on the operator, senior operator and shift supervisor programs, as opposed to some of the other programs for training. Only two countries, France and the Federal Republic of Germany, reported standardization at the national level.

None of the countries that reported indicated that training is based solely on regulation. In almost every case there was some mixture or combination of regulatory guidance and utility practice, and in some cases utility organizations participated in the development of training. When it is regulation-based, of course, the compliance with that regulation is monitored through inspection by the government authority. The criteria for those inspections is generated by the government, the utility, or some combination of utility industry working with government.

From the standpoint of analysis, i.e., how does one determine the need for training, or what type of training should be used? We found that needs assessment is used to identify training needs in almost all the countries, the majority of the countries, at least. Detailed assessments are performed mostly for the license operator, the senior operator, and the shift supervisor. Those are

the people who actually control the plant. These analyses are performed primarily by the utility, with the assistance of the government or through a combined effort of industry organizations. In the US, the task analysis performed by INPO has been the basis for a number of training programs that have been developed.

With regard to the design of training programs, job performance measures have been developed, again primarily for operator training. As you can see so far the emphasis has been on the operator. It seems to be that way still, but we are beginning to see some change in the emphasis toward the other positions, such as maintenance, I&C, and radiation protection technicians.

More learning objectives are used in training. There are learning objectives for most of the programs now, which have been developed by a combination of the instructors, subject matter experts, the trainees or the people in the field already doing that job.

The development of training programs reflects on issues such as what media is used or how the training is accomplished. We see many more simulators in use in the United States. We are moving towards use of simulators, not only in training but also for examinations. Mr. Tanguy discussed the use of simulators in EDF. I see they are moving away from the big plant-specific, or full-function simulator, to the more concept-based simulators. Of course, resources and the availability of equipment is a factor in the development and use of simulators as well as various other media.

From the standpoint of implementation of the training programs, there are multiple approaches to training facilities, on-site training facilities, group training facilities where a number of plant or utilities might use a common training facility with the simulator available there. Selection criteria are becoming more important. The survey indicates that there have been some attempts to increase the educational level, experience level and the use of psycho-technical exams. Only one country at this point requires a college degree for non-licensed and licensed operators -- Spain. They also require psycho-technical tests and personal interviews. Non-licensed operators spend the greatest portion of their time in training. The longest training program is for licensed personnel where the use of simulators is about 20 percent, in terms of total training time.

The final phase reviewed was evaluation. How is the training that is developed and implemented actually evaluated? There are combinations of methods used, including evaluations of the trainee during training as well as after training. Operator

experience and job performance is used as feedback to improve and modify the training programs. The last finding was that not all of the countries have specific practices for evaluating instructors. I think, again, from other examples I have seen, that such evaluations are increasing.

Some of the Task Force members asked me how I was going to state the conclusion, because we did not publish conclusions in the document. There are no real conclusions. I have seen a movement towards more formalization. There was an earlier survey done in 1980 by the NRC, which we reviewed. There are now more analyses of the jobs being performed. Questions such as, what is the need for training? What do these people need to know? Feedback, operating experience for evaluation purposes is now being used much more frequently.

Again, the purpose of this survey was to serve as a means of sharing experience and information among the member countries. If you are attempting, as a representative of your country's training effort, to develop or improve your own training program, or regulations regarding training, you now have an example of how other countries are doing it, and what experiences they have had. You can go to the people who have used different techniques and talk with them, both based on the survey itself, and through contacts with the various respondents who are listed in the report. Many of them are here; that was the purpose of this conference, for you to be able to share information, both formally through the presentations, and informally during the breaks. We have half-hour breaks which we made available so you can, after looking at the survey and hearing some of these papers, actually share information back and forth so that we can learn from the errors of others and the good things that others have done.

QUALIFICATION, TRAINING, LICENSING/AUTHORIZATION
AND RETRAINING OF OPERATING PERSONNEL IN
NUCLEAR POWER PLANTS

Some Requirements and Practices Commonly Shared
in the European Community Member States

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Introduction

At the end of the fifties a treaty was signed instituting between six countries the European Community for Atomic Energy, or in brief, Euratom. This treaty, in addition to the Common Market Treaty and the Coal and Steel one, constitutes the legal frame of the European Community which, at present, comprises 12 Member States. A commission, the so-called Commission of the European Communities (or in brief CEC) has to implement the provisions laid down in the treaties.

In the frame of its duties and responsibilities in the nuclear domain, the Commission, since the beginning of the seventies, has conducted exercises of consultation and analysis with the objective of inducing a progressive harmonization of the safety requirements and criteria applied to nuclear installations in the Community. The Commission's aim in pursuing this work has been to ensure that as far as possible the safety criteria to which each nuclear installation is designed, constructed and operated enjoy the benefit of review and possible refinement in the light of the whole competence and experience of designers, constructors, operators and safety authorities of the Community which are represented in the relevant working group of the Commission.

A major benefit from such activities from a safety point of view derives from the exchange and pooling of information and comments upon the approaches evolved by different organizations and countries. The ensuing process of analysis and the diversity of scrutiny of the various approaches tends to consolidate the confidence in each other's approach and to ensure that potentially severe sequences of accidents have not been overlooked. Furthermore, the countries with the smaller nuclear program can benefit from the strength of knowledge and experience of the others. Overall the effect is to promote convergence to an equivalent assurance of safety throughout the Community.

In 1981, the Commission issued a Communication on Safety Principles for Light Water Reactor Nuclear Power Plants containing a set of fundamental and basic safety principles and a scheme for subsequent requirements and criteria formalizing the technical consensus already reached.

One of the basic safety principles states, "The personnel of a NPP must be sufficiently qualified and trained to perform the required tasks."

As a logical consequence qualification, training, licensing and re-training of operating personnel have been the subjects of an in-depth exchange of views and information in the frame of the work conducted by the Commission. The evaluation of the regulations and practices in countries of the EC and some other countries having a large nuclear energy program, has led to the identification of some generally valid concepts. This synthesis, made with the assistance of a consultant, is now published under the form of an EUR report (EUR 10981). The main topics addressed within this report are the following:

- Shift staffing and staffing of the control room
- Personnel selection
- Qualifications necessary for recruitment
- Training and retraining
- Licensing/authorization

Qualification, training, re-training and licensing are dealt with hereafter.

Qualifications

It is difficult to consider the entrance qualifications and the subsequent training courses separately since possible "deficits" in an entrance qualification may be compensated for by suitable training. Nevertheless the responsible authority should stipulate the entrance qualification required by taking into consideration the national educational system, the practical experience required and the subsequent training.

For example, the supervisory shift personnel, especially the shift supervisor, should have the capacity for the understanding and analysis of complex technical situations and the shift supervisor should have an appropriate engineering qualification. Alternatively, and as a minimum, a member of the staff having such an engineering qualification as well as sufficient experience should be available in the plant at any time and empowered to give orders to the shift personnel during abnormal operational occurrences and accident situations.

The overall qualifications of the personnel include knowledge, abilities and experience originating from the entrance qualification as well as from training.

The qualification of the reactor operator for example, requires knowledge and abilities in the fields of:

- general scientific-technical fundamentals,
- general fundamentals of nuclear engineering, nuclear physics and nuclear safety, radiation protection and industrial safety
- necessary plant-specific knowledge
- experience in the repair and operation of the plant and its systems.

Training and Retraining

Reactor Operator

During the training, a balanced combination of theory and practice is needed for effective training. The use of senior shift personnel as tutors for training purposes represents one of the possibilities of providing a close link between theory and practice. Special emphasis should be laid on practical work and on the knowledge of plant layout since this is necessary as a basis for the comprehension of procedures and plant behavior. It is desirable that personnel training for new plants should actively participate in the commissioning tests and in the review of manuals and operating procedures.

Training of control room supervisor/shift supervisor

The training of personnel for these positions should essentially be carried out according to the same principles as are applied to the RO's training. However, emphasis should be laid on a deeper knowledge in all fields and on:

- sufficient practical experience within the plant in the different positions of shift personnel,
- sufficient training in incident analysis and incident diagnosis (e.g. on simulators) as well as strategies for coping with abnormal occurrences, incidents and accidents,
- thorough knowledge of procedures, regulations, rules and documents especially in the field of emergency procedures and consequence mitigation as well as in operational documents,
- abilities in leadership, motivation and communication.

Also, it is important that advanced theoretical training is given.

Preparation for Unexpected Events

During the training sequence, the shift personnel should be trained to cope with unexpected events during the operation of the plant (e.g. multiple failures). The licensed or authorized shift personnel as well as the shift engineer should participate together in the training.

Simulator Training

Training of the shift personnel on simulators is of utmost importance. After the conventional training, all licensed authorized members of a shift should be trained on a simulator which resembles their plant. The training should include:

- operation of the plant under normal conditions,
- execution of infrequent tasks (e.g., start-up and shut-down of the plant),
- operation during plant perturbations as well as correcting the perturbations,
- operation during plant incidents, especially the analysis of the plant condition, monitoring of automatic actions, manual intervention if necessary,
- to the extent possible, operation during major plant incidents.

During the training, special emphasis should be laid on multiple failures and, as far as possible, on different initiating events. The period of time scheduled for simulator training should be sufficiently long, so that the candidates, apart from familiarizing themselves with the simulator, have sufficient time for exercises and discussions. A period of up to, say, 120 to 160 hours of the control room work and approximately the same time for discussion and evaluation of exercises seems to be adequate.

Retraining

The shift system, among other things, substantially influences the time available for retraining measures. It is important that the system should not restrict the period of time available for retraining.

The production of programs covering long-term retraining seems to be of major importance. It is preferable that the theoretical work is conducted at regular intervals throughout the year.

Objectives of the theoretical part - in addition to repetition and deepening of the standard training program contents - should, in particular, be the transfer of operational experiences and modifications to the plant as well as the discussion of operating procedures and plant conditions, the evaluation of events occurring in the plant or in similar plants and information concerning the interpretation and revision of documents and regulations.

Training Facilities

Separate training systems such as simulators should be made available to cover plant operations and problems which cannot be dealt with by on-the-job training. The training systems are to be selected according to the level of knowledge or training of personnel as well as to the training objectives, e.g.:

- training of beginners on analog and/or basic principles simulators in order to give a general understanding of basic subjects,
- advanced training and retraining on a plant-typical or plant-specific simulator which allows training in plant manipulations, and gives the opportunity for the trainees to familiarize themselves with the dynamic behavior of the plant and to respond to incident situations.

For training on complex accidents and for the review of operating and emergency procedures, the use of a simulator representing the characteristics of the plant processes during normal and abnormal operating conditions together with the possibility to generate specific false signals in the control room is a very desirable solution.

When such complex simulators based on real plant are employed, operational results from the plant including actual incidents and findings resulting from training practice should be evaluated in order to update the simulator at suitable intervals. This implies that the design of simulators should include sufficient flexibility to allow for additions and adjustments.

Training centers require permanent staff who are properly qualified for theoretical as well as practical training and also personnel for maintenance and repair of the facility and realization of all necessary improvements.

Responsibility for Training

In accordance with practice, the executive responsibility for the training of personnel and their qualification should be with the plant manager. However, in a larger sense it rests with the

utility of the licensee. Since this implies a formal responsibility, the plant staffing should include one or more persons responsible for planning, coordinating and supervising the training of the personnel. This position requires a suitably qualified member of the staff who has had several years experience of work in power plants and especially in the operation of the plant and additionally some knowledge and skills in training management. The organizational plan should ensure that this person reports to a sufficiently high level of plant management. By this means, the independence of training and retraining matters from day-to-day needs of operation may be ensured.

Licensing/Authorization

The technical qualification of the responsible shift personnel should be tested and documented in a manner which demonstrates adequate independence. This could be an independent training body within the utility or an independent competent institution. Apart from the possibility of determining the qualification of a shift staff member by way of a formal examination, emphasis should be laid on profession-related judgement by superiors.

The measures to test the qualification should also include a practical part. In this respect, in addition to the abilities in plant operation, emphasis should be laid on the analysis and evaluation of plant conditions, evaluation of instrument displays, comprehension of processes, conduct in the operation of the plant and communication with the other shift members.

Conclusion

These are some noteworthy topics identified by the evaluation of practices in some countries of the European Community.

NRC METHODS FOR EVALUATION OF INDUSTRY TRAINING

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Abstract

On March 20, 1985, the Nuclear Regulatory Commission published the Policy Statement on Training and Qualification. The Policy Statement endorsed the INPO-managed Training Accreditation Program because it encompasses the five elements of performance-based training. This paper described the multiple methods that the NRC is using to monitor industry efforts to improve training and implement the NRC Policy Statement on Training and Qualification. The results of the evaluation of industry training improvement programs will be reviewed by the Commissioners in April 1987 to determine the nature of continuing NRC policy and programs for ensuring effective training for the U.S. nuclear industry.

Introduction

On March 20, 1985, the Nuclear Regulatory Commission published the Policy Statement on Training and Qualification. The Policy Statement endorsed the INPO-managed Training Accreditation Program because it encompasses the elements of effective performance-based training, which are: analysis of the job, performance-based learning objectives, training design and implementation, trainee evaluation, and program evaluation.

In approving the Policy Statement, the NRC deferred rulemaking on training and qualification for two years in recognition of the industry's accreditation efforts, provided that the industry programs produce the desired results. The NRC also began an independent evaluation of utilities' implementation of training improvement programs to determine the possible need for further NRC action.

The NRC evaluation of training programs includes evaluations of the INPO accreditation process and accredited utility training programs. The NRC staff observes the INPO Accreditation Team Visits during on-site reviews of training programs and the National Nuclear Accrediting Board meetings where decisions regarding the granting of accreditation are made. On-site reviews of a sample of accredited training programs are performed to verify implementation of performance-based training programs. In addition, the staff has

compiled data from Systematic Assessment of Licensee Performance (SALP) reports, licensed operator examination reports, inspection reports, and input from NRC Regional Offices. The following is a discussion of the NRC methods for independent evaluation of utility programs.

Team Visit Observations

An NRC observer accompanies a sample of INPO teams during on-site reviews of utility training programs to determine if the INPO teams conduct a thorough review of training programs against INPO criteria and objectives for accreditation. INPO Accreditation Teams include both INPO staff members and peer evaluators selected from utilities other than that being evaluated.

Observations of the National Nuclear Accrediting Board

The National Nuclear Accrediting Board is composed of nuclear utility executives, non-utility industrial training experts, educators, and an individual recommended by the Nuclear Regulatory Commission. The Board relies heavily on the review work performed by INPO at the Team Visit and in subsequent interactions between the INPO staff and the utility. The NRC staff observes this Board when it deliberates on whether or not to grant accreditation. Before the Board meets, the NRC staff observer reads the specific utility self-evaluation report and, if available, the report of the NRC staff member who observed the original INPO Accreditation Team Visit. The observer will also read the report of the Accreditation Team and the utility response to that report. Reviewing this background material helps the NRC observer to assess the Board's effectiveness in determining whether a utility has met the objectives and criteria for accreditation.

SALP Reports

The Systematic Assessment of Licensee Performance (SALP) provides an evaluation of plant performance in ten functional areas, including, since November 1985, Training. Each functional area is reviewed to determine management involvement in assuring quality, approval to resolving safety-related technical issues, responsiveness to NRC initiatives, enforcement history, operational events, and staffing. The reports result in identifying positive aspects of training programs as well as problems in operating activities and training program administration, content, and evaluation. The reports are used to evaluate problems which may be attributed to training program deficiencies among accredited and non-accredited training programs.

Inspection Reports

NRC training inspections are intended to evaluate the effectiveness of training implementation. The inspection approach embodied in inspection procedures, revised in June 1985 is performance-based in that it focuses on the ability of the plant staff to perform their jobs after training. Specifically, the new procedures require that inspectors determine whether there have been abnormal events or unusual occurrences that might have been caused by deficient training. These judgments are made through interviews with plant personnel and evaluations of the adequacy of classroom, on-the-job, and simulator training.

In addition, inspectors determine whether the lessons learned from these events or activities were effectively factored into the training program. Training inspection findings are reviewed to identify problems in both accredited and non-accredited training programs.

Examination Reports

Narrative reports on NRC licensed operator examinations are reviewed to extract information on performance of candidates for operator's licenses that could be linked to the effectiveness of utility training programs. The results of NRC examinations in terms of pass/fail rates, including requalification examination results, are analyzed to determine whether any significant difference exists in examination performance between candidates from accredited and non-accredited training programs.

Event-Based Reviews

Event-based evaluations of training programs are performed in response to reportable operating events or in response to a special request for an in-depth review of training at a particular facility. These reviews evaluate the licensees' training programs against the elements of performance-based training as described in the NRC Policy Statement on Training and Qualification.

Post-Accreditation Reviews

The staff conducts post-accreditation reviews which evaluate a sample of training programs to determine whether the objectives of performance-based training are met and implemented in accredited programs. To be selected for review, the utility's programs should have been accredited for at least six months. The staff has also tried to choose plants of different types and from different vendors. The reviews are conducted on site, using Training Review Criteria and Procedures that were developed by members of the staff of the Division of Human Factors Technology. These criteria have been published as NUREG-1220. Although somewhat different in format and structure, the criteria are very similar to those used by INPO.

The criteria are organized around the five essential elements of performance-based training, i.e., a systematic analysis of jobs to be performed, learning objectives that are derived from analysis of jobs to be performed, learning objectives that are derived from that analysis and that describe desired performance after training, training design and implementation based on the learning objectives, evaluation of trainee mastery of the objectives during training, and evaluation and revision of the training based on the performance of trained personnel in the job setting. Because these criteria apply to all performance-based training, they can be used for monitoring plant and industry trends and events involving personnel errors as well as for post-accreditation reviews.

Each of the five elements has its own review objectives and all of these objectives are worked through during the on-site evaluation. For instance, some of the criteria under the analysis element are:

- o Was a systematic method used for identifying and selecting tasks for which training will be provided?
- o Is a differentiation made between those tasks requiring initial training only and those requiring continuing training?
- o Is the task analysis adequate for the development of learning objectives, i.e., have knowledges and skills for the tasks been identified?
- o Does a mechanism exist to keep analysis information current as the job requirements change?

The element concerning development of learning objectives includes criteria such as:

- o Do learning objectives state the job performance behaviors expected of trainees upon completion of training?
- o Do learning objectives state job performance-based conditions and standards?
- o Are there procedures that require modification of learning objectives when job performance requirements change?

The design and implementation element includes criteria concerning the goals, objectives, and responsibilities of the training organization, qualifications of the staff, quality of lesson plans, and appropriate sequencing of training. The last two

elements, trainee and program evaluation, determine how well the first three elements have been implemented and contribute to the dynamic nature of the program. The criteria included under these two elements determine the bases for exemptions from specific portions of the training program, appropriateness of trainee evaluations or examinations with respect to job performance requirements, consequences of below standard performance, and precautions to preclude test compromise. In addition, the program evaluation element criteria address methods that are in place for analyzing and evaluating trainee test scores, use of critiques of the program by instructors, trainees, and supervisors on the job, whether a program exists for soliciting on-the-job experiences from job incumbents, and finally, whether findings of both internal and external audit or evaluations of the training program are used for overall program evaluation. When used for an event-based review or monitoring plant and industry trends, there is a flow chart that provides a way of determining an efficient way to use the procedures based on the characteristics of the problem.

Conclusion

The NRC staff has recognized that it would not be valid to assess industry efforts to improve training using any one parameter. To this end, the staff selected a number of methods with potential for identifying training strengths and weaknesses and for determining whether performance-based training is being effectively implemented throughout the industry.

Discussion

MR. LONG (GPU Nuclear): You have told us the evaluation process. What conclusions, generally, have you drawn regarding the effectiveness of the utility training program.

DR. PERSENSKY: We can respond in a general way because it is the subject of a Commission paper which, at this point, is pre-decisional. But we can provide a general view of where we stand.

MS. MORISSEAU: I would say that, as a result of going out and doing a lot of the evaluations, there has been a vast improvement in training in the industry. We would certainly not be able to fault the process. It seems to have had good results.

DR. PERSENSKY: But there are some improvements that we see needed both in the utility programs and in the INPO program, and we will be working with INPO on that.

REGULATORY REQUIREMENTS AND TRAINING OF
REACTOR OPERATORS AND SENIOR REACTOR OPERATORS IN SPAIN

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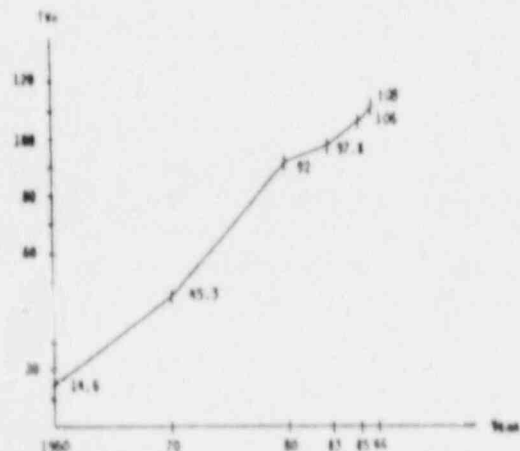
Introduction

At the CSNI Specialist Meeting on Operator Training and Qualifications, held in Charlotte, N.C. (USA) in October, 1981, Spain presented a paper entitled "Experience Gained in Spain in Licensing Reactor Operators." This paper contained information on the different types of nuclear power plants in operation or under construction in Spain, the generations to which these plants belonged and the Spanish contribution to their design, construction, testing and commercial operation, as well as presenting detailed information on the training and qualification of reactor operators. This presentation is aimed at updating that document, providing fresh data and indicating the changes that have taken place with respect to the applicable criteria and their implementation.

The evolution of the energy situation in Spain is illustrated in Table 1, which shows that the installed nuclear power amounts to 5815 MW, 13.8% of the total. Figure 1 shows the evolution of the demand for electrical energy in Spain. At present, Spain is the eleventh country in the world in production of electrical energy, being the consumption "per capita" in 1986 of 2,760 kilowatt hours.

Figure 1. Evolution of Demand for Electrical Energy (1960-1986)

Table 1. Installed Power Contribution (MW)



Source \ Year	1960	1970	1981	1986
Hydro	4.128	10.443	13.215	15.208
Conventional Thermal	1.594	6.505	17.811	21.029
Nuclear	-	160	2.050	5.815
TOTAL	5.722	17.108	33.076	42.052

Table 2 shows the main characteristics of Spanish nuclear power plants, while Figure 2 indicates their geographical location.

Table 2. Nuclear Power Plants in Spain

Figure 2. Nuclear Power Plants in Spain

Name	Power (MW)	Type	NSSS Supplier	Date of Commercial Operation		
1st	1	José Cabrera	160	PWR	W	1968
2	Sta. M. de Garoña	450	BWR	GE	1971	
Gen.	3	Vandellós I	500	BWR	CEA/SFAC	1972
4	Almaraz I	900	PWR	W	1981	
5	Ascó I	930	PWR	W	1983	
2nd	6	Almaraz II	930	PWR	W	1984
7	Cofrentes	975	BWR	GE	1984	
Gen.	8	Ascó II	930	PWR	W	1985
9	Leóniz I	930	PWR	W	Mothballed	
10	Leóniz II	930	PWR	W	Mothballed	
11	Vandellós II	950	PWR	W	1987	
12	Trillo I	1032	PWR	KWU	1987	
13	Valdecaballeros I	975	BWR	GE	Mothballed	
Gen.	14	Valdecaballeros II	975	BWR	GE	Mothballed
15	Trillo II	1041	PWR	KWU	Mothballed	



- In OPERATION
- UNDER CONSTRUCTION
- MOTHBALLED

The first generation plants indicated in Table 2 were turnkey projects; participation by Spanish industry in the second generation amounted to 80%, and so far a 90% participation is foreseen for the third generation.

This evolution, along with the impact of different operational events (TMI, Crystal River, Davis Besse, etc.) has given rise to modifications to both regulatory requirements and training programs in an attempt to improve the already excellent qualification of licensed operators and supervisors in Spanish plants.

Regulatory Perspective

October 8, 1982, Royal Decree 2519/82 was published, approving the National Regulations for the Protection of Health against Ionizing Radiations. This Decree, and the Regulations governing Nuclear and Radioactive Installations, approved by Ministerial Decree 2869/72 in 1972, develop respectively the aspects of radiological protection and licensing contained in the 1964 Nuclear Energy Law, later modified by the law passed in 1980 that gave rise to the creation of the "Consejo de Seguridad Nuclear" (Nuclear Safety Council). According to this law, the above-mentioned body (CSN) is the sole competent authority for matters related to Nuclear Safety and Radiological Protection.

On the basis of the regulations dictated by the competent international bodies, the regulations contained in the Royal Decree of 1982 establish the criteria and objectives on which radiological protection norms should be based.

The entire Operator and Supervisor licensing process was described in great detail in 1981. Generally speaking, the requirements established with respect to the training, qualification and evaluations of operations personnel of those Spanish nuclear power plants initiating exploitation in 1982, (Asco, Unit I), 1983 (Almaraz, Unit II), 1984 (Cofrentes) and 1985 (Asco, Unit II) were the same as the demands made of Almaraz, Unit I in 1980. These requirements are specified in the Safety Guidelines governing basic regulations in this area. However, the demands have been extended to include additional knowledge of plant systems, safety-related or otherwise, in order to avoid or mitigate the consequences of accidents giving rise to serious core damage; of the peculiarities of the Three Mile Island accident; and of the possible evolution of loss-of-coolant accidents in each specific plant. The above has permitted greater knowledge to be achieved with respect to the fundamentals of thermohydraulics and postulated transients in each plant.

Qualification Requirements

As a result of publication of the above-mentioned 1982 Regulations and of the recommendations derived from the TMI accident, to the extent that these relate to the training of operations personnel, as well as several other actions such as the implementation of new emergency procedures based on the Emergency Response Guidelines (ERG's), Safety Parameter Display System (SPDS) detailed Control Room Design Review and implementation of emergency operations facilities, and on the basis of the experience acquired, the Nuclear Safety Council has updated the regulations contained in the Safety Guidelines. The following Guidelines, published in March and October, 1986, replace all previous Guidelines.

- o CSN Safety Guideline 1.1. "Qualifications for obtaining and using nuclear power plant operations personnel licenses."
- o CSN Safety Guideline 7.4. "Basis for medical surveillance of workers exposed to ionizing radiation."

The main differences between Guideline 1.1 and its predecessor are: the requirement of a minimum number of hours of training in the areas included in the examination, on the simulator and in operation of the candidate's Plant prior to obtaining the license; and the requirement for continued training in all cases for license renovation.

This Guideline presents far more detailed information on the items to be included in training and retraining programs and examinations, and even points out the operations practices recommended and the activities to be carried out in order to guarantee the level of experience demanded.

The personnel of the third generation plants (Trillo and Vandellos II), and the new personnel for plants of previous generations, have either been trained, or will be trained, in accordance with these new criteria, the corresponding examinations being carried out after March, 1986.

Initial Training Program

Figure 3 shows a typical Spanish training program for licensed operators and supervisors aimed at complying, on the one hand, with the regulatory requirements and, on the other, achieving a maximum level of competence in the plant operators. The figure refers to licenses for plants in operation; in the case of plants under construction, alternative training programs have been developed substituting plant operating experience for candidate participation in home-station start-up activities.

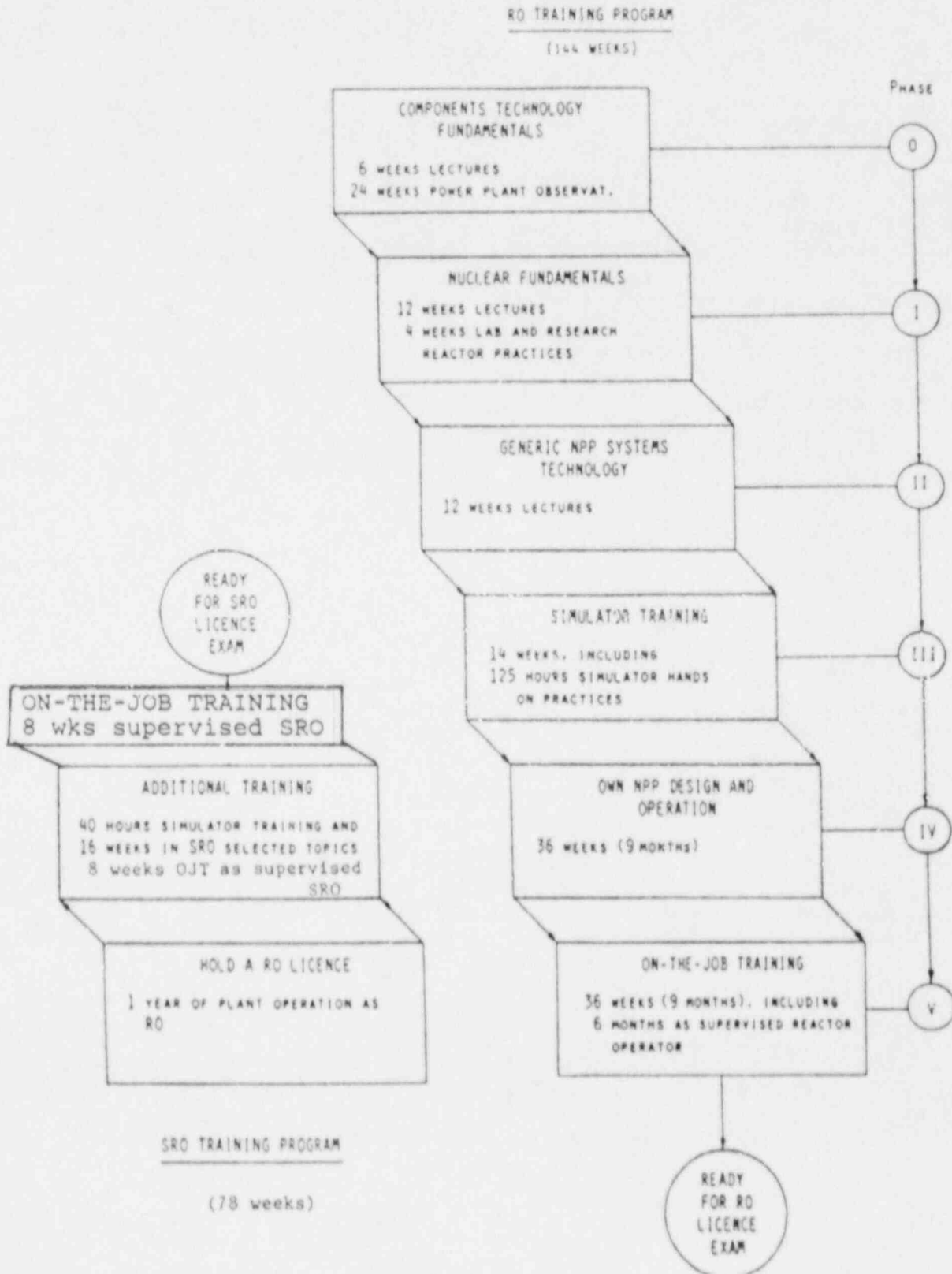
Regualification

Regualification programs are aimed at maintaining the professional competence required for safe and efficient performance of assigned functions. Spanish Safety Guideline GS-1.1/86 defines the requirements to be fulfilled by the regualification programs submitted by each NPP utility-owner, and which must be approved by the NSC.

Bearing in mind that the regualification programs address people performing the routine tasks associated with their respective job position functions, these programs must be based on four different lines of action:

- o To refresh theoretical subjects and administrative procedures, as well as professional skills, especially those rarely if ever used, in order to avoid the potential risk of degradation of operator capability to cope with assigned duties.
- o To assure operator knowledge of any design changes at the home plant impacting the plant physical processes and, therefore, the operating procedures.

Figure 3. RO/SRO Training Program



- o To correct detected performance failures by using the data sources described in the preceding items.
- o To alert the operator with respect to lessons learned from own and third-party operating experience in order to avoid recurrence of errors.

Figure 4 shows the structure of a typical requalification program administered to the six shifts of one Spanish NPP during the last two years' requalification period.

Simulator training practical sessions are established on the basis of the operations experience accumulated by the operators and supervisors during their shifts. This individual experience is included in the operations record of each license holder, in which the following information is reflected every six months:

- Number of days in each operational mode
- Criticalities
- Reactor trips
- Grid couplings
- Load variations in excess of 5%
- Turbine Runs
- Plant cooldowns and warmups
- Malfunctions and/or emergencies
- Tests/Surveillance
- Operations of interest

The operations that have not occurred during the shift are programmed for performance on the simulator.

Table 3 shows the real operations record of a senior reactor operator (SRO) for the first six months of 1986.

Candidate Evaluation

Evaluations are performed by the Tribunal of the CSN responsible for verifying candidate qualifications by means of three different exams: final written examination, oral examination on the PWR or BWR simulator and oral examination at the candidate's home plant. The characteristics of the written examination are as before, and similar to those of the examinations held in the majority of countries.

The examinations set on the simulator are performed in groups, although each candidate is assessed individually. These groups include three people, acting as Supervisor, Reactor Operator and Turbine Operator. The examination sessions last an average of four hours, during which time the shift is rotated on the basis of

Figure 4. RO/SRO Retraining Program

OBJECTIVE

TO MAINTAIN & UPGRADE THE LEVEL OF
PROFICIENCY OF THE LICENSED RO'S AND
SRO'S

LENGTH

TWO YEARS' CYCLES

CLASSROOM

TOPIC	HRS./YEAR
BASIC KNOWLEDGES	1/4 25
. REACTOR OPERATION THEORY & PRINCIPLES	
. PLANT DESIGN & OPERATION CHARACTERISTICS	
. PROTECTION & SAFETY SYSTEM	
. CORE PARAMETERS & FUEL HANDLING (SRO'S ONLY)	
. RADIOLOGICAL PROTECTION	
. RULES AND REGULATIONS	
DESIGN CHANGES & OPERATION	25
. PLANT DESIGN & OPERATION CHANGES	
. NORMAL AND EMERGENCY PROCEDURES	
. TECHNICAL SPECIFICATIONS	
. OPERATION ADMINISTRATIVE PROCEDURES	
OWN PLANT OPERATING EXPERIENCE	30
INDUSTRY-WIDE OPERATING EXPERIENCE	20

PRACTICES

SIMULATOR TRAINING	20 HRS./YEAR
. PLANT START-UP & SHUTDOWN	
. SG & FW MANUAL CONTROL	
. REACTIVITY CHANGES GREATER THAN 10 %	
. LOSS OF COOLANT	
. LOSS OF CORE COOLING FLOW, NATURAL CIRCULATION	
. LOSS OF ALL FEEDWATER	

ADDITIONAL TRAINING UP TO 25 EXERCISES TO BE RUN EVERY TWO YEARS	

LOCATION

LECTURES: PLANT SITE
PRACTICES: SIMULATOR FACILITIES

Table 3. Operating History

1. No Days of Operation in Different Modes

Mode 1 - 57 days	Mode 2 - 4 days
" 3 - 5 days	" 4 - 2 days
" 5 - 20 days	" 6 - 8 days

2. Criticalities

06-01-86

3. Trips

None

4. Grid Couplings

06-01-86

08-01-86

5. Load Variations

06-01-86 - From 0 to 100 MWe
07-01-86 - From 347 to 585 MWe
08-01-86 - From 0 to 280 MWe
12-05-86 - From 458 to 673 MWe

6. Turbine Runs

06-01-86 - From 0 to 1500 rpm
08-01-86 - From 0 to 1500 rpm

7. Warmups and Cooldowns

03-03-86 - Cooldown from 140°C to 70°C
28-04-86 - Warmup from 125°C to 140°C
29-04-86 - Warmup from 210°C to 290°C

8. Malfunctions

None

9. Tests

19-04-86 - OP2/PV-3.22 (Engineered safeguards channel actuation)

10. Operations of Interest

From 13-01-86 Reception and storage of new fuel, from casks to New Fuel
to 14-01-86 Storage Racks

From 13-03-86 Refuelling operations (transfer of elements from core to
to 21-03-86 pool and vice versa)

the post being evaluated. The session is initiated from a stable plant situation, an average total of ten equipment or system-related failures, some leading to emergency conditions, being introduced during subsequent load increases or decreases. The sessions are pre-programmed in order to permit evaluation of the behavior and actuation of the candidates within the group and with respect to plant auxiliary staff, as well as of the handling of documentation available on the simulator.

The oral examination held at the plant is divided into three parts, previously planned. The first part is a classroom session in which the candidate is presented with a Failure Operation Instruction and one or two Emergency Operation Instructions. The candidate, who may consult the instructions, is then asked questions relating to the objective of the procedure, monitoring of the process (evolution of parameters) and possible failures and emergencies: symptoms, diagnostics, automatic and manual actions and precautions.

The second part of the examination is held in the Control Room, and generally consists of a given scenario and an assumed incident implying the intervention of the procedures selected in the first part of the exercise. The candidate is required to identify this incident on the basis of the data obtained in the Control Room and from the plant auxiliary staff, and to specify the actions to be taken throughout the transient. During this exercise, the candidate must correctly interpret the alarms generated on the panel and the data supplied by the recorders, identify the instrumentation associated with the different systems, locate and correctly use the documentation available in the Control Room, make whatever calculations are required and record the necessary data.

The third part consists of a plant walkthrough, during which the candidate has to locate and identify the equipment and components associated with the selected failure instruction.

The results achieved so far after this evaluation are frankly very positive, as 95% of candidates pass the three examinations set.

The Supervisor's license for handling of new fuel in the storage pool prior to core loading is awarded following successful completion of an oral examination at the candidate's home plant, which is aimed at demonstrating the candidate's skill in handling fuel elements and his knowledge of nuclear safety and radiological protection requirements during fuel handling and storage operations.

The number of Supervisor licenses per Unit for start-up of second generation Plants (Almaraz, Asco and Cofrentes) has increased considerably as shown in Table 4. This is due to the fact that the Nuclear Safety Council, adopting the recommendations made in the wake

of the TMI accident, requires two Supervisor license holders per shift instead of the one required before. One of these people will be on site at all times, and will act as Supervisor Chief as from the moment in which the fuel is loaded into the reactor core. The other Supervisor will act as Assistant Supervisor Chief in the same situations as the Supervisor Chief, but his work will normally be carried out in the Control Room.

In plants having two units, the Supervisor Chief may be common to both.

Two operators, one of them RO licensed, are required to be at the Control Room per Unit.

The first generation plants (Jose Cabrera, Sta. M. de Garona and Vandellos I) are gradually increasing their staff in order to satisfy this requirement, and are also increasing the number of shifts from five to six as a result of limitations on the working day and minimum rest times, as well as to permit greater operations personnel dedication to retraining.

Table 4. Licenses Issued by Regulatory Authority for Nuclear Power Plants in Spain

YEAR	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986															
PLANT	SRO RO		SRO RO		SRO RO		SRO RO		SRO RO		SRO RO		SRO RO		SRO RO		SRO RO		SRO RO															
	JOSE CABRERA	7	5	2	3	2		2	2		1	4	2		4	1	2	6	3	2	4													
STA. M. GARONA				12	4	2	1		1		3	1	1	3		3	6			1	8													
VANDELLOS I						4	12	2	2	5	2	1	1	1			1	3			5													
ALMORAZ														2*	1*	8	12		12	11	1	1	3	5										
LEONIZ															1*																			
ASCO														5*		12	7	5	6	6	4	2	1											
COFREPES														8*			11	4	4	11			2											
TRILLO																								5*										
VANDELLOS II																								8*										
TOTALS	7	5	2	15	4	2	10	12	4	3	2	5	5	2	2	8	1	8	3	1	29	16	4	8	25	27	14	10	13	17	8	23	20	6

* NEW FUEL POOL HANDLING

ISSUED: 324

UNDER EVALUATION: 51

EXPERIENCE GAINED FROM THE IMPACT OF REGULATION
AND TRAINING MEASURES ON SHIFT PERSONNEL QUALIFICATION
IN THE FEDERAL REPUBLIC OF GERMANY

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Abstract

The shift crews of German nuclear power plants consist of the so-called responsible shift personnel (shift supervisor, deputy shift supervisor, licensed reactor operator), the non-licensed reactor operators and the roundsmen. In accordance with the particularly high qualification requirements, the paper focuses on the responsible shift personnel. The typical training paths for this group of persons are described. Following this, the results of an evaluation of personnel data and examination results are presented. In about 1980-81, the training requirements underwent a material change. This is why the evaluation of the data is restricted to the years from 1982 through 1986. It is the basis of a few conclusions or recommendations regarding the further improvement of personnel qualifications.

Educational/Vocational Paths

The selection of candidates for the career path leading to shift supervisor, deputy shift supervisor or licensed reactor operator is preceded by educational and vocational training which begins at the age of 6-7. The paths depicted in Figures 1-3 may be considered as typical.

Fig. 1:
Typical Educational/Vocational Path
Leading to Selection for RO Training

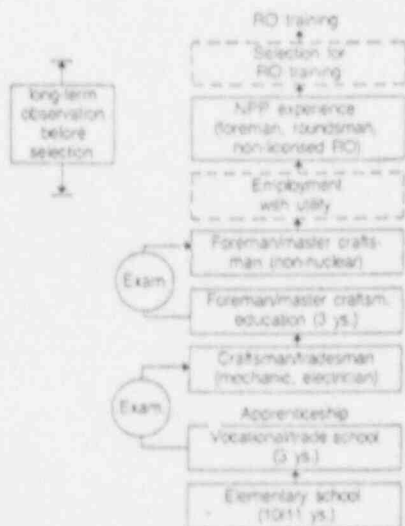


Fig. 2:
Typical Educational/Vocational Paths
Leading to Selection for SRO Training
(Deputy Shift Supervisor)

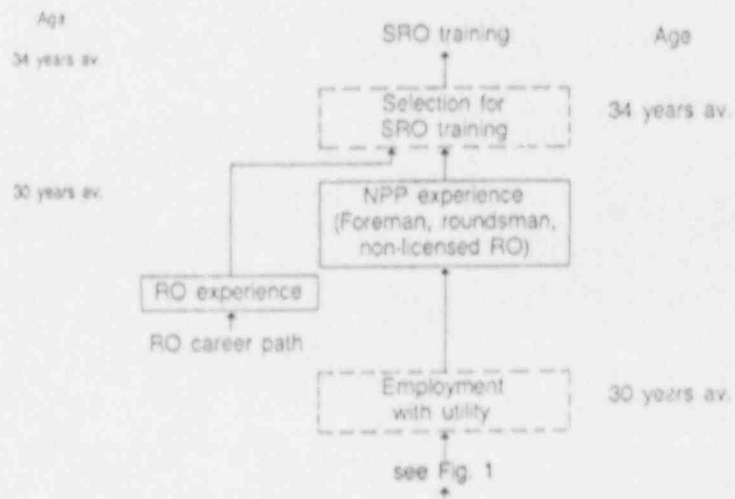
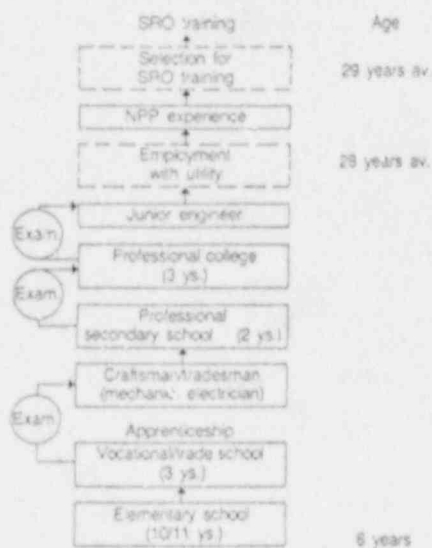


Fig. 3:
 Typical Educational/Vocational Path Leading
 to Selection for SRO Training (Shift Supervisor)



The licensed reactor operator attends elementary school for ten years followed by three years of practical and theoretical vocational training in the lines of mechanical or electrical engineering and a final examination. Following this, he acquires several years of practical occupational experience as a skilled worker in this line. Every third skilled worker undergoes further training to the level of master in his craft and takes the respective final examination. On an average, employment at a nuclear power plant starts at about the age of 30. At the plant, the employee is generally assigned the duties of roundsman and/or non-licensed reactor operator.

Statistics show that, on an average, selection for licensed reactor operator training takes place after long-term observation of more than four years.

The future deputy shift supervisor also undergoes the education and training depicted in Figure 1 until he is employed at a nuclear power plant. Further training to the level of master is mandatory. The selection for training to the level of deputy shift supervisor, which training is identical with that to the level of shift supervisor, takes place either after several years of practice as a roundsman and/or non-licensed reactor operator, or following successful work as a licensed reactor operator (Figure 2). The guidelines provide scope for either possibility. The shorter way to the level of deputy shift supervisor without any prior practical experience as a licensed reactor operator is being increasingly favored.

As a rule, the future shift supervisor, after having undergone training as a skilled worker, attends a professional secondary school (two years) and a professional college (three years) from which he graduates as a junior engineer (Figure 3). Qualification as an engineer in a technical line which corresponds to his future employment in a nuclear power plant is mandatory. Experience shows that he has little or no practical experience as an engineer at the time he is employed at the nuclear power plant. The

decision concerning his later employment as a shift supervisor is made at the time he is engaged or during the first year of his employment at the plant (no long-term observation). At this time, the average age of the candidate is around 29 years.

Prior to employing new personnel, the licensees carry out personality tests to an ever increasing extent (testing intelligence, behavior under stress, recollection, concentration and communication abilities, reliability, etc.), although corresponding regulatory requirements do not exist.

Training considering the specific aspects of nuclear power plants takes place at one of the four training centers, at a simulator laboratory and at the plant itself. All candidates attend a three-month outside training course in order to become acquainted with nuclear fundamentals. They finish the course with a written and oral examination at the respective level for which they were trained (licensed reactor operator, shift supervisor). Depending on the plant in question, the plant-specific initial training at the simulator takes six to nine weeks. One BWR and three PWR full-scope simulators are available for this purpose. Contracts have been awarded for two further full-scope simulators. Plant-specific training on the spot varies with the plant in question. Basically, however, it consists of several months of theoretical training, several months of work in various departments and protected participation in shift service in the control room. The candidates finish plant-specific training with a final examination comprising written and oral tests. Figure 4 is a simplified presentation of the career path leading to the level of licensed reactor operator, whereas Figure 5 shows that leading to the level of deputy shift supervisor or shift supervisor.

Fig. 4:
Typical RO Career Path

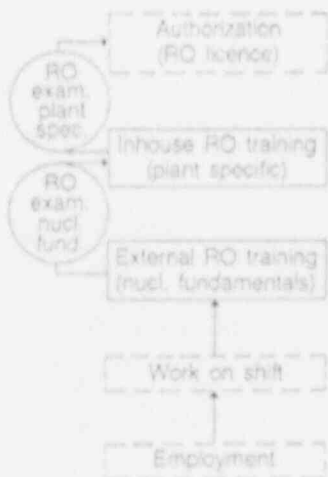


Fig. 5:
Typical SRO Career Path



Following their employment at the nuclear power plant, the skilled workers may undergo additional training in order to specialize in nuclear power plant engineering. They may also take the master's examination in this line. With respect to the career path to the level of licensed reactor operation (Figure 4) or deputy shift supervisor (Figure 5), this additional training is not mandatory. However, it is encouraged and sponsored by the utilities in order to provide the candidates with an intensive preparation for their assignments for the operation of the plant. It is not unusual for licensed reactor operators and deputy shift supervisors to be trained and undergo the respective examinations in two lines, e.g., mechanical engineering and nuclear power plant engineering, or electrical engineering and nuclear power plant engineering.

Shift supervisors and deputy shift supervisors follow the career path depicted in Figure 5 if they do not yet have any practical experience as licensed reactor operators. This applies in particular to all engineers (shift supervisors). Following the successful examination as shift supervisors, they are first licensed as reactor operators, whereas the actual shift supervisor license is only issued after six months of experience as a licensed reactor operator.

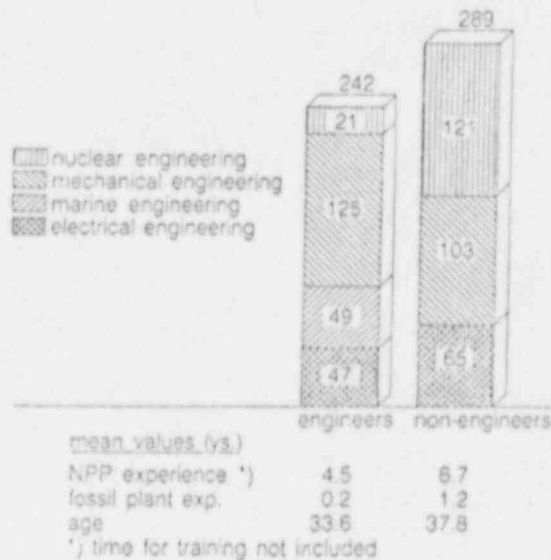
During their studies, future engineers may specialize in the line of nuclear power plant engineering, although this does not seem to be particularly attractive to students. (Also university studies focus more on the design of plants than on their operation.) To a greater extent, university graduates in the line of marine engineering decide upon a career as shift supervisors.

Evaluation of Data

From 1982 through 1986, a total of 531 persons have finished their training to the level of responsible shift personnel, 46% of them engineers, and 54% non-engineers. Of the non-engineers, 26% are skilled workers, 56% of them are masters, and 18% technicians. The training level of technician is more or less halfway between master and engineer. As they account only for a relatively small percentage of the responsible shift personnel, their educational and vocational training is not discussed at any greater length here. Skilled workers and masters account for the group of licensed reactor operators, masters and technicians for the group of deputy shift supervisors.

At the time of their being licensed, the average age and the mean values of their practical experience were almost identical for licensed reactor operators and deputy shift supervisors. This is why they could be represented together in a single block in Figure 6 (non-engineers) and compared with the block of the shift supervisors (engineers). As a rule, the shift supervisors are a couple of

Fig. 6:
SRO/RO Licenses (1982 - 1986)



years younger, and have definitely less nuclear power plant experience, when beginning their employment. Contrary to the deputy shift supervisors and the licensed reactor operators, it is only in exceptional cases that they have experience from fossil power plants. Before being employed at the nuclear power plant, they had specialized in one of the four lines of mechanical engineering (52%), nuclear engineering (9%), marine engineering (20%), and electrical engineering (19%). (Actually, nuclear engineering and marine engineering are special branches of general mechanical engineering.) Among non-engineers, only the lines of mechanical engineering (36%), nuclear engineering (42%) and electrical engineering (22%) are represented.

The examination data bank also permits a statistical comparison of examination results. Such a comparison only makes sense if the examinations are held at the same level. Figure 7 provides an overview of the oral shift supervisor examinations in nuclear fundamentals which, as a result of the regulatory requirements, have to be carried out at the level of engineer (shift supervisor and deputy shift supervisor). There is a clear-cut lead in the performance of engineers (shift supervisors) as compared with that of non-engineers (deputy shift supervisors). Figure 8 shows the results of the plant-specific final examinations which are carried out in the control room (administration, normal operation, occurrences, accidents, radiological protection). It is evident that there is practically no difference between the performance of engineers and that of non-engineers.

Fig. 7:

Oral SRO Examination Results
in Nuclear Fundamentals (1982 - 1986)

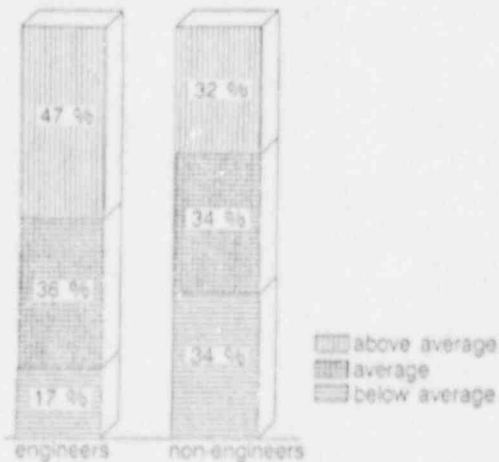
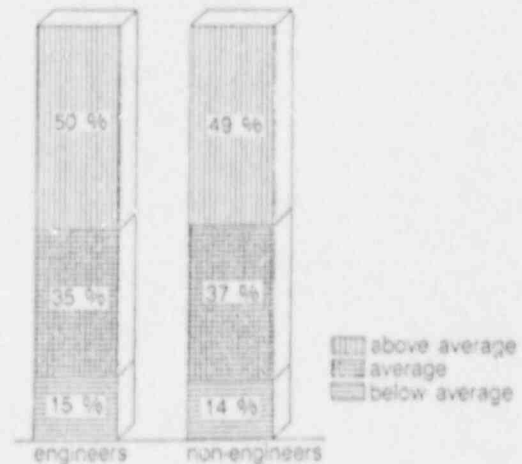


Fig. 8:

Results of Final SRO Examinations (1982 - 1986)



The examination data bank may also be used for other evaluations, e.g., a comparison of performance as a function of age or the candidates' practical experience or technical specialization. The impact of modified regulatory goals on the responsible shift personnel's technical qualification or job descriptions can be traced. Current trends and developments can be identified at an early stage. The data bank indicates differences in the training or examination levels of the training centers and shows whether comparable standards are used with respect to inhouse training at the nuclear power plants and how written examinations (at the center, inhouse) have to be assessed in comparison with oral examinations (inhouse and external examinations). The candidates' particular data concerning the performance of their examination and their professional career are stored in the data bank.

Conclusions, Trends

At regular intervals, the responsible shift personnel's training and retraining programs are reviewed by the responsible authorities and have to be adapted to the latest state of the art. In recent years, this has led to both a steady improvement in quality and a quantitative extension of training measures. As far as quality is concerned, it is in particular the following aspects that should be mentioned:

- o Optimization of training materials. For example, the periodic review of training materials every two or three years, as prescribed by the authorities, leads to the preparation of revised materials.

- o Availability of efficient training simulators. The software and hardware of the older PWR and BWR simulators were removed and adapted, as far as possible, to the current state of the art (increase in simulation scope, accuracy and flexibility). An advanced PWR simulator was put into operation in 1986, and one additional PWR and BWR simulator each were ordered.
- o Greater appreciation of the position of training manager as a result of modified regulatory requirements.

Within the scope of a revision of the guidelines, new and/or extended curricular contents were defined which are taken into account in the training programs:

- o In-depth treatment of thermohydraulic questions (engineer's level) with a view to accident situations.
- o Intensified evaluation of occurrences.
- o Training in the symptom-based approach.
- o Treatment of the phenomena which are characteristic of serious events.
- o In-depth treatment of fire protection.

The qualification of the responsible shift personnel is influenced not only by the authorities' direct impact on the training programs, but also by the regulatory requirements for the proof of technical qualification (examinations). In the Federal Republic of Germany, the oral examinations are held by an examination board comprising members of all parties involved. Each board consists of six members, i.e., a representative of the authorities, independent authorized experts and representatives of the training centers (examinations in nuclear fundamentals) or the licensee (plant-specific examination). With the aid of the examination data bank, it can be demonstrated that the examination boards use similar standards in the examinations of nuclear fundamentals and in the plant-specific examinations. Experience shows that the examination boards take care to ensure that:

- o there is a factual harmonization of interests among the examiners involved,
- o there is both self-control and mutual control among the examiners,

- o there is a collective availability of the necessary expertise and/or examiners' competence (i.e. individual gaps in knowledge do not pose any problem),
- o all in all, a higher degree of objectivity is attained than is in the written examinations (see below).

It is improbable that a candidate will pass an examination although his knowledge is insufficient. An unqualified candidate could pass the final examination only in the case of a false decision on the side of all the examiners, since positive decisions require a unanimous vote.

Passing the written examination is a prerequisite for undergoing the oral examination. To a great extent, the written examinations are organized and carried out by the training centers and/or the licensees themselves. The evaluation of these examinations has shown that there are great differences between the requirements and the standards of evaluation. This is why, at present, the rank of the written examination is considered comparatively low. For the examination in nuclear fundamentals, a data bank of examination questions has been developed which is to make a contribution to a future harmonization of the procedure.

A couple of years ago, detailed regulatory provisions were issued for the written examinations (nuclear fundamentals). Of utmost importance was the introduction of a 85% limit for examinations passed, i.e. 85% of the possible total points have to be reached since then. However, practice has shown that the goal pursued by this approach - to ensure a particularly stringent performance evaluation - was not attained. Instead, as a result of the 85% criterion, the preparation, execution and evaluation of the examinations changed along a line that cannot be in agreement with the regulatory intentions. Overcoming the obstacle of the examination became the foremost objective, and preparation for responsible assignments in the control room receded to the background. In connection with the introduction of the data bank of examination questions, a modification or elimination of the 85% criterion is being discussed.

The possibilities of an evaluation of qualification are not exhausted by the written and oral examinations. Another important method is the performance evaluation during work at the plant which, as a matter of fact, has to be done by the superiors. However, this method also offers itself at the simulator. In this connection, further elements of competence can be evaluated beside technical qualification such as team work, behavior under stress, decision-making capabilities, ability to communicate, individual authority, sense of responsibility. In a draft amendment of the Guideline Relating to the Technical Qualification of Nuclear Power Plant Personnel, an evaluation of the results of training at the

simulator (initial training and retraining) is required for the first time. This evaluation is left to the simulator instructor and the coach attending the simulator course in order to take care of the shift crew (training manager, operations manager).

In accordance with the amendment of the Guideline, the duration of initial training at the simulator is to be extended to at least six weeks (from four weeks at present). Industry has become aware of the special advantages of this training method, and several licensees have already adopted the general policy of delegating their control room personnel to eight or nine week basic training courses.

Discussion

MR. BOHANON: Are there similar patterns, in principle, in the programs that you use in Germany for other complex facilities, like petrochemicals or the aviation industry?

MR. FARBER: In general, I can say there are no similarities compared with the aviation industry.

DR. PERSENSKY: On the 85% passing criteria, your finding that if you increase the criteria, then you get simpler questions. That appears to indicate no real change.

MR. FARBER: It did not, and the reason was that there are four national training centers competing in one way or another. As I mentioned in the presentation, we are now going to create a uniform catalog of questions for all training centers. This is why we have discussed eliminating the 85% rule, because it is of little value.

MR. TADYCH: Prior to the institution of the 85% criteria, what was your previous criteria?

MR. FARBER: We have always had an 85% passing criterion, but just for nuclear fundamentals exams, and not for plant-specific exams.

THE CEGB APPROACH TO THE SELECTION AND TRAINING
OF NUCLEAR POWER STATION PERSONNEL
WITHIN THE UK REGULATORY FRAMEWORK

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Abstract

This paper considers the approach to the selection and training of engineering, and scientific staff for the Central Electricity Generating Board's (CEGB) Nuclear Power Stations. Formal academic training will have taken place within the State system of education, typically up to the age of at least twenty-one. The CEGB recruits to meet its requirements from those who have successfully completed such programs, some of whom it will have sponsored from the age of eighteen. On recruitment to the CEGB, further structured training programs are utilized to develop the skills and knowledge required to undertake the duties of specific jobs. In the case of Nuclear Power Station staff, account has to be taken of the requirements of the Operating Licence given to the CEGB by the Health and Safety Executive, the regulatory body. This imposes amongst other responsibilities, a requirement on the CEGB to ensure the competency of its Nuclear Power Station staff. The CEGB discharges this through comprehensive training programs designed to meet the requirements of all levels of posts in the various disciplines required to operate a Nuclear Power Station both safely and efficiently.

Nuclear Site Licence in Great Britain

Before a Nuclear Power Station may be built and operated within Great Britain, a Nuclear Site Licence must be issued by the regulatory body (the Health and Safety Executive) in accordance with the requirements of the Nuclear Installations Act, 1965. This Nuclear Site Licence imposes on the licensee, the Central Electricity Generating Board (CEGB), the responsibility for the safe operation of the nuclear installation. Operating Rules, required by the Nuclear Site Licence, are formulated as instructions from the licensee to the station manager. These Operating Rules are made with the objective of ensuring the safe operation of the plant and detail the methods, procedures and conditions under which the plant may be operated.

As a condition of the Site Licence, the licensee ensures that the plant is not operated except under the control and supervision of a person appointed for that purpose and that it is manned by sufficient competent staff to ensure nuclear safety is not prejudiced. These definitions place a responsibility for ensuring the competency of the control room staff with the station manager.

The authorization of staff to operate a Nuclear Power Station is given internally by the CEGB and not by the Regulatory Body.

The Staffing of a CEGB Nuclear Power Station

The CEGB is the only utility responsible for the generation and transmission of electricity in England and Wales. It currently has an installed capacity of 52,363 MW from 78 power stations, of which 5,029 MW is nuclear plant in operation with a further 3,300 MW currently being worked up to full electrical output.

The CEGB's nuclear power program began in the latter part of the 1950's. Since then it has brought into operation eight nuclear power stations using the Magnox type of gas cooled reactor, four stations utilizing the Advanced Gas Cooled Reactor (AGR) and has one further AGR station scheduled to load fuel later this year - all these stations are twin reactor units. Permission has just been received to construct a 1,320 MW Pressurized Water Reactor which is scheduled to load fuel in 1993.

Since its first Nuclear Power Stations became operational in 1962, the CEGB has acquired 25 years experience of the staffing and operation of Nuclear Power Plants. The design of these Gas Cooled Reactors has imposed particular requirements on the engineering equipment provided, for example, on load refuelling equipment, and hence on the staffing needed to operate and maintain the plant. The CEGB has always placed considerable importance on each station having a professional scientific and engineering capability to cope with a range of eventualities associated with the safe and efficient operation of the plant. A consequence of this policy is that reactor physics, health physics and engineering skills are available on each site. A typical staff structure for a twin reactor AGR station is shown in Figure 1.

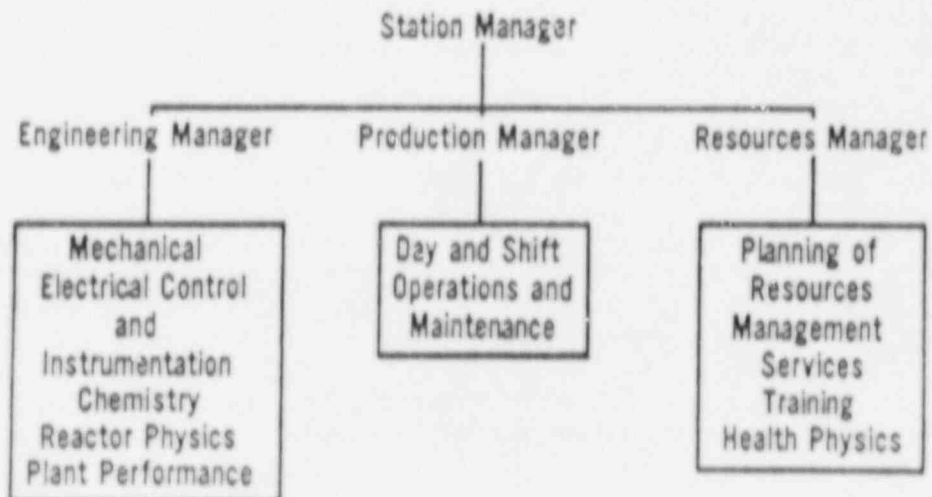


Figure 1

The Academic and Professional Training and Selection of Technical and Engineering Staff

Great Britain has a well established system of education, funded through government, which is compulsory up to the age of 16 years. Progression to higher levels of education can be undertaken up to the age of 18 either by remaining at school, or by transferring to a Technical or 'Sixth Form' College.

It is during this stage that selection of some future CEGB technical and engineering staff begins with a number being chosen each year to be sponsored through a period of education at University, leading to a first degree qualification. Students are selected for sponsorship on the basis of an interview and their examination results.

For a number of years, sponsorship in several forms has been utilized. One scheme covers the combination of a B.Sc. degree in electro-mechanical engineering with a two year program of professional engineering training. The degree course content was established by the University of Aston in conjunction with the electricity supply industry and is broad based with various options appropriate to the technology in use within the CEGB. The period spent at the University is interspersed with modules of professional engineering training providing both formal and on-job training in several spheres of the CEGB's activities, e.g., fossil and nuclear power station operation and maintenance, power station design, transmission system design and operation. In addition, a period is spent in a manufacturer's works developing an understanding of the processes employed in, for example, the design and construction of a turbo alternator.

More recently other schemes have been developed for sponsoring students on courses selected as having special relevance to the Board's needs, particularly in electrical engineering. Sponsorship may be for the whole of, or final year of, an undergraduate's course. Selection for the latter will depend on successful completion of an industrial placement prior to the sponsorship period.

The above schemes are utilized for only a proportion of the CEGB's requirements. Each year a manpower survey is undertaken aimed at identifying the additional numbers and skills it will be necessary to recruit from those completing first degree courses (who have not been subject to CEGB sponsorship). For example, last year 17 were recruited to undergo training to work in the reactor physics departments of nuclear power stations.

In considering its requirement for technical and engineering skills, the CEGB is also mindful of the need to recruit some

graduates with the capability to progress through technological posts into more general management. This is borne in mind in an interview process with both the sponsored students and those recruited directly in their final year of the course. Those whom initial screening suggests might have the potential to progress into general management attend for two days at an Assessment Centre (48 candidates went through this process in 1986). Here a series of individual interviews, written tests and group activities are undertaken, overseen by personnel specialists and involving senior CEGB line managers. Those selected and accepting job offers (around 15 per year) will undergo a two-year training program.

The fundamental purpose of this type of training is to prepare an individual for a professional engineering career with sufficient awareness of aspects of management to understand the context in which he will undertake his work. The program meets the requirements of the major engineering institutions, such that when allied with a number of years of responsible job experience as a "Professional Engineer," the individual should be able to achieve "Chartered Engineer" status.

Recognizing the commitment the CEGB is making to its future in these individuals, a "mentor" at Director level is appointed for each graduate. The primary role of the mentor is seen to be that of guiding and counselling so that he/she becomes competent across the full spectrum of activity associated with a professional engineer. The effectiveness of individuals is dependent upon their own personal qualities and upon their recognition of the contribution all grades of staff can make in a particular environment or situation. These qualities have to be developed in the emerging engineer in parallel with the application of academic knowledge and practical training. Only when the professional engineer has the confidence and ability to initiate useful work and make an original contribution which optimizes the resources at his disposal, can he claim to be fully developed. From this source the CEGB will make appointments throughout its organization but including a number into the junior posts on nuclear power stations.

In addition to these University degree qualified staff, the CEGB has undertaken recruitment exercises to train technician engineers. In Great Britain this will entail a formal academic education in a Technical College or Polytechnic up to the age of 21, to obtain a B Tec/H.N.C. in Electrical or Mechanical Engineering. Many staff trained through this route are employed in junior engineering posts on nuclear power stations. Such staff have undergone an engineering training program with a more practical bias. (This group should not be confused with staff employed for their craft skills in the mechanical, electrical, and control instrumentation fields who undertake the majority of the "hands on" maintenance to power station plant under the supervision of either a Technician Engineer or Chartered Engineer.)

A further source of staff for the specialist nuclear power station fields of reactor physics and health physics has recently been established. Following selection interviews, up to four persons per year are being sponsored in each subject through appropriate Master of Science degree courses. Such individuals are selected from those gaining acceptance onto the course and who then wish to apply for the sponsorship.

The above has described the sources by which the CEGB recruits staff to fill the junior posts on its nuclear power stations. Some will also come from fossil-fired power stations, there being open competition at all levels on jobs throughout the utility. It is appropriate to record that the engineer responsible for operation of a reactor unit is two promotions higher than the level at which new recruits are appointed. Hence, CEGB Operations Engineers have several years of prior power station experience before commencing the training program to equip them to operate a reactor unit safely and efficiently.

Staff bring with them a range of knowledge and skills. Following appointment to a post, it is then necessary to provide a training program which will develop those existing capabilities into those necessary to undertake the duties of the new post.

The Training of Power Station Staff

The CEGB have produced a generic document entitled the "Standard Specification for the Nuclear Training of Staff and Nuclear Power Stations." It lays down the formal patterns of training to be established at nuclear power stations, taking into account the Board's responsibility for the safe and efficient operation of its plant. It only covers training related to the nuclear field. Principles of training are outlined for the different grades of staff employed in these stations; it establishes principles for the organizational aspects of this training, including the need for recording and assessment of training, and it recommends the broad content of training common to different groups of staff, including the training necessary to cover the provisions of the Nuclear Emergency Plan. The pattern of training it establishes includes both on-job training at the power station and off-job training at the Board's central Nuclear Power Training Center (NPTC), which are complementary to each other.

Whilst the specification outlines the principles and sets the standards of training in nuclear stations, it recognizes that circumstances differ between stations because of differences in plant and organizational aspects. Hence, each station is required to produce its own training document incorporating these principles but applying them to the specific location, bearing in mind the

requirements of the Site Licence, Plant Specifications and the operating regime of the particular site. The generic "Standard Specification" is intended to assist the Station Manager in fulfilling his responsibilities to ensure the adequate training of his staff and in no way detracts from this role.

In developing the station-specific training document for each post on the power station, the opportunity is also taken to incorporate the non-nuclear training requirements, such as supervisory/management and specialist technical courses.

Initial nuclear power training programs have been established for all the disciplines shown in Figure 1. Use is made of the systematic approach to training model for their development (see Figure 2). In analyzing the various posts to identify the tasks

the individual must be competent to undertake, use is made both of formal job task analysis and also the considerations of a committee involving subject matter experts, instructors and educational specialists. The aim is to produce a series of learning objectives from the skills and knowledge requirements from which a series of modules can be designed which utilize appropriate media (e.g., on-job training, simulators). From the aims and objectives of the training program allocated to particular modules, the time-table for the module can be developed.

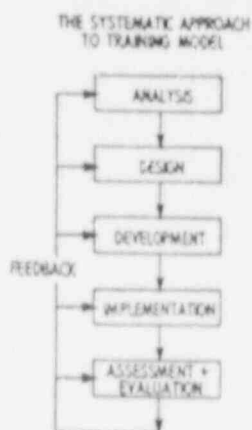


Figure 2

Experience has shown that particularly at the earlier stages of the training program, many jobs in different disciplines require the same learning objectives to be met and hence it is possible for such groups to attend the same modules. This also has the benefit of improving the mutual understanding of the

roles of the different groups through the questions and exchanges that take place.

At the later stages in the program, training has to be structured so that there are appropriate specialist modules for each discipline - for example, health physics, reactor physics, operations, maintenance and chemistry specialist courses are provided at the Nuclear Power Training Center.

For all modules there is an assessment of the trainees by the most appropriate means for the particular training medium. For a classroom-based course this could well be a written examination of multiple choice or essay type questions. On-job training modules require assessment by the trainee's supervisor, principally orally. The use of testable training objectives for all types of modules facilitate assessment more readily. Satisfactory completion of a module is required before progress can be made to the next one.

Because the Station Manager has overall responsibility for the competence of his staff, the results of assessments carried out at NPTC are reported back to him. He can then consider the progress of the individual, taking into account the reports of the individual's competence arising from completion of the on-site training modules. A number of posts require a final formal authorization interview which takes place after completion of the training program.

Evaluation of the training program and of modules within it is undertaken to validate their effectiveness. Various techniques are used involving the students, the trainers and the students' supervisors.

Training does not stop with the completion of the initial training program for a post. Revision and updating requirements are considered and are included in both the "Standard Specification" and the Station Training Specifications.

The Management of Training within the CEGB

Although a number of aspects relating to management responsibilities with respect to training within the CEGB have been referred to in earlier sections, a number of further points are appropriate to this paper.

The CEGB employs approximately 48,000 staff. Responsibility for education and training lies with the Corporate Training Manager, who reports to the Corporate Director of Personnel. All the CEGB's Training Centers are under his control and he is responsible for providing specialist advice to other departments of the CEGB. The major "customer" of the nuclear power training programs is the Generation Division (which lies within the Production Department) which encompasses all nuclear power stations. In order to provide the Corporate Director with advice, a Nuclear Power Training Advisory Committee was established with representatives from all groups who are involved in nuclear power activities with the CEGB. It is chaired by a Director of Generation and includes the Corporate Training Manager and the Principal of NPTC.

Its role is to consider current arrangements for training and future requirements. Proposals for changes to training programs or the need to establish new ones are considered and if supported will either be directly implemented at NPTC or will be presented by the Corporate Director of Personnel to the Production Directorate as specialist training advice for implementation on all their nuclear power stations.

In order to monitor the adequacy of the implementation of the Board's nuclear power training programs, a Nuclear Training Audit is carried out every two years by a small team (the 1986/87 audit

team of five contains two Directors) who visit all nuclear power stations and NPTC as part of their audit and are supported by other specialists who undertake preparatory investigations. The audit team findings are reported to the Corporate Director of Personnel who in turn presents them to the Head of the Generation Division.

Conclusions

The requirements of the nuclear site licence which imposes responsibility for the safe operation of the Board's 12 operating nuclear power stations on the Station Manager, has been a central feature in the development of the CEGB's policy on nuclear power training. Due to the existence of 11 different designs of nuclear power plant, a considerable part of the training programs have to be undertaken on each station. However, the CEGB has chosen to issue a generic training document which encompass both NPTC based courses and on-site training requirements. The development of training programs within these mandatory guidelines takes place using a systematic approach which is overseen by the Nuclear Power Training Advisory Committee. In order to check for adequate integration of on and off-site training and for compliance with the "Standard Specification," a nuclear training audit is undertaken every two years.

This implementation of structured nuclear power training programs commences with the appointment of staff who have adequate potential to develop the necessary competence. To meet this need, the CEGB has established a flexible approach to recruitment and sponsorship over a wide range of disciplines.

Over the 25 years during which the CEGB has been operating nuclear power plants, considerable evolution of training programs has taken place. This evolution will continue and, by doing so, will ensure the maintenance of a highly skilled work force capable of discharging their duties safely, effectively and efficiently.

A REGULATOR'S VIEW ON TODAY'S LICENSED
OPERATOR TRAINING PROGRAMS

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Abstract

We see new and complex challenges for trainers and their managers as nuclear plants strive to improve their licensed operator training programs. As more trainers attempt to apply the Systems Approach to Training (SAT) principles, the lack of available human resources experienced in the application of this process limits its effectiveness. Also, the SAT method does not resolve the "needs to know" versus the "nice to know" debate. More use of replica, full scope simulators for training and testing demands a unique type of trainer who is both technically strong, and knowledgeable in simulator testing techniques.

Introduction

We work with the Operator Certification Group of the Atomic Energy Control Board of Canada. This group's two main functions are to provide five different types of written, oral, walkthrough or simulator examinations for control room operator and shift supervisor trainees, and to assess and evaluate the content and delivery of training programs used to train operations staff at all nuclear power reactor plants in Canada.

Canada currently has seven plants (19 reactors) in operation, and one under construction. All reactors are of the CANDU design with unit sizes ranging from 25 MW(e) to 880 MW(e). We have chosen to share with you some of the experiences we have gained during the normal course of our work.

New Challenges

While the usual competition with other utility objectives and budgetary constraints continue to limit resources available, the demands on nuclear plant trainers continue to increase. These additional demands come from:

- o Less Experienced Trainees.

Back in the late 1950's, a significant number of persons selected for operator positions in the Canadian nuclear industry were those with extensive experience in other related industries such as

hydraulic, fossil-fired or chemical plants. Today, a larger number of appointees are not long from senior high school, community colleges, or even the university community. These new types of trainees are often well developed in fundamental principles, but very limited in operating experience. The operating "model" has to be developed within their cognitive process.

- o Increasing Plant Complexity,
Automation and Design Changes.

Both older plants and new plants are becoming more complex with time. More current technical analyses have resulted in the need for retrofitting safety and safety support systems in old plants and, of course, continue to introduce more complexities into new stations. Increased use of the latest state-of-the-art form of automation is being made at new plants, and older plants also acquire some of these devices. Trainers must constantly monitor these changes and continue to keep up to date. The impact of plant automation on current training methods and objectives must continually be assessed and programs modified as required.

- o More Use of Modern Training Aids.

Effective use of full-scope high fidelity training simulators demands specialists who are not readily available. This requires staff who technically understand simulator modeling, know and understand the operation and analyses of the plant, know plant operating procedures, and are also developed in sound training and testing methodology. This topic is further discussed in this presentation. More use of micro-computer simulations and micro-computer-based training aids also requires further expertise.

- o Requirements for Auditable Training Programs.

The development and implementation of processes that track trainees throughout their development is not a new requirement, but better methods and more complex systems have been put in place. The need for more auditability has also expanded the use of Systems Approach to Training (SAT) based training programs, and it has become evident that large resources are required to develop and implement such programs effectively.

- o More Commitment to SAT-Based Programs.

Application of the SAT process to complex nuclear plant training programs has revealed unexpected limitations and the need for variations of its basic principles. For example, true job and task analyses are often not being done, the time and effort required to complete them having proven to be too extensive. It has been observed that some current SAT programs lack sound technical content and do not show that the relevant "needs to know" versus "nice to

know" information has been analyzed sufficiently during their development. It has also been observed that before using such programs extensively, all staff involved in their design, development and implementation need to be extensively trained in SAT principles and techniques to ensure program effectiveness.

o Demands from Regulatory Agencies.

Society continues to demand that nuclear plants be operated by effectively trained and knowledgeable operators. Therefore, regulatory personnel responsible for ensuring that high standard operating procedures, operating practices and training programs are in place must continue to assess the effectiveness of the trainers and their programs accordingly.

"Needs to Know" Versus "Nice to Know"

What is the minimum that an operator should be taught to perform and understand operating tasks? Below is an actual CANDU plant operating procedure converted into SAT training objective format to demonstrate some of the difficulties in clearly determining what an operator "needs to know" to correctly apply such a well defined operating procedure.

Terminal Objective. By using all the relevant control room devices and aids, shutdown a defective heat transport (HT) circulating pump without lifting any of the HT liquid relief valves (LRV) with the reactor initially operating at full power. (1)

Enabling Objectives (list not complete):

- o Identify the operating procedure relevant to the status of the pump being forced out-of-service and the current state of the unit. (3)
- o Locate and correctly implement the operating procedure selected.
- o Assess whether the defective HT circulating pump conditions are deteriorating rapidly or slowly by referring to the HT pump computerized status display. (4)
- o Lower reactor power to 10E-3 FP by implementing the additional procedure called up by the the original procedure, or trip the reactor depending on the results of the assessment completed in the item above. (5)
- o Determine whether the HT system pressure setpoint needs to be reduced to 9 MPa(g) based on the pump to be shut down.

- o If required and time permits, enter in steps, new pressure setpoints into the HT control program, and ensure the depressurization rate does not exceed (6) 1 MPa(g) per 15 minutes.
- o Shut down the defective pump and ensure its brake becomes applied automatically.
- o Shut down the corresponding pump in the other HT (7) loop.
- o Switch the "process trip setpoint selection" handswitches on both shutdown systems to the correct position according to the pair of HT pumps still in operation.
- o Switch the "neutron overpower trip setpoint selection" handswitches on both shutdown systems to the "2 pumps" position.
- o Cool down the HT system at maximum rate in the 2 pump mode of operation by implementing the additional procedure called up by the original procedure.
- o Determine whether cooldown is being accomplished. (8)
- o Changeover HT system to thermosyphon configuration, (9) if required, by implementing an operating procedure not identified by the original procedure.
- o Read out HT temperature on computerized status (10) display and when at 149° C, transfer to shutdown cooling pump operation by implementing the additional procedure called up by the original procedure.
- o Cool down the HT system to 37° C using shutdown cooling pumps by implementing the additional procedure called up by the original procedure.

Entry-Level Skill and Knowledge. The list below contains a number of examples of knowledge items that must be addressed to determine whether they are required for completing the operation of shutting down a defective HT pump, with the unit initially operating at full power, by application of the prescribed procedures. The descriptions of some examples are obvious and therefore brief, while others are more complex and detailed, especially where the operating procedure does not contain sufficient information.

NOTE: The numbers on the left refer back to the points numbered on the right in the objective list above.

- (1) Location and correct use of all relevant devices and aids available in the control room must be known.
- (2) The operator must know what an LRV is, its function and have a sufficient understanding of the thermodynamic principles relevant to what would cause an LRV to open under these conditions, especially since the operating procedure goes on to require the operator to perform a cognitive assessment (i.e., if time permits the pressure to be lowered). Also, the consequences of an LRV opening should be known.
- (3) Knowledge of the Operating Manual's location, number and overall format is required.
- (4) Knowing where to read and how to monitor pump vibrations, seal cavity temperatures and bearing temperatures is needed here. Also, the capability to assess the "rate of deterioration" is required.
- (5) The skills and knowledge regarding the procedure on lowering reactor power are required.
- (6) The required enabling objectives, skills and knowledge regarding the procedure for lowering HT pressure now enter into this already complex training activity.
- (7) The fact that the pumps are paired by an "even" and "odd" numbering system must be known, and the skills to perform this activity are required.
- (8) Determining whether cooldown is being accomplished requires both overt and covert activities. Monitoring appropriate HT temperatures by trending on computerized display needs to be carried out, and before making the decision, an analysis of the temperature trends relative to where they are being measured on the system must be made. Situations and conditions that could prevent cooldown must also be understood. The operating procedure does not assist the operator here.
- (9) A complex activity with its requirements and objectives now enter the process. Knowledge of the fundamentals of thermosyphoning may be important for achieving and confirming the establishment of this state.
- (10) The complexity of applying the cooldown procedure now enters with its own objective requirements.

This exercise demonstrates the complexity and difficulty in determining what knowledge the operator must specifically possess to perform correctly all objectives that must be satisfied to complete this procedure. It is clear that more is required than just following the procedure and performing the actions necessary to satisfy the objectives established by application of basic SAT principles. Therefore, the method for determining entry level knowledge when applying true performance-based principles to training is not a simple matter. The differentiation of knowledge between "needs to know" versus "nice to know" requires great care and judgment.

Training System Development Based on Job and Task Analysis (JTA) Techniques.

The use of JTA techniques as the foundation for developing performance-based training documents requires specialized technical and training resources with specific knowledge and skills not readily available to most utilities. Because of the complex technical nature of nuclear plant training, use of subject matter experts with extensive knowledge of plant systems and operation is required for the development of these training documents and for teaching the corresponding courses.

To achieve training program quality and effectiveness, these technical experts must be sufficiently trained in the principles and techniques of writing effective training objectives, the specific course material and related lesson plans. They usually need the support of educators to verify correct implementation of these principles and techniques.

Our review of training manuals produced as a result of implementation of the SAT process has revealed a number of interesting problems that can be related to a lack of thorough understanding of the basic principles involved:

- o Training objectives found to be inappropriate as they fail to state the performance that the trainee must execute.
- o Training objectives that are incomplete as they do not specify the conditions under which the performance will be accomplished nor the criteria of acceptable performance, thus making it very difficult for the user to determine the scope and depth of the objective.
- o Lack of correspondence between the training objectives of a lesson, the content of the lesson and the associated test items and assignments.

Writers of such documents must be sufficiently trained and developed in the SAT principles and techniques. Lack of such development has resulted in the writing of training objectives only to satisfy the rules set out in the training program. The objectives then become ignored and the training manuals written include whatever the author thinks the trainee should know, as it was often the case in the old unstructured approach to training. Even when the process is monitored by educators, these defects often remain undetected, primarily because the training specialists were often not sufficiently knowledgeable in the technical aspects to appreciate the resulting lack of correspondence between objectives and training course content. In short, experience has demonstrated that it takes great skills and technical knowledge to apply the SAT process to establish technically correct and pedagogically effective training programs.

Simulator Training and Testing

Simulator training and testing bring an additional dimension to nuclear plant training programs. Together with the known advantages, the use of replica, high fidelity simulators for training of control room operators (CRO) introduces complexities and problems that need to be recognized and resolved to make the most effective use of this training method.

The great complexity of large modern nuclear plants and their operation becomes reflected in the design and operation of full scope simulators. Instructors selected for simulator training programs must have extensive and in-depth knowledge of plant systems and operation as well as technical expertise regarding operation of their plant. This expertise will allow recognition of the limitations of the simulator models and capabilities. It will help in identifying important limitations that require simulator improvements and permit developing training procedures that will be effective in spite of any remaining limitations in the simulator facilities. As the instructors are in fact the main users of the simulator, they are in the best position to help develop and maintain simulator fidelity, versatility and reliability. To achieve this, they will also need a high degree of support from the power plant technical staff and from computer simulation experts. This is not only required in the initial commissioning period of the simulator but throughout simulator life, as the number of simulator options available on modern full scope simulators and their possible combinations are so large that it is almost impossible to verify initially the fidelity of them all. Also, significant simulator modifications are frequently required to reflect the on-going changes to the power plant itself.

Simulator instructors also have to be thoroughly knowledgeable in important plant procedures and the analyses behind

them to be able to interpret and effectively apply these procedures under conditions which vary somewhat from the one usually assumed.

These simulator instructors, who are often selected from previously authorized experienced CRO's or Shift Operating Supervisors, also need to be suitably trained and developed in the skills of performance training and testing. This key point could easily be overlooked on the assumption that if instructors had been themselves good performers they should not have difficulty in training others in the performance of identical tasks.

Development in performance testing is particularly important as the assessment of simulator tests is especially difficult, considering the diversity and complexity of the performances being measured. An effective testing methodology must be developed in order to make a valid assessment of these performances. Suitable observation and evaluation techniques must be learned and criteria of satisfactory performance have to be developed. Establishment of such criteria will be difficult due to the complexity of such human performances.

There are many practical matters which arise when one considers the use of simulators in real-time performance assessment of CRO's. There are decisions to be made with regard to the course to be followed: if an error is made by the CRO during the test; if the CRO error results in an unforeseen event sequence (handled successfully or unsuccessfully). There are many questions to be answered: how does one evaluate the performance of an individual in a multi-man control room situation? how does one select realistic test scenarios? The levels of complexity and length of scenarios to produce a valid test have to be determined.

Simulator testing requires objective and comprehensive assessment of a trainee's ability to diagnose complex upsets, to stabilize the plant and then to identify and apply the relevant operating procedures correctly and completely. The latter should not be overlooked. Due to time constraints, simulator testing is often centered on diagnosis of upsets and performance of initial actions to stabilize the plant, then ending shortly after the trainee has started implementing the relevant abnormal operating procedure. This approach is based on the assumption that the trainee would then have no difficulty to continue to perform the steps specified in the procedure. For major upsets, it has been found that it is often during implementation of the procedures that the trainees will make errors or unknowingly omit key steps due to the distractions and pressure caused by the prevailing conditions.

The training of CRO's must therefore place enough emphasis on the systematic execution of operating procedures under major abnormal conditions, paying special attention to the development of

the CRO monitoring skills that will confirm the correctness and effectiveness of the actions performed and that will reveal any significant operator errors or equipment malfunctions that may need to be addressed before proceeding further with the procedure.

In order to ensure effective testing, an extensive bank of plant upset test scenarios must be developed and made available. We have observed cases where simulator training and testing tend to be limited in scope and diversity. The number and types of plant upsets covered in training must be extensive and not be limited only to the upsets that have been experienced in the past at the power plant. Analysis and credible inventiveness are required on the part of the instructors to develop and predict complex plant upsets which are realistic and which have to be included in the training and testing program.

In addition, scenarios used for testing should contain some second order variations and not be exact repetitions of the scenarios that were used for training on specific upsets. This will serve several useful purposes. First, this will demonstrate that the CRO trainee is fully capable of coping with the given type of upset and the unplanned secondary failures that could occur during such an event. This will also indicate that the trainee has developed the monitoring skills required to confirm systematically the effectiveness of his actions and to detect the possible additional failures during major plant upsets. Such failures, if they would remain unnoticed, could have a significant impact on the ultimate consequences of the event and on the effectiveness of the implementation of the emergency operating procedure used to cope with the particular upset.

Finally, we emphasize the fact that effective simulator training for CRO's requires the existence of a good up-to-date set of plant operating procedures. These procedures are in fact the foundation of a simulator training program for CRO's. They are essential to define objectively and consistently the criteria of acceptable operator performance. In their absence, it becomes almost impossible to perform a valid and consistent measure of complex operator performances.

Discussion

MR. BOHANON: Do you plan to couple your operator emergency response system to the emergency preparedness response in the sense that you would go on to what we call the emergency operation facility and the technical support facility, and then to off-site activities, which then would test the operator at a full-scale exercise, besides an internal scenario? Are there any plans like that, or can you comment on that approach?

MR. GRANDAME: We do not have any current plans for that form of testing.

COMMISSIONER CARR: Do you have continuing training for your simulator instructor? Do you rotate them back into the plant for plant refresher before you continue on with them as instructors?

MR. TURCOTTE: As far as we can tell, there is no continuing training for instructors. I think there is some rotation of instructors back to the plant. But again, we are not aware of any specific requirements by any of the utilities.

MR. GRANDAME: We do not mandate training, as is done in the United States. The design of the training format and programs are laid out by the utilities. I am aware that the utilities do have a program where they do rotate current licensed people into their simulator program along with their permanent trainers, to get this current knowledge into their training program on simulators.

DR. PERSENSKY: You talked a lot about learning objectives and some of the failures you have had. What guidance was provided or what guidance was followed in the development of the learning objectives?

MR. GRANDAME: It is my understanding that the guidance of most of the utilities in Canada is based on the TSD system developed by INPO.

CHAIRMAN'S SUMMARY

Dr. J. J. Persensky
United States

The session was introduced by the Session and Task Force Chairman with a brief summary on the survey "Approaches to Training Programs in NEA Member Countries" - CSNI Report No. 128 which was prepared by Task Force #5 of PWG #1. The purpose was described as a means to provide for the exchange of information concerning the analysis, design, development, implementation and evaluation of training for nuclear power plant personnel in NEA member countries and as an impetus for the current Specialist Meeting. Findings were discussed but no conclusions were reached since that was not the purpose of the survey. The survey and the Specialist Meeting were intended to provide a source of contacts with experience in various training program development schemes.

Mr. Pelé of the CEC presented a discussion on generally valid concepts and criteria as recommendations concerning staffing, qualifications, training, licensing/authorization and retraining of operating personnel which were developed to ensure that NPP personnel are sufficiently qualified and trained to perform safely. The principles and concepts presented are intended to be of a general nature so that they can be useful to NPP operators, licensing authorities, designers, and safety assessors.

Mr. Morisseau, of the US NRC, discussed the various data sources used to evaluate the INPO-managed training accreditation program relative to the Commission Policy Statement on Training and Qualification (March 20, 1985). The measures include: observation of INPO Team Visits and the Accreditation Board, SALP and inspection reports, licensing examination pass rates and reports and results of post-accreditation reviews. The purpose of these evaluations is to ensure that US power plant training programs which have been accredited are based on appropriate analyses, have complete learning objectives, are properly developed and implemented and have both trainee and program evaluation procedures in place.

Mr. San Antonio of Tecnatom, S.A. (Spain) described the evolution of training and qualification programs for reactor operators since 1981. Demands have been extended to include additional knowledge of plant systems, both safety-related and otherwise, mitigation of core damage in severe accidents and loss-of-coolant accidents. The revised CSN safety guidelines include minimum hours of training, simulator exercises and experience requirements and a requirement for continuing training. The paper went on to discuss requalification and candidate evaluation.

Mr. Farber, of GRS in the Federal Republic of Germany, discussed the qualification requirements for responsible shift personnel. Typical training paths for these personnel were described relevant to their education and experience backgrounds. Reviews of shift personnel training and retraining have noted improving quality and quantitative extension of training measures. This was attributed to optimization of training materials, availability of simulators, and appreciation of the position of training manager. It is interesting to note that use of the 85% passing criteria has resulted in easier tests, so a question bank is being developed to address this concern. Actual performance evaluation by supervisors is being used to supplement the written and oral examinations.

Mr. Tompsett, of the CEGB, presented a paper prepared by Mr. Madden of the United Kingdom on selection and training of engineering and scientific staff for CEGB nuclear power stations. CEGB recruits and sponsors the formal education of some staff from the age of 18 until graduation at age 21 whereupon further structured training begins. The training provides the skills and knowledge needed to perform their various jobs. NPP staff are trained to the requirements of the Health and Safety Executive By Holder of the Operating License. CEGB ensures that these requirements are met through comprehensive initial and refresher training programs designed to provide qualification at all levels of positions in the various disciplines. This is accomplished using a systematic approach overseen by the Nuclear Power Training Advisory Committee through audits every two years.

Messrs. Grandame and Turcotte (of the AECB, Canada) described the attempts of their utilities to improve their licensed operator training programs through application of Systems Approach to Training (SAT) principles. The AECB has found problems in the implementation of this technique because of a lack of available human resources experienced in the application of SAT, thus limiting its effectiveness. Samples of inadequate learning objectives were shown to exemplify this problem. The question of "Need to Know" versus "Nice to Know" was also addressed. The need for uniquely qualified simulator instructors who are both technically strong and knowledgeable in simulator training and testing was stressed.

SESSION 2:
APPROACHES TO TRAINING AND
REGULATORY PRACTICES (II)

CHAIRMAN: Mr. M. F. Grandame

EVOLUTION OF GPU NUCLEAR'S TRAINING PROGRAM

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Abstract

GPU Nuclear Corporation (GPUN) manages the operations of Three Mile Island Unit 1 and Oyster Creek Nuclear Generating Stations and the recovery activities at the Three Mile Island Unit 2 plant. From the time it was formed in January 1980 GPUN emphasized the use of behavioral learning objectives as the basis for all its training programs. This paper describes the evolution to a formalized performance based Training System Development (TSD) Process. The Training & Education Department staff increased from 10 in 1979 to the current 120 dedicated professionals, with a corresponding increase in facilities and acquisition of sophisticated Basic Principles Training Simulators and a Three Mile Island Unit 1 Control Room Replica Simulator. The impact of these developments and achievement of full INPO accreditation are discussed and related to plant performance improvements.

Introduction

GPU Nuclear (GPUN a subsidiary of General Public Utilities) manages the operation of the Three Mile Island Unit 1 and Oyster Creek Nuclear Generating Stations and the recovery activities at the damaged Three Mile Island Unit 2 plant. Since 1979, training at GPU Nuclear has evolved from a conservative traditional approach to a dynamic, performance-based process. This process is the result of a strategic design that carefully incorporated the company's desired approach to training based on four themes:

- o Training content and delivery systems
- o Training organization structure
- o Selection, qualification and evaluation of instructional staff
- o Training facilities

Over the years following the TMI-2 accident, these four key elements were carefully designed, built and integrated into a support system that truly reacts to the needs of the nuclear station

personnel. Even more importantly the training process, which began as a response to TMI-2 and was accelerated by unprecedented regulatory and industry scrutiny, now maintains itself as a thoroughly integrated part of our corporate culture.

In this paper we describe the behavioral learning objective, training systems development approach to instructional programs which has been applied at GPUN. We then describe some of the staffing, facilities and processes which have evolved in support of training. Finally, we discuss training program accreditation and some of the potential problems as well as positive impacts and improvements in plant and personnel performance.

Training Systems Development

Since early 1980 GPUN has used a behavioral learning objective (BLO) approach to training. This approach clearly supports the process for effective learning, communicates the intent of learning and assures the clarity and accuracy of the training evaluation process. GPUN instructors are required to be well versed in the BLO approach. Also beginning in 1980, the company used data from the NRC generic job and task analyses (JTA) to improve the training for the reactor operator and senior reactor positions. Subsequently, more detailed job and task analyses prepared by INPO for most disciplines have served as a basis for plant-specific JTA activities. Today at GPUN all new training is based on plant specific JTA's conducted by training and subject matter experts from each discipline. The various investigations of the TMI-2 accident, including GPUN's own internal review, indicated the need for a special emphasis in operator training programs on basic principles of plant system behavior and interaction. In the summer of 1981, GPUN began the process of designing and developing a basic principles training simulator (BPTS) for each of its plants. The BPTS simulation of plant operation is based on full-scope simulator software and provides the capability to simulate in real time normal and abnormal conditions for a variety of transient and steady state conditions.

A very important element in preparing the BPTS specifications was the development of detailed behavioral objectives for each of the BPTS training activities. Broad training goals were followed by statements of behavioral learning objectives for each concept which described specific actions that a student was expected to take at the console to demonstrate his/her understanding of the concept. In some cases these actions involved the student presenting an explanation of particular evolutions while other actions required the manipulation of the BPTS controls to accomplish stated objectives.

After the learning objectives were formulated they were used to evaluate the proposed design of the BPTS simulators in order to assure that the machines could accomplish the objectives. Thus the statement of behavioral learning objectives became an integral part of our BPTS design process and ultimately our overall simulator program.

In addition to the programs accredited by INPO, GPUN has fully used the training systems development (TSD) process in programs developed for its radiological controls engineering staff, core engineers, security guards and selected Human Resource programs. For these programs, GPUN educational and subject matter experts have assured themselves, the Corporation and the students that the programs truly reflect the needs of the job incumbents. The TSD process includes detailed procedures covering the following steps:

- o Needs analysis
- o Job/task analysis (JTA)
- o Program development
- o Program implementation
- o Program evaluation
- o Trainee evaluation back-on-the-job

As our programs continue to evolve the Training & Education Department is in a constant quest to provide the most effective vehicles and strategies for training delivery. We are looking at increased use of computer-based instruction and interactive video. These processes are helping to improve activities such as self-paced learning, small group instruction, remote classroom and remedial instruction. Although much of this type of instruction is costly in the initial stages, the long term benefit lies in the saving of instructor time and resources as well as reducing the time off the job required of the trainee.

Staffing and Facilities

In 1979 approximately ten people were dedicated full-time to the training needs of three nuclear sites. Today 120 dedicated professionals administer well-defined performance-based programs in all disciplines. The Director of Training & Education administers an annual budget of \$10,000,000 and the corporation also supports its training commitment with an additional \$15,000,000 related specifically to hardware, trainee salaries and other support costs. The average percent of time spent in training annually for GPUN employees is 5% to 7%.

More than 35,000 square feet of dedicated training space are provided at the TMI facility and 20,000+ square feet are provided at the Oyster Creek site. Included in these new well-equipped facilities at both nuclear sites are labs for hands-on training of maintenance, radiological controls and chemistry technicians.

Classroom training is complemented with on-the-job training (OJT) on actual plant equipment. Operator, engineer, and technician training are complemented with the use of Basic Principles Training Simulators and, at TMI-1, a site specific simulator. The purchase of an Oyster Creek replica simulator is underway and plans are for it to be ready for training by October, 1990.

GPUN's long-term plan is to apply state-of-the-art approaches to the training of our licensed and non-licensed personnel. We want our people to expect the unexpected and to be able to function effectively so that handling abnormal events becomes normal. Plant personnel should react swiftly and correctly to any plant condition.

Instructors at GPUN must qualify and maintain their qualifications in a rigorous and demanding qualification process. Instructors of licensed personnel must also achieve and maintain an NRC license or instructor's certification. Senior training management personnel at GPUN possess either master's or doctorate degrees.

The Internal Process and Support of Training

The Educational Development (ED) Section was formed to centralize the instructional technology functions of the GPUN Training & Education Department. Its primary task is the development and administration of the Training Systems Development (TSD) guidelines. The ED section also assists and consults with all of the functional groups within GPUN on the application of these guidelines. GPUN's training programs have been developed in close cooperation with the company's functional groups. Both formal and informal task analysis have aided in the defining of behavioral learning objectives for each program. This organizational design and effective working relationships have assured that each established program, as well as each new training request, follows a logical path from inception to completion and evaluation.

For example, operators and supervisors are trained to: recognize abnormal plant responses; identify accident causes from the diverse data sources available to them; apply their plant knowledge and use procedures effectively to correct the conditions; and make the decisions that result in proper action during casualty situations. Supervisors are also trained in methods of administering the plant to insure that operators are always aware of system and equipment status and are prepared to respond to abnormal situations. Plant engineering staff members are trained in plant operations so that they are better equipped to apply their knowledge to support the operations staffs in areas of: procedure writing, review and implementation; operations review; and evaluating and advising during abnormal plant conditions. In addition, plant groups such as auxiliary operators, radiological control technicians, maintenance

technicians and other support personnel are trained in a similar fashion to understand their role and be effectively trained in job task specifics.

Required teaching skills are developed through basic and advanced instructor development courses. These course offerings, taught in-house by Educational Development and other T&E Department personnel, address the specific skills needed to effectively deliver the required training. A 40-hour basic instructor development course focuses primarily on presentation skills while including such topics as the characteristics of the adult learner, the role of the instructor, training systems development process, lesson plan development, behavioral learning objectives and testing and evaluation. Advanced instructor development activities are conducted in modules from four hours to several days in length. These modules, although topically specific, are flexible to be able to react to the ongoing needs of the professional staff.

All instructors, and indeed all GPUN personnel, are thoroughly indoctrinated in the examination process. Instructors are required to assure the integrity of this process and through effective counseling, assure the acceptance by the students of the need for this integrity. Instructors are also evaluated on the administration of the testing process.

GPUN also offers an extensive Management Development Program which ranges from a pre-supervisory program through executive development. In addition, a GPUN Corporate Training Advisory Council has been formed to support this process. Made up of senior level executives from each division, the Council's charter is to review and consult on the overall training effort.

INPO Accreditation

In December, 1986, GPU Nuclear became the seventh utility to receive approval as a full member of the National Academy for Nuclear Training. This achievement was the result of a corporate-wide involvement and commitment to the accreditation process which had started several years earlier. In February 1985, five key programs at TMI-1 were the first to be accredited, in part as a result of extensive interactions with the Atomic Safety and Licensing Board (ASLB) TMI-1 Restart Review of these programs. An additional audit of the licensed operator programs, required by the ASLB, was recently conducted and the programs were found to be of the highest quality and in direct support of plant training needs. In September 1985, all ten programs at the Oyster Creek Generating Station were accredited by INPO; and in December, 1986, the remaining five programs at TMI received accreditation approval. Several INPO good practices were cited as a result of these examinations of GPUN programs.

In addition to the achievement of accreditation, GPUN actively supports INPO by providing peer evaluators for accreditation visiting teams to other utilities. To date 15 GPUN people have served on INPO teams and more are expected to participate during 1987. Also the GPUN Vice President of Nuclear Assurance serves as a member of the Advisory Council for the National Academy for Nuclear Training.

Ancillary Training Programs

The Training & Education and Human Resource Departments are involved in ongoing efforts to address the needs of the Corporation and its employees for professional growth and development. Employees are assisted in earning college credits for self-development, degrees and job requirements. The GPUN Educational Assistance Program (EAP) pays 85%-100% of the cost of college courses that are job related and/or job required. The program covers courses offered by correspondence, on campus at local colleges and universities, on-site degree programs and external off-site degree programs. Through special arrangements, on-site programs leading to a BSME degree are being conducted at Oyster Creek by the New Jersey Institute of Technology and at TMI by the Pennsylvania State University. An MBA program offered by Monmouth College is presented at Oyster Creek. External degree programs such as those of the New York Board of Regents, Thomas Edison College and Elizabethtown College Adult External Degree Programs allow employees to earn associate or bachelor degrees in various fields. GPUN programs at Oyster Creek have been evaluated by the National Program of Non-Collegiate Sponsored Instruction (PONSI) process for 90 semester credit hours applicable toward various undergraduate degrees.

Reflections on Performance

Reflecting on the advances made during the past six years leads to a major concern. With all the emphasis on increasing staff size, improving facilities, and formally documenting the conduct and content of the training programs, it has been difficult to keep focused on ensuring the quality of learning experiences occurring in the classroom and laboratories. There is an on-going risk that the completion of formal job and task analyses, training matrices and evaluations of employees once back on the job will be viewed as ultimately assuring quality learning experiences. For example, as a direct result of applying the BLO approach to operator training over an extended period of time, the formalization of documentation required for accreditation did not result in major changes to program content or classroom practices. However, the technical administrative work load is now significantly higher and instructors have less time to prepare for and instruct in the classroom. As program content and practices continue to evolve further, we must keep in mind that the best assurance of effective training continues

to be a dynamic, well-qualified instructor who teaches job related skills and knowledges. At GPUN, we are striving to keep this focus.

Some of the concerns competing for instructor time include: the maintenance of existing accredited programs; the possibility of new programs being brought into the accreditation process; and the difficulties of maintaining our present ongoing programs while developing new ones to address industry and company initiatives. These activities have continued to place what appears to be an ever-increasing amount of pressure on the training groups. But we want to emphasize again that challenging and exciting learning experiences must remain the primary focus. And we must assure that trainees have the demonstrated abilities to improve performance.

The impact of training on performance has been very evident at GPU Nuclear. Since fully implementing our Training Systems Development (TSD) process, we have identified numerous instances of training having a positive and measurable impact on plant performance. Plant shutdowns have been avoided, personnel exposures are being significantly reduced and costly call-outs are being avoided resulting in large visible dollar savings. Some specific examples are:

- o At Oyster Creek, plant scrams had been experienced due to Nuclear Instrumentation (NI) interlocks with the Reactor Protection System (RPS). Training was designed and implemented on the NI and RPS interlocks both in the classroom and on the simulator. Since this training has been implemented, no new scram incidents from this cause have occurred.
- o At Oyster Creek, operation of the turbine control system had been a source of recurring problems. A vendor simulator, which had been used as the simulator for operator training, used a system which was very different from Oyster Creek's. Another simulator with a turbine control system more like the one at Oyster Creek was evaluated and selected. Since switching over to this simulator, the company has noted a significant improvement in operator performance on the turbine control system.
- o At Three Mile Island Unit 1 (TMI-1), operational upsets and problems had been induced by failures and transients in power supplies and instrument input signals to the Integrated Control System (ICS). This has been a common problem in B&W plants. As a result of training designed and implemented by the operator training section, two of the newest operators were able to properly respond to and manage an ICS power failure

while the unit was operating at 100% power. The plant was able to stay on line at the 100% power level as a direct result of their actions.

- o At TMI-1, severe reactor power imbalance and soluble boron/rod position control problems during x/non transients, as experienced at other similar plants, were avoided during startup. This was directly related to the awareness and specific pre-startup training which was designed to address this problem.
- o At Oyster Creek pre-drywell entry orientation training was directly responsible for reducing the accumulated dose to QA inspectors by a factor of two. The training consisted of a short videotape which showed work areas in the drywell model and still photographs of the model. This approach reduced inspection time and improved work planning. The job had been estimated at 32 rem and actual total exposure was only 14 rem.

It is clear from these examples that training is making a difference. Using our Training Systems Development approach we are confident that many more innovative solutions to performance problems will be developed as problems in the plants arise.

Conclusion

GPU Nuclear's training management is committed to the ongoing needs of their nuclear sites and the industry-wide effort toward the pursuit of excellence. Any plans, however, for the future will obviously have to remain dynamic and flexible. Training professionals are going to have to constantly challenge themselves in order to assure this crucial ongoing support of the nuclear option. We will have to be aware of the need to rapidly accommodate new initiatives. Regulators, public advocates, a skeptical public, indeed the nuclear industry itself, will not allow us to be satisfied with the status quo. We are confident that our efforts at GPU Nuclear have put in motion a process that will assure our ability to successfully meet these future challenges. GPU Nuclear's aim is to place TMI-1 and Oyster Creek in the front ranks of the U. S. operating nuclear plants. With the nuclear option under such strong public scrutiny, it is in the best interest of all nuclear utilities to achieve standards of training and educational excellence which will help assure the most cost effective approaches to successful power plant operations.

Discussion

MR. BUDNICK: You talked about innovative approaches for the recall program. Have you utilized any type of challenge exams, home study, any type of training which is not what I will call "pure" classroom, for the requalification of licensed operators?

MR. LONG: We have not used challenge exams. We have to be very careful about asking people to do home study. We know that they do, but the union gets involved in our case so that we cannot require them to do it. I think innovations have come more for us in the use of the basic principles trainer device, in giving them some pre-tests so that we do not cover material that they clearly know, and then going on to industry experience reviews. We have also incorporated, as part of the regular training effort, exchanges with senior plant management during the training week.

MR. HANDLEY: I have two questions. First, what is the cost of a part-task simulator? Have you done any cost-benefit analyses on that?

The second question, how do you go about getting degrees for operators who are on shift?

MR. LONG: The first question, about part-task analysis -- the system that we use at Oyster Creek cost around \$200,000. The difficulty of doing cost-benefit analysis is, as you know, in many cases the money you save is "funny money". The Board of Directors does not know you have saved it. We think that we have some significant impacts on particular surveillance activities which we have tried to cost out. This is after the fact. We did not have the cost-benefit before we bought the simulator. We bought that because of the company's commitment.

The second question, about getting operators degrees while they are on shift -- this is proving to be very difficult. We started out in both those degree programs with about 35 students who were committed over a period of five to seven years, depending on where they started, to getting their degrees completed. Recent reviews of that program show that we are now down to less than ten at each site. Most of the operators have dropped out. They find it very difficult. We had provided special counseling. At Oyster Creek, in fact, we were offering the classes twice a day so they could come before a second shift if they happened to be on a second shift, and they could catch it late in the day if they were on a third shift. It is a real challenge and we are now looking at sending some people off to school full time.

MR. VAN DE WALLE: You spoke about CAI methods, computer-assisted instruction. How do you evaluate the effectiveness of those methods? Do you have a special program to do this?

MR. LONG: We have not had a special program to evaluate the effectiveness of the training compared to other things. The evaluation of the effectiveness of the training for an individual student is simply based on their accomplishment of the learning objectives at the end of the training. For instance, with the pressure-sensitive plot training, that proved to be a very successful program and we got all 36 of our operators through that program with a very strong capability in analyzing pressure-temperature problems, with very little classroom assistance. We have not made comparative studies between doing that in the classroom and using the computer.

TRAINING PROGRAM FOR NUCLEAR POWER PLANT PERSONNEL

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Abstract

Nuclear power generation in Japan reached 24.7% of its electric power supply with its capacity and time availability factors of 76.2% and 77.1%, respectively (in the calendar year 1986 - as of December 31, 1986). One of the reasons for such high performance is attributable to high quality of operating and maintenance personnel in the nuclear power plants.

Ministry of International Trade and Industry of the Japanese Government has an overall responsibility with relation to the safety regulations and supervises all scope of training, while the Thermal and Nuclear Power Engineering Society is authorized to conduct licensing activities to qualify the chief shift supervisor of nuclear power plant operation and individual utility companies are required to train their plant operating and maintenance personnel.

General status of training for plant personnel is briefly described in this paper, touching the practical education and training systems of utility companies and operation and maintenance training facilities.

The Position of Training in the Operating
Administration of Nuclear Power Plants in Japan

Thirty-three nuclear power plants are being operated in Japan with the electricity generation of 24.7%, and the capacity factor of 76.2% respectively (as of the end of December, 1986). One of the reasons for such a high performance is considered to be the high quality of operating and maintenance personnel in the nuclear power plants. Training programs for the personnel are important to keep such a quality.

In the operating administration of Japanese nuclear power plants, the basic policies are as follows:

- o To secure the complete safety and assure the stable plant operation,
- o To win the confidence of the local inhabitants and society, and
- o To promote efficientization of plant operation.

Based on these policies, the plant operating administration system is to be strengthened, and also the following measures are being executed to enforce above policies more effectively, in which the training of the operators and maintenance personnel is clearly positioned.

The counter-measures to improve the plant safety and reliability:

- o The preventive measures for incidents and failures.
- o The systematic training and education of operators and maintenance personnel, including:

Securing and training the necessary personnel under a long-term training and education plan.

Expanding and completing the training facilities and improving the training methods.

- o The safety administration system.
- o The quality assurance system.
- o The improvement of the periodic inspection.
- o The improvement of the maintenance work management.
- o The emergency preparedness.

The counter-measures for reducing the radiation exposure.

The efficientization of plant operation.

In Japan, the number of incidents and failures in the nuclear power plants are decreasing reflecting the effects of the

above mentioned measures. On the other hand, however, this fact rather keeps operators and maintenance personnel off from the actual experiences of such incidents and failures, making the training the most important means for them to cope with the actual plant incidents. This problem would become more important in the future along with securing the necessary personnel for new plants.

Outline of the Training of Nuclear Power Plant Personnel in Japan.

In Japan, education and training for keeping and upgrading the capability of operating personnel are performed mainly by individual electrical utilities through either sending those personnel to the specific training facilities or utilities' own educational systems.

For training facilities, in the period 1967 through 1973, training facilities in the U.S. were used for this purpose. After 1974, as Nuclear Power Training Center (NTC: for PWR operation) and BWR Training Center (BTC: for BWR operation) were established, more broad education and training became available domestically.

These two training facilities have the initial training course, the re-training course, the operator shift group training course (known in Japan as "family training course") according to the operator's abilities, and a total of about 15,000 operators have been trained there as of the end of JFY 1985. (March, 1986)

Furthermore, the Japan Atomic Energy Research Institute's training course and others are also utilized to obtain basic knowledge of atomic energy.

Content of the Execution by the Government on the Training of Operators and Maintenance Personnel of the Nuclear Power Plants.

Notification of Long-Term Plan on Operators' Training. In September, 1983, the Ministry of International Trade and Industry issued a notification to individual electric utility companies for instructing them to strengthen their safety education and training of operators. The content of the notification is as follows:

- o Individual electric utility company's safety education and training plan for operators based on the safety regulation (for each fiscal year) shall be submitted to the Ministry of International Trade and Industry beforehand of its execution.
- o Individual electric utility company's long-term training plan, based on the long range consideration for keeping and upgrading of the capability of

operators and securing a sufficient number of operators, shall be submitted to the Ministry of International Trade and Industry.

According to this notice, each electric utility company is obligated to submit its long-term operator training program with the following contents to the Ministry, attend the hearings held by the Ministry and receive its guidance, if necessary. The program should contain the following:

- o The basic policies for the operator training.
- o The operation system.
- o The operator's qualification and role (duty).
- o The training plan for the operators of newly or additionally installed units.

The basic policies for the operation plan.
The operator training plan to cope with the installation of new or additional units.

- o The training plan for keeping and upgrading of the operators' capabilities.

Dispatch plan of operators to the operation training facilities.
The re-training plan of operators of each class.

- o The operators' training patterns.

- o The contents of education and training; this year's plan and the previous year's results.

The education and training related to the operation training facilities.

The education and training outside the operation training facilities.

Further, the electric utility companies shall also prepare the same kind of materials and attend the Ministry's hearings concerning the education and training of the maintenance personnel.

Qualification of Chief Shift Supervisors for Commercial Nuclear Power Plants. In Japan, chief shift supervisors are required by law to possess a qualified license of "responsible operator," and the Ministry of International Trade and Industry is executing the licensee qualification through its designated licensing organization.

Definition of the responsible operator is a person who conducts instruction and supervision of operators within the control room of the power plant.

Historical background of qualification system of Responsible operator: It has been understood that, during the accident which occurred at Three Mile Island Nuclear Power Station (TMI) in March 1979, a major cause of enlarging the accident was misinterpretation of the plant status and violation of technical specifications by its operators.

Based on such lessons, it has been re-recognized that the keeping and upgrading of capabilities of the operators is extremely important to secure safety of a nuclear power plant.

On the other hand, the education and training of nuclear power plant operators in Japan had consistently been made under the voluntary safety activity plan of individual electric utility companies since 1966, when the first commercial reactor began operation.

Individual electric utility companies have planned their own education and training programs and carried out its training based on the plan to improve the operations capabilities utilizing the training facilities both domestic and abroad.

Considering the case of the TMI accident, however, responsibility of the responsible operator, who should interpret the plant situation appropriately in the emergency conditions and give the adequate instructions for operation activities to respond to those conditions based on comprehensive judgment, should be very high.

For this purpose, from the consideration that it will be necessary to train and secure a responsible operator of high capability under the long-range plan, laws and regulations were revised and a notification was issued accordingly and the Thermal and Nuclear Power Engineering Society (TNS) has been designated as the licensing organization in January, 1981.

Outline of the Qualification System:

- o The personnel to be qualified. The responsible operator who supervises other operators in the control room of the commercial nuclear power reactor. (Chief shift supervisor class)

- o Qualification procedure (refer to Figure 3-1)

Figure 3-1 Qualification Procedure



- o The operator who wishes to be qualified should apply to the qualification organization (TNS) through his belonging organization by submitting an application form with a letter of recommendation of the belonging organization, a personal history and a medical certificate.
- o The qualifying organization (TNS):
 - performs examination of qualification first by the applicant's operating experiences in the nuclear power plants
 - executes examination on practical operating technique and operating skill
 - makes certain the applicant received short term educational course
 - perform oral examination, and
 - based on the comprehensive evaluation, qualification is decided. The qualifying organization issues qualification certificate by the reactor type. Qualification is effective for three years after the certificate is issued.

The number of qualified operators as of the end of March, 1985, is shown below:

Reactor Type	Number of Qualified Operators
BWR	118
PWR	109
GCR	13
Total	240

Practical operating technique and skill examination examines applicants on the knowledge of procedures in normal operation, diagnostic ability of plants in case of accidents and procedures to deal with the events. The aim is to check if they have proper skill and technique necessary for responsible operators in the event of emergency. It is conducted at BTC or NTC by authorized examiners using simulators.

Oral examination (including attendance at a short-term educational course) examines applicants on the knowledge of nuclear power technology, regulations for nuclear power, and managerial ability. The aim is to check if they have proper knowledge necessary for responsible operators. It is conducted by an examination and screening committee, to be established within the licensing organization after completion of the educational course.

Content of the Execution by the Electric Utilities on the Training of Operators and Maintenance Personnel of the Nuclear Power Plants

In general, thanks to the lifetime employment system in the major enterprises in Japan, education and training of employees are being performed systematically and continuously within the enterprises themselves. Promotion of the employees is also corresponding to these education and training systems and the employees are usually promoted according to their experiences and capabilities. Therefore, employees have a rather strong sense of belonging to the enterprises and usually a strong intention for self-development and work improvement.

Education and training of nuclear power plant personnel are conducted, with the above social backgrounds, by the electric utility company continuously from the freshman level to the manager level. There are nine electric utility companies and one nuclear power company in Japan and their methods on education and training of the nuclear power plant personnel are basically the same.

Education and Training of Operators

As the operator's role in the operating safety of a nuclear power plant is extremely important, individual electric utility companies are executing their own education and training of the operators based on the long-term vision of nuclear programs.

- o Education and Training System. Figure 4-1 shows an example of the operator education and training system of a BWR owner utility company. Operators are classified into:

apprentice
 assistant operator
 reactor operator
 assistant shift supervisor
 chief shift supervisor

according to the level of capability and experience and training is also performed to give appropriate knowledge and techniques for each level. They are:

Initial training
 Operating speciality training
 Advanced operating specialty training and
 Supervisor/Manager training

Figure 4-1. Education and Training System for Operators
(Example of a BWR Owner Utility Company)

Job Function	Apprentice	Assistant Operator	Reactor Operator	Assistant Shift Supervisor/ Chief Shift Supervisor
Training Course	Initial Training (1 year)	Operating Speciality Training (3 - 4 years)	Advanced Operating Speciality Training (5 - 9 years)	Supervisor/Manager Training
Training inside the Company	Assembled Education	Shift Training		
		Training in the Daytime Work Shift		
Training at BTC		Basic Lecture	Re-training	
		Short-term Basic Training	Standard Training	Advanced Training
		Family Training (Team Training)		
Training at the Specific Training Organization				
General Education	Education for Freshmen	Education for General Employees		Education for Managers

Initial training. In the initial training, operators learn basic knowledge on the nuclear power generation and nuclear power plant facilities as well as operation practices. Usually this training is provided by the class room style lecture and on the job training during normal shift.

Operating speciality training. An operator who acquired basic operation technique is classified as assistant operator. The assistant operator receives operating specialty training while being engaged in the operation of auxiliary systems. During this training, the assistant operator learns start-up and shutdown operation of the plant and operation for abnormal conditions by on the job training and training in the daytime work shift. After experiencing three to four years as the assistant operator, he receives initial simulator training at the BWR Training Center (BTC) as the final step of this training course.

Advanced operating specialty training. Upon the completion of the initial training at BTC, the assistant operator is authorized to proceed to the reactor operator. The reactor operator is required to receive advanced operating specialty training to keep and upgrade his knowledge and skill on operation and handling. This training includes training in the daytime work shift and simulator training at BTC.

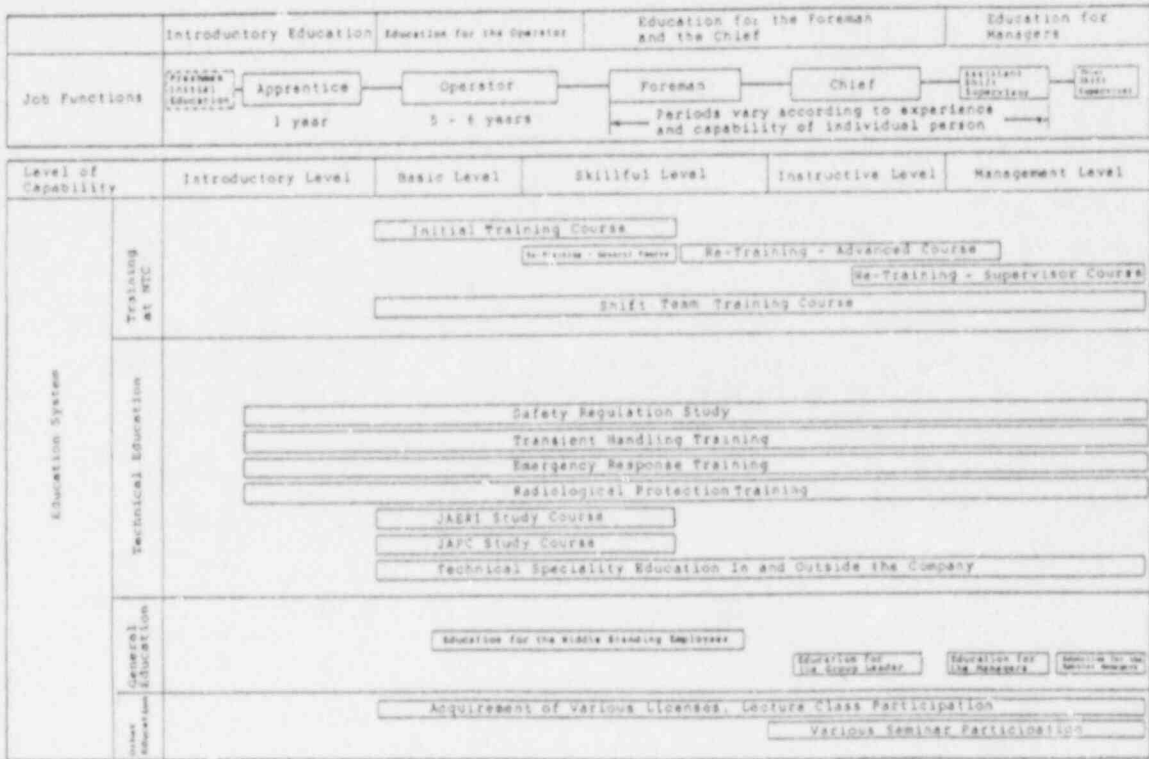
Supervisor/manager training. Among the reactor operators having experience of reactor operation for a few years, those who showed superior performance are selected as the assistant shift supervisors. Further, some excellent assistant shift supervisors are selected to apply for qualification of the responsible operator by the government. The chief shift supervisor is nominated from the qualified responsible operators. Assistant shift supervisors and chief shift supervisors receive supervisor/manager training to upgrade their capabilities of supervising and instructions. This training includes training in the daytime work shift and advanced simulator training at BTC.

Other training. There is general education of a full company scale which gives necessary knowledge, remindness as an employee, and necessary managing skills such as educational or instructional methods of his staffs, etc., through initial education for freshmen and the education made at each step of promotions. The above-mentioned education and training is an example of the utility company which owns BWR nuclear power plants. Figure 4-2 shows an example of the education and training system of another utility company which owns PWR nuclear power plants.

The Contents of Education and Training.

The training within the company. The training within the company consists of an assembled education, on job training during

Figure 4-2. Education and Training System for Operators
(Example of a PWR Owner Utility Company)



the operation shift and training in the daytime work shift. The operators are organized to form five groups corresponding to four operation shifts with three shifts per day and one shift for daytime work. A daytime work shift is mainly allocated for education and training. The assembled education is performed at the initial training level and its content is shown in Figure 4-3. Training during the operation shift is the on the job training mainly for operation and handling of the plant systems and is instructed by an operator in charge of education for each shift. Training in the daytime work shift is shown in Table 4-1 and is instructed by the chief shift supervisor or the assistant shift supervisor.

Training at the training center. Two training centers are being operated in Japan - the BWR Training Center (BTC) for BWR nuclear power plants and Nuclear Power Training Center (NTC) for PWR nuclear power plants. Each training center has two simulators respectively. Electric utility companies send their operators to these facilities for simulator training. Brief descriptions of the facilities are shown in Table 4-2 and lists of the training courses are shown in Table 4-3 and 4-4.

Figure 4-3. Contents of Initial Training

Training Schedule	Assembled Education I	Assembled Education II	Assembled Education III	Assembled Education IV
	4 weeks	2 weeks	3 weeks	1 week
		Shift Training	Shift Training	Shift Training
		3 months	3 months	3 months

Contents of Training	
1. Assembled Education I	Outline of the power plant facilities necessary for shift training and basic matters for the operator
2. Assembled Education II	Outline and Specification of individual systems and component of the power plant
3. Assembled Education III	Function and design philosophy of individual system and components of the power plant
4. Assembled Education IV	Integration of above educations (group discussion and presentation on the specific topic)
5. Shift Training	Component arrangement, method of patrol inspection, composition of each system, basic items for operation and handling, operation and handling of auxiliary systems

Table 4-1. Contents of Training in the Daytime Work Shift

Item	For	Contents
Plant General	Apprentice Assistant operator	Study of : outline, function, design philosophy, structure of each system and component of the power plant, technical specifications, regulations, etc.
CAI Training	Apprentice Assistant operator	Study of reactor physics using CAI
Plant Function Simulator Training	Apprentice Assistant operator	Study of operation and plant behavior using plant function simulator
Emergency operation Training	Above assistant operator	Emergency operation training using mimic control console
Operation Review Meeting	Above assistant operator	Review of operation procedures responding to the behaviours of nuclear power plant during accidental conditions
Operating Experience Review Meeting	Above assistant operator	Review of operating experiences at its owned or other utilities' nuclear power plants
Operation Procedures Review Meeting	Reactor Operator	Review and revision of remarkable points in the operation procedures, etc.
Lecture Class Inside and Outside the Company	All Shift Crew	Lecture class inside the company (radiation control, quality control, core management, water chemistry control, etc.) Lecture class outside the company (computers, relays, reactor control, human factor, etc.)

Table 4-2. Outline of Training Centers for Nuclear Power Plants

Item		B T C	N T C	
Name		BWR Operation Training Center, Co.	Nuclear Power Training Center, Ltd.	
Location		651, Aza Chuo-dai, Ohasa Ottozawa, Okuma-cho, Futaba-gun, Fukushima Pref.	129 Kutsumi, Tsuruga City, Fukui Pref.	
Established in		April, 1971	June, 1972	
Number of Instructors		23	19	
Outline of Facility	Simulator Unit 1	1. Start of training	April, 1974	April, 1974
		2. Model plant	Unit No. 3 of Fukushima Daiichi NPS of TEPCO (784 MWe BWR-IV)	Unit No. 1 of Zion NPS of Commonwealth Edison Company (US) (1,040 MWe - 4-loop)
		3. Control panels	Main control panel in the central control room (reactor, turbine-generator ECCS, etc.) Instructor console	Main control panel in the central control room (reactor, turbine-generator ECCS, etc.) Instructor console
	Simulator Unit 2	1. Start of training	October, 1983	March, 1983
		2. Model plant	Unit No. 3 and 4 of Fukushima Daiichi NPS of TEPCO (1,100 MWe BWR-V)	Unit No. 3 of Takahama P.S. of KEPCO (870 MWe - 3-loop)
		3. Control panels	Main control panel in the central control room with CRT (reactor, turbine-generator ECCS, etc.) Instructor console with CRT	Main control panel in the central control room with CRT (reactor, turbine-generator ECCS, etc.) Instructor console with CRT

Table 4-4. Outline of Training Courses at NTC

No.	Training Course	Outline	Period
1	Initial Training Course	Standard course to understand basic principles necessary for the operator of the nuclear power plant. Phase I Basic lecture Phase II System lecture and visit of nuclear power plant Phase III Simulator training	22 weeks (120 hrs for simulator training)
2	Re-training - General Course	Let the experienced operator learn operation procedures at the abnormal conditions and learn supplementarily reactor theory and plant characteristics.	10 days (28 hrs for simulator training)
3	Re-training - Advanced Course	Let the well experienced operator learn operation procedures mainly for abnormal and emergency responses	5 days (15 hrs for simulator training)
4	Re-training - Supervisor Course	Let the experienced supervisor learn knowledge necessary as the supervisor such as judgement, countermeasures, instruction, etc.	5 days (16 hrs for simulator training)
5	Shift Team Training Course	Simulator training of a shift team for mainly abnormal conditions is performed to strengthen combination play of a shift team	1 day (8 hrs for simulator training)
6	Special Training Course	This course is provided for specific purpose other than above training courses. Content and period of training is decided upon discussion with the utility who sends the trainees	-

Table 4-3. Outline of Training Courses at BTC

Course	Outline	Period
Standard Training	Necessary training for the operator of the nuclear power plant is performed from the basic matters to the application and educate the operator in the short term. Training is consisted by lecture, simulator training, practicing, self-study and examination	12 weeks (128 hrs for simulator training)
Short-term Basic Training	For the operators, who already finished lecture of the standard training and have practical experiences, operating procedures of nuclear power plant is learnt in the short term. (mainly through simulator training) Grade of this training is the same as graduate level of the standard training and the training is consisted by simulator training, lecture, and examination.	3 weeks (128 hrs for simulator training)
Re-training	Training is for the operator, currently engaged in plant operation, and is mainly for the training of abnormal conditions to keep and upgrade of operation capabilities by training periodically.	9 days (40 hrs for simulator training)
Advanced Training	This training is for the high rank operator of the operation shift, who have completed re-training course, and is to upgrade management capability including interpretation of plant conditions, instruction and order as the senior staff by lecture and simulator training.	5 days (20 hrs for simulator training)
Family Training (Team training)	For upgrading of operating technique and strengthening of team work, training is made for a team including Chief Shift Supervisor and assistant operator. Content of the training is decided upon discussion with the utility who sent the team.	1 day
Special Training	Provided for specific purpose. Content and the period of the training will be decided upon discussion with the utility who sent the trainees. 15 days training for general technical personnel is one of examples.	
Basic Lecture	In principle, this course is for the personnel who plans to receive the standard training course. Education on necessary items for reactor operator including reactor physics, radio chemistry, safety analysis and regulation, etc., is performed.	2 weeks

Training at the specific study and training organizations. As the study and training organizations for the basic nuclear technologies, there are those attached to the Japan Atomic Energy Research Institute (JAERI) and Japan Atomic Power Company which are educating engineering staffs relating to nuclear power. The electric utility companies send their technical employees including the plant operators to these organizations according to their education plan for studying the basic nuclear technologies. General description of these organizations is as follows:

Radioisotope and nuclear engineering school of Japan Atomic Energy Research Institute (General course, reactor engineering course)

Contents: These courses provide fundamental knowledge of nuclear power such as reactor physics, health physics, reactor materials, reactor thermal engineering, etc. Frequency of course: Once a year.

Item	Term	Capacity	Remarks
General course	6 months	32 men	For university graduates in science and engineering field
Reactor engineering course	3 months	24 men	

Tokai Training Institute of Japan Atomic Power Company. Contents: These courses provide fundamental knowledge of nuclear power such as reactor physics, health physics, reactor materials, reactor thermal engineering, etc. Frequency of the course: Once a year.

Item	Term	Capacity	Remarks
A course	5 months	20 men	For high school graduates
B course	4 months	10 men	For university graduates

Education and Training of Maintenance Personnel. The role of the maintenance staffs, who are in charge of keeping integrity of the facilities, is also important to the safety operation of the nuclear power plants. In Japan, most of the maintenance work is performed by the contractors to the electric utility companies. Maintenance staffs of the electric utility companies mainly work on the planning, administration and inspection activities including preparation of maintenance plan, management of maintenance works, coordinating with other departments of the company, witness of the inspections, response activities for the occurrence of any trouble.

Practical maintenance activities are performed by the maintenance technicians of the contractors. Under a maintenance system like this, the individual electric utility company is executing education and training of maintenance staffs to have enough knowledge on structures and functions of plant components, methods and procedures of maintenance works, standards of acceptance on result of maintenance, etc.

Education and training system. Figure 4-4 shows an example of the education and training system of a BWR owner utility company. Usually, maintenance personnel receives initial training as operator and then is given his post in the maintenance organization.

Figure 4-4. Education and Training System for Maintenance Personnel (Example of a BWR Owner Utility)

Job Function	Apprentice	Maintenance Staffs			Asst. Section Mgr. / Section Manager
		Basic Maintenance Training (1 year)	Maintenance Speciality Training (5 years)	Instructor Education	
Training Course	Introductory Training (1 year)	Basic Maintenance Training (1 year)	Maintenance Speciality Training (5 years)	Instructor Education	Manager Education
Training Inside the Company	Assembled Education	Training at the Maintenance Training Center	Training at the Maintenance Training Center		
	Shift Training	OJT	OJT		
	Training in the Daytime Work Shift				
Technical Lecture Course by the Component Manufacturer					
Training at the Specific Study and Training Organization					
General Education	Education for Firemen	Education for General Employees			Education for Managers

After getting his post, the maintenance personnel receives the basic maintenance training (for one year) and maintenance specialty training (for six years)

- o Basic maintenance training. The maintenance personnel receives basic maintenance training at the maintenance training center while being engaged in the rather simple job for on the job training. During the basic training, he learns basic items common to the maintenance works, irrespective of the mechanical, electrical or instrumentation fields.
- o Maintenance specialty training. Training is made separately for the specific fields of mechanical, electrical and instrumentation for the first three years. During this period, the trainees receive training at the maintenance training center and technical lecture course by the components manufacturers while taking charge of actual systems or components in the nuclear power plant and practicing routine works on planning, administration and inspection for maintenance activities. By completing these trainings, they become regular maintenance staffs five years after they started training. In the later three years of the specialty training, they are trained to obtain broader knowledge of the nuclear power plant.

Explained above is an example of a BWR owner utility company. Another example of education and training system for a PWR owner utility company is shown in Figure 4-5.

Contents of Education and Training.

Training within the company. The training within the company consists of on-the-job training through the practical work, or work of routine maintenance and periodic inspection, etc., and the training done at the company's own maintenance training center. Table 4-5 shows the outline of the maintenance training center owned and operated by individual electric utility companies in Japan. In these training centers, training is made for structures, functions, overhaul and inspection, assembling, adjustment and trial run of each component using the training facilities. Table 4-6 and 4-7 show the outline of the training at the maintenance training centers for BWR and PWR respectively.

Figure 4-5. Education and Training System for Maintenance Personnel (Example of a PWR Owner Utility)

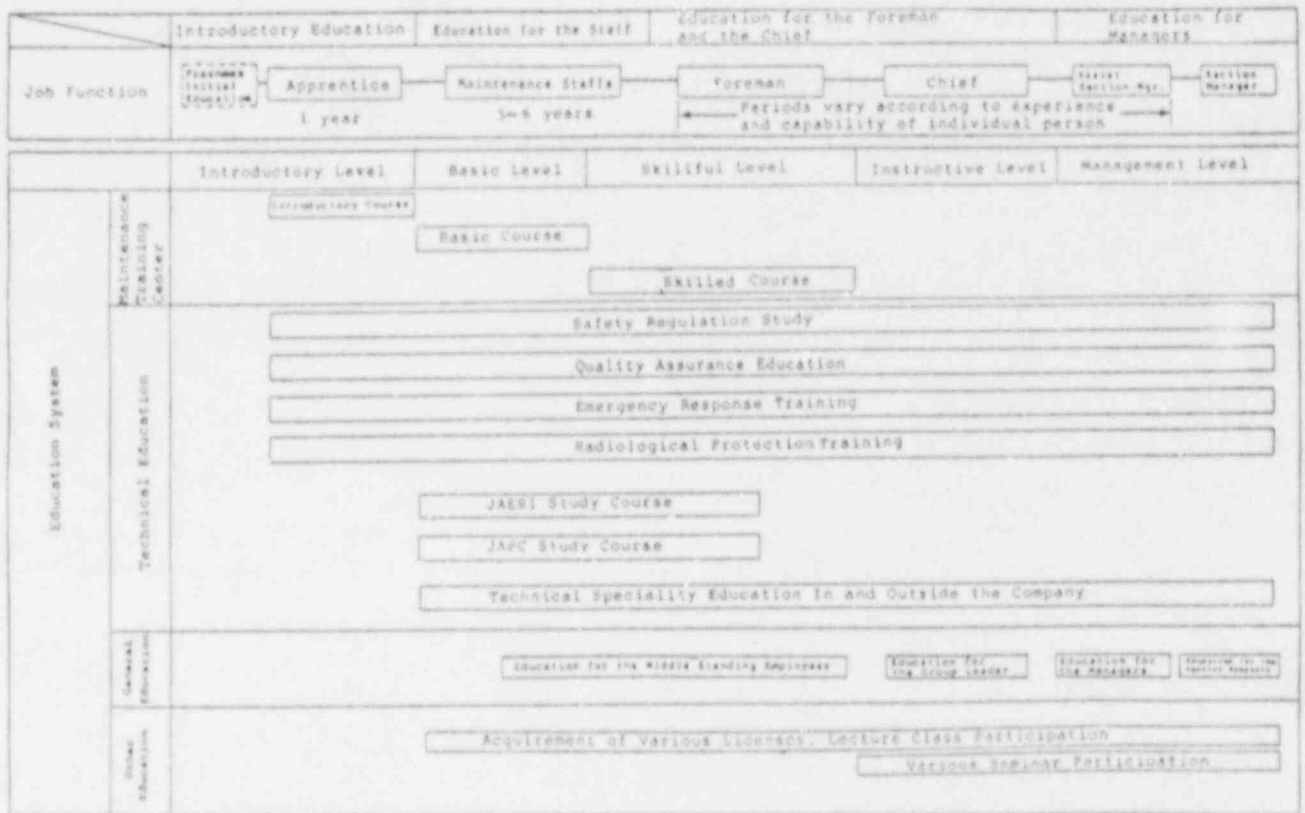


Table 4-6. Outline of Training
at the Maintenance Training Center
(An Example of BWR)

Item of Training			
Basic Training	<ol style="list-style-type: none"> 1. Work procedures (21 items) 2. Safety administration 3. Quality control 4. Maintenance work guideline 5. Work supervisor education and RST 		<ol style="list-style-type: none"> 6. P & ID and ECWD 7. Materials 8. Structure 9. Construction method 10. Inspection, measurement and adjustment
	(30 days)		
Specialty Training	Mechanical	Electrical	Instrumentation
	<ol style="list-style-type: none"> 1. Seals (incl. Mechanical seal) 2. NDT-2(RT,UT,ET) 3. Vertical pump 4. Horizontal pump 5. Steam turbine 6. Boiler 7. Emergency Diesel Generator 8. Crane, hoist 9. Refrigerator 10. Valve 11. CUW pump 12. CRD dismantling, removal and installation, core components 13. Waste disposal 14. Oil/mechanical snubbers 15. Recirc pump mechanical seal 16. Turbine control EHC 17. MSIV pilot valve 18. Vibration analysis 19. ISI 20. Incident/failure case study 21. Maintenance of nuclear power plant and related regulations 	<ol style="list-style-type: none"> 1. Electric circuit- General (I) 2. Electrical Instrumentation 3. Electric construction 4. Motor 5. Relay (I) 6. Circuit breaker (I) 7. Electro-magnetic valve 8. Motor operated valve 9. Low voltage motor dismantling and assembling 10. Relay (II) 11. Circuit breaker (II) 12. Electric circuit General (II) 13. Transformer 14. Electrical work 15. High voltage motor 16. Sequence controller 17. NDT-2 18. Relay (III) 19. Relay (IV) 20. Circuit breaker (III) 21. Circuit breaker (IV) 22. Generator 23. Vibration analysis 24. Battery 25. Incident/failure case study 26. Maintenance of nuclear power plant and related regulations 	<ol style="list-style-type: none"> 1. Electronic, logic circuit 2. Analogue instrument 3. Digital instrument 4. Control valve 5. Special instrumentation 6. HCU 7. Radiation monitor 8. Nuclear instrumentation 9. TIP drive system 10. Instrumentation control model plant 11. Process computer Core performance calculation Plant diagnostic system 12. RPS separation spec. 13. Special control system 14. EHC, EPR, MGU 15. Incident/failure case study 16. Maintenance of nuclear power plant and related regulations
	(40 days)	(44 days)	(45 days)
	<ol style="list-style-type: none"> 1. Incident/failure case study 2. Factory visit 3. Aseismic design 	<ol style="list-style-type: none"> 4. Safety design 5. Accident analysis 	<ol style="list-style-type: none"> 6. Radiation exposure evaluation 7. Shielding design 8. Water chemistry control (7 days)

Table 4-7. Outline of Training at the Maintenance Training Center (An Example of PWR)

Step (referenced level)	Item	Content of Training	Period
Introductory (the first year of training)	Maintenance Common items	<ul style="list-style-type: none"> Structure and function of general equipment Basic maintenance of pump, valve, motor, etc. Handling of various instrumentation 	5 days
	Maintenance Common items	<ul style="list-style-type: none"> Outline of quality assurance Outline of periodical inspection work 	4 days
	Mechanical items	<ul style="list-style-type: none"> Structure, dismantling, assembling of pump, valve and blower, etc. NDT outline, inspection technology Vibration analysis, materials outline, machining practice 	43 days
	Electrical common items	<ul style="list-style-type: none"> Basic sequence control, circuit composition Piping and wiring Handling of various instrumentation 	15 days
	Electrical items	<ul style="list-style-type: none"> Structure, dismantling, assembling of motor, metal clad and power center, etc. Structure, dismantling, assembling of circuit breaker, motor operated valve, etc. Theory and maintenance of protection relay 	23 days
Basic (personnel having experience of a few years)	Instrumentation items	<ul style="list-style-type: none"> Outline and functions of instrumentation for the primary system Structure, handling and maintenance of instruments Structure, dismantling, assembling of air-operated control valve 	41 days
Step (referenced level)		Content of Training	Period
Skilled (middle standing technical personnel)	Mechanical related items	<ul style="list-style-type: none"> Structure, functions and maintenance of main component of the primary system Structure and function of steam turbine 	24 days
	Electrical related items	<ul style="list-style-type: none"> Theory and maintenance of the generator controller and power supply for instrumentation Structure and maintenance procedures of middle - and large - size motors 	17 days
	Instrumentation related items	<ul style="list-style-type: none"> Theory, inspection technology and analysis of ECT for steam generator Instrumentation inside and outside the reactor, radiation monitors Functioning theory, inspection and adjustment of turbine monitoring instrumentation, etc. 	30 days

Note: The long training could be given by dividing it into shorter periods

Training through the technical lecture course by the component manufacturers. The electric utility companies which do not have their own maintenance training center, or even those which have such training center, make their maintenance personnel participate in the lecture course prepared by the component manufacturers to train them for the special components or components needed for knowledge of advanced specialty.

Training at the specific study and training organization. Same as the operators, maintenance personnel are also sent to the specific study and training organizations outside the company to study basic nuclear technologies.

Education and Training of the Maintenance Technicians of the Contractors. As mentioned previously, actual maintenance work of the nuclear power plant is done by the maintenance technicians of the contractors and the upgrading of quality of these technicians is also important. Individual electric utility companies are making an effort to establish such a contractor system by their subsidiary companies. Contractors are voluntarily providing training for their maintenance technicians. Electric utility companies also give contractors their guidance and advice on the planning and execution of the training. An electric utility company having its own maintenance training center offers it to the contractors for the training of their maintenance technicians. Furthermore, for the periodical inspection, the company also orders the team of maintenance technicians to make a rehearsal training at its maintenance training center in advance of the actual overhaul and inspection of important components like CRD.

Conclusion

Based on the high performance of nuclear power generation, it is expected that the share of nuclear power in the electricity supply in Japan would further increase and, accordingly, operators and maintenance personnel (including those of the contractors) would be required to increase quite an extent in the near future.

Furthermore, one may also expect changes in the environment of nuclear power generation, such as change in the mode of operation, introduction of advanced technologies, lack of experience on incidents and failures as well as a change of generation of the operators and maintenance personnel. To cope with these situations, improvement of the education and training plan of the operators and maintenance personnel is becoming more and more important from the viewpoint of securing safety and reliability of nuclear power generation. Currently, education and training status in Japan is generally satisfactory, the result of which is reflected on the high performance of nuclear power generation. However, it is considered that education and training will become much more important in the above mentioned circumstances, and the government and industry of Japan would like to work further on this matter.

Discussion

MR. TANGY: In France we barely achieve on-site training of operators five days a year, clearly identified and prepared as on-site training," and 10-15 days per year off-site training, such as simulator retraining and operation. We intend to move to 10 days on-site training and 15 days off-site training, of a daytime nature. In Japanese stations, what is the actual time devoted to on-site training?

MR. IKEDA: Approximately 25 days per year. For the daytime training we have some intervals -- two weeks daytime work shift for each 10 weeks. So eight weeks on shift and two weeks daytime work. Annually we have nearly 50 days for daytime work shift, half of which is allocated to training.

MR. VANDEWALLE: You said you qualified your operators for a period of three years. How do you re-qualify operators? Is it only upon the basis of courses which are taken or something like that? Or do you give them special examinations?

MR. IKEDA: We do not have any re-qualification process for operators. We only have re-qualification for shift supervisors. But we do re-training of operators every three years at the BWR training center.

MR. VANDEWALLE: Is that sufficient to be able to re-qualify a person?

MR. IKEDA: I think it is enough, because we also have daytime work shift training and team training at the BWR training center three days per year.

MR. STICKNEY: Would you explain how you make your initial selection of personnel who enter your training program?

MR. IKEDA: New employees are selected on an annual basis in Japan, at the end of the fiscal year by an entrance examination. The selection is made for all new employees of one company. In my company's case, about one hundred university graduates and about one thousand high school graduates are hired. Among them, those who show excellent performance are assigned to the nuclear field.

THE MANUFACTURER'S PART IN
NPP PERSONNEL TRAINING IN THE FRG

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Abstract

This paper describes the regulatory guidelines and the training and retraining procedures and programs for NPP personnel in the Federal Republic of Germany.

Reference is also made to the three years dual workshop/factory and classroom education of skilled workers in Germany. KWU as a turnkey manufacturer of Nuclear Power Plants holds the nuclear operating license towards the authority after first fuel loading of a new plant. In this respect it has extensive overall training obligations not only towards its customers but also with regards to its own shift personnel during nuclear power operation up to commercial operation and hand over of the plant.

KWU's philosophy of training, its infrastructure, its various obligations and services are described for new plants as well as with regards to retraining for older plants.

Regulatory Guidelines for NPP Personnel in the FRG

The first "Guideline relating to the proof of the technical qualification of nuclear power plant personnel" was published in 1974. It specified that shift supervisors, their deputies, and reactor operators have to take a written and oral examination, specifically for the plant in which they perform these functions (Figure 1.).

In 1984, this regulation was revised and re-published for the second time. It specifies that the plant managers be at least graduate engineers. Knowledge of nuclear and reactor physics, reactor engineering and reactor safety, and in the fields of health physics, fire protection, and occupational safety is required. They must know all the details of the construction of their plant, and its behavior under normal operating and faulty conditions.

The law governing the use of atomic energy, all official ordinances, codes, standards and guidelines, and the applicable operating instructions, especially the alarm schedule and the safety

1. Guideline relating to the proof of the Technical Qualification of NPP Personnel

- 1. Version 08. 10. 1974
- 2. Version 17. 05. 1979
- 3. Version 04. 04. 1984

2. Guideline for the content of the licensing exam for responsible Shift Personnel of NPP's

Version 10. 05. 1978

3. Guideline for programmes to maintain the Technical Qualification of Shift Personnel of NPP's

Version 17. 05. 1979

4. Guideline relating to the proof of the Necessary Knowledge of other persons working in NPP's

Version 30. 10. 1980

5. Guideline for the Technical Qualification in Radiation Protection

Version 19. 09. 1982

6. Guideline relating to the proof of the Technical Qualification of Research Reactor Personnel

Version 18. 03. 1976

Fig.1: BMI - Guidelines relating to NPP Personnel

BM 1-11
PSW 22
7.85

specifications, are part of the mental equipment in daily use by the plant engineers in charge. How practical experience is to be acquired is also specified in detail. Shift supervisors are required to hold an engineering degree.

In a new draft detailed training requirements are specified for the Training Manager and the QA manager of the plant, the requirements for previous practical training and simulator training are increased and the new aspect of accident management measures is introduced as part of the training requirements.

In the "Guideline relating to the contents of the examination of the technical qualification of the responsible shift personnel at nuclear power plants," fields in which shift staff is to be examined are defined.

The "Guideline relating to programs for the preservation of the technical qualification of the responsible shift personnel at nuclear power plants" specifies that these personnel must take refresher courses, consisting of a theoretical and a practical part, lasting at least 100 hours per annum and per person, in a three-year cycle.

The knowledge, i.e., training, lecture, or instruction, required of those groups of persons not covered by the regulations mentioned above is specified in the "Guideline relating to the assurance of the necessary knowledge of other persons engaged in the operation of nuclear power plants."

The necessary knowledge of these groups of persons, which must be documented to the regulatory agency, must cover at least the four safety-related subjects of health physics, fire protection, occupational safety, and plant operation. Three levels of knowledge are distinguished, depending on the type of work performed:

- o Level 1 for personnel working under supervision
- o Level 2 for personnel not requiring supervision
- o Level 3 for personnel in positions of authority.

Training Procedures in the FRG

The training program for NPP's in the FRG can be divided into five steps (Fig. 2):

- The preparatory phase with basic theoretical training
- The practical training on-the-job in similar installations
- The plant-related special training
- The simulator training
- The commissioning of the own plant.

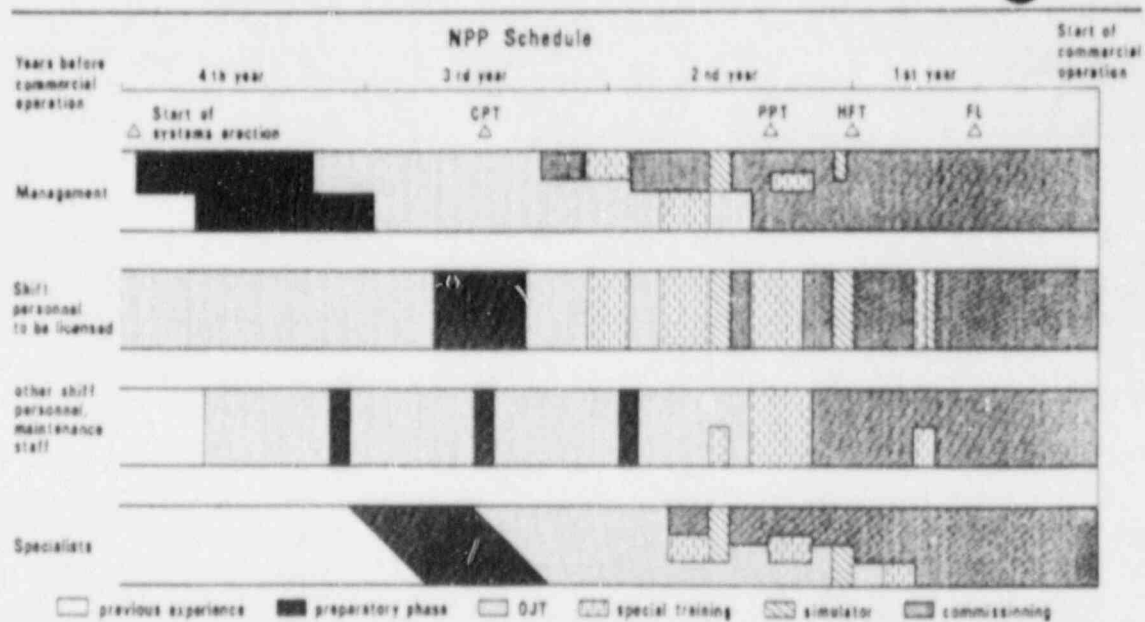
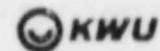


Fig.2: Training Program for NPP Personnel in the FRG

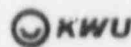
The basic theoretical training covers general basics of NPP technology, reactor and neutron physics, health physics and thermohydraulics. It consists normally of one three-month course in a research center, at a technical university or in a utility-owned school and a six-week introductory course at KWU.

A high level of practical experience is required for working in an NPP, which applies not only for craftsmen level but especially for management functions including the crucial function of shift supervisors.

For these groups of personnel practical training in an operating NPP is important in order to gain experience in the day-to-day operation. The aim of such practical training can be defined as twofold:

- o The participants shall become familiar with the NPP, its components and systems, its operation and maintenance.
- o The participants shall learn organizational structures in order to know later on the distribution of functions, responsibilities, and assignments and the safety rules applicable to their work.

Therefore, the trainees take part in regular shift duty. They accompany the shift staff making their tours through the buildings, and actively assist them in the execution of their duties. The active involvement of the trainees is of vital importance for their training; therefore, they have not only to stay in the control room. The trainees shall thoroughly familiarize themselves on their own with a number of specified systems, prepare reports on them as part of their normal shift reports on events and actions, and give the reports to the other training groups. During the day shift, the trainees are briefed and instructed by the training supervisor on site. Other personnel, depending on their later functions, are similarly trained on-the-job.



The design and operation of the individual systems of the own plant as well as malfunctions and operation of the whole plant are covered in the plant course (Figure 3). This course is subdivided into three stages with a duration of approximately two months each and a total of more than 100 subjects:

1st stage: General principles, thermohydraulics, components, identification system, measuring techniques, NSSS and auxiliaries, fuel and radiation protection.

2nd stage: Secondary plant and auxiliaries, turbine generator set and controls, cooling water systems and chemistry, station service systems, reactor protection hardware.

3rd stage: Instrumentation, reactor controls, reactor limitations and protection, operating behavior, malfunctions, external events and accidents, operating manual and design-objective-oriented strategy and behavior.



Fig.3: B 121 PWR KWU-Plant Course, Structure

12345 101
1234 201

KWU teaches this course by special instructors and partly by using authors from its special engineering departments. Video tapes and transparencies are used for intensifying the information. Written and graphic material, specially designed for each plant, is provided on each subject to each trainee.

The lectures are presented in the morning. In the afternoon the personnel work through the material treated the same morning. To this end the personnel will be divided into seminar groups. The written accompanying documents are available for this purpose and the test questions given by the instructors must be answered. At the end of the afternoon the instructors gather all the trainees and ask individual participants to present their answers to the others for discussion. If in the morning or afternoon any question occurs, they are either answered directly by the training instructors or else collected for a colloquium. After a complex of subjects has been completed (i.e., after several working days), such a colloquium takes place at which a specialist from a particular engineering department may give a final general survey of the material treated and answer any questions which have not yet been cleared up.

After each stage KWU holds a partial exam which is reviewed by the regulatory authority. They are accepted as the written licensing exam for the shift staff.

Simulator training is another important phase of NPP training. It applies for the future shift personnel, however, managerial staff for operation should also undergo thorough simulator training as part of their practical qualification process.

In Germany, simulator training is divided into two stages: the first stage emphasizes start-up, shut-down and power operation, and the second stage covers controls, limitations and malfunctions.

The most important phase of the whole training and qualification program is the participation of the trainees in the commissioning of their own plant. The knowledge gained in previous courses can now be put into practice during the commissioning and shift operation of their own plant, with additional instructions by the commissioning engineers of the contractor. The trainees can follow the progress of work during this phase by means of the erection and commissioning documentation used by the contractor, through participation in the individual component checks, system tests and pre-operational and performance tests.

The training of skilled workers is of special importance for the safe and efficient operation and maintenance of NPP's (Figure 4.). It is normally performed in educational workshops equipped with the corresponding instruments, machinery and work places.

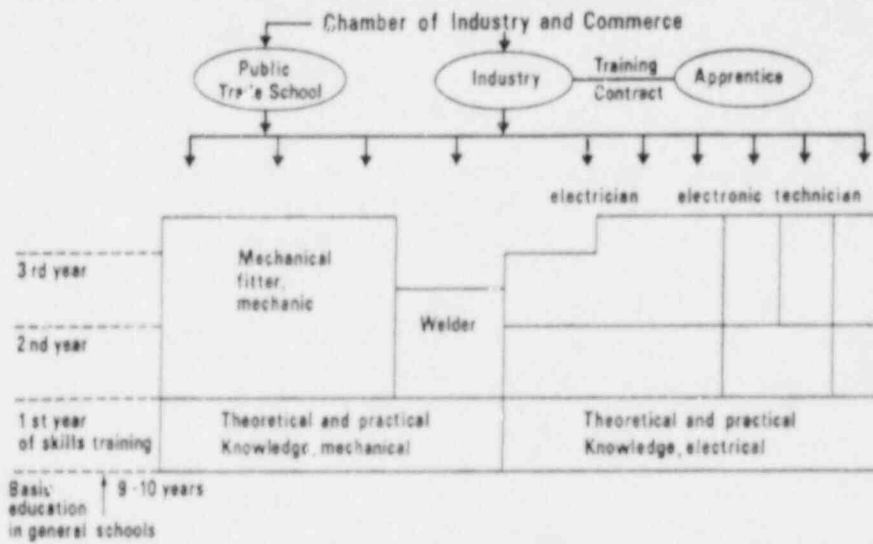


Fig.4: Vocational Training in Germany

The following skills are imparted: Working with metal and plastic, use of machine tools and machines, fundamentals of welding, brazing and heat treatment, reading and preparation of technical drawings, fundamentals of electrical engineering.

Vocational training in Germany takes approximately three years until the participants get a certificate from the Chamber of Industry and Commerce.

The utilities have developed special training schemes for skilled workers and foremen to become NPP skilled workers and NPP foremen respectively (Figure 5.)

This training for the first category consists of 22 additional months of practical training in the plant and a total of 13 weeks of theoretical instruction. The training for foremen again consists of an additional 18 months part of guided practical work and four modules of theoretical instruction of a total duration of one year.

As defined in the regulatory guide for the preservation of the technical qualification of the responsible shift personnel, they have to undergo a thorough retraining.

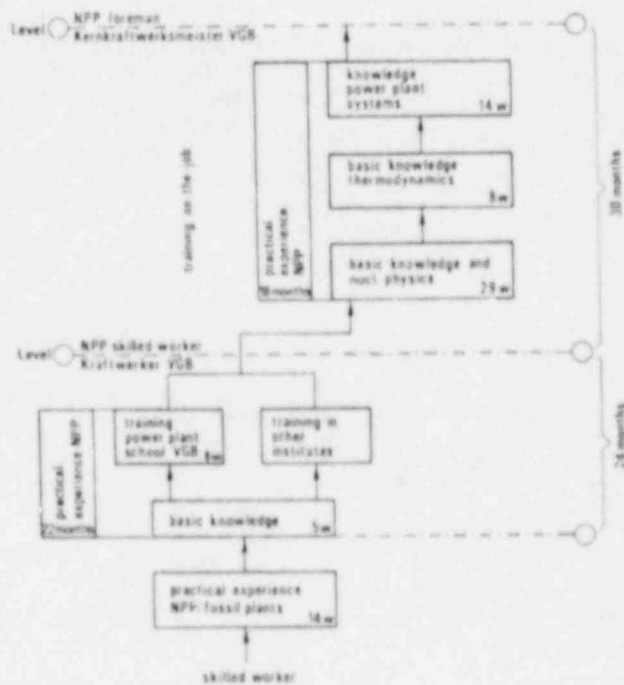


Fig.5: NPP Skilled Workers and Foremen Training in Germany

The utility has to develop a three-year program for each individual with a minimum of 100 hours per man and year. It has to contain a theoretical part covering fundamentals of operating and malfunction behavior, plant design with emphasis on design changes and operating experience (also from other plants). Surveillance tests and reactivity controlling manipulations, malfunction discussions and health physics exercises form the practical part. Simulator retraining of at least one week per year is current practice.

KWU's Involvement in Training in Germany

KWU is the major plant manufacturer in the FRG with more than 14,000 employees, with 40% of them holding an engineering degree or equivalent. As a turnkey supplier of nuclear power plants it covers all technical aspects of NPP's with PWR, BWR and HPWR, through its affiliates the whole fuel cycle and also breeder reactors. NPP's from KWU hold first places in the world with regard to availability and electrical power production.

Being a turnkey supplier, KWU is also a licensing applicant for new plants and has the overall nuclear responsibility under the German Atomic Energy Act from the first fuel load up to end of trial operation and hand-over to the customer. KWU trains its own shift supervisors who also have to undergo the licensing exam. With its commissioning staff at site and the support of the commissioning staff of its subcontractors (who may run up to 700 different subcontractors), KWU nevertheless relies on the future NPP staff of the utility, i.e., KWU provides only two engineers per shift. The remainder is supplied by the customer. This is the reason why KWU's function as a manufacturer of NPP's in the FRG differs significantly from that of foreign manufacturers.

KWU designs overall training programs for its customers and develops them further in close cooperation with them. This also includes of course the implementation of other training resources such as training institutes and special courses of subcontractors or even utility designed courses.

KWU provides a large number of courses and seminars for initial training, retraining and replacement training which not only include technical subjects like technical basics, systems design, control and instrumentation, reactor controls, limitations and protection, coolant transients and malfunctions, accidents, external events or design-objective-oriented strategy and behavior but also managerial courses on management, communication, behavior under stress a.s.o.

Simulator training normally is within the responsibility of the utility-run simulator training center. However, KWU is involved to a large extent in the training for the convoy and the retraining for the pre-convoy plants.

In 1983 and 1984 KWU has provided 5,500 hours of simulator training, which were analyzed for various aspects. The result of this study lead to a "Functional Trainer," due in 1988 which covers more than 80% of the simulator training with only 30% of the scope of a full scope simulator. The reason for this is the need for extensive training of the reactor control, the reactor limitation and the protection systems and the major malfunctions in the nuclear or conventional area affecting these complex systems.

In addition to that, KWU has developed a "Nuclear Plant Analyzer" which, with the help of design codes and a high speed data link, provides specially processed displays of transients and system status on graphical displays. This device can be installed at site and hooked onto the KWU mainframe computer via telephone line.

KWU further developed ICS, an interactive communication system for individual training and retraining and also for motoric repetition of complex logics of systems. Suitable in-house produced videotapes are copied on disc which is controlled via a PC and special mixing equipment. A specially designed editor system helps to develop interactive lectures with inbuilt motivation loops, subject knowledge tests and visualized instruction.

For all this KWU disposes of a comprehensive customer training organization with all technical specializations necessary and all facilities required to not only provide such training but also to develop the curricula and the appropriate training material and equipment. It continuously maintains an exchange of experience with its customers and the design departments so as to keep up-to-date in NPP training in all aspects.

THE IMPACT OF REGULATION
ON TRAINING PROGRAMS
THE BELGIAN APPROACH

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Abstract

This paper described the Belgian approach related to training programs. After a short description of the situation before the TMI-2 accident, the evolution of training programs will be presented with emphasis on the impact of regulation and requirements set forth by the Belgian regulatory body. The original solution adopted for the use of full-scope simulators will be described. This solution takes into account the design differences between the seven operating nuclear power plants.

Introduction

The Belgian nuclear power plants are presently producing more than 40% of the internal electricity demand. The nuclear program began in the sixties with the start-up of BR3, a small PWR power plant producing 10 MW(e). This experimental power plant was mainly intended to demonstrate the feasibility of a Belgian nuclear development. The NSSS supplier was Westinghouse and the power plant was built in collaboration with Belgian industries and architect engineers. The reactant coolant system included one steam generator and two primary pumps installed in two loops.

The first tentative was successful and was followed by the construction of the SENA nuclear power plant, in collaboration with Electricite de France (EDF). This 300 MW(e) power plant, located close to the Belgian border, had a four-loop primary system and started in 1967. This plant is now operating under the responsibility of EDF.

In 1974 and 1975, we started the first Doel and Tihange nuclear power plants. On the site of Doel, a twin-unit of 2 x 390 MW(e) was built (Doel 1 and 2). These Westinghouse PWR reactors have two loop primary systems. The auxiliary systems are partially shared between the two units. A three loop PWR reactor was built, once again in collaboration with EDF, in Tihange (Tihange 1), having a nominal power of about 870 MW(e).

Following the success of nuclear electricity generation, the Belgian authorities approved the proposal of the utilities to build four more nuclear power plants: two on the Doel site (Doel 1 and 2) and two on the Tihange site (Tihange 2 and 3). The Doel 3

and Tihange 2 units started in 1982. These are three loop 900 MW(e) power plants. The NSSS supplier was Framatome and the architect engineer was Tractionel for the Doel unit, and Electrobél for the Tihange unit. The Doel 4 and Tihange 3 units started in 1985. As for the previous units, they are three loop power plants, delivering 1,000 MW(e). The NSSS supplier is Westinghouse and, similarly, the corresponding architect engineers contributed to the construction of the Doel and Tihange power plants.

This short description (see summary in Table 1) of the actual nuclear power plant equipment shows that there are some significant differences between the nuclear units operating in Belgium. Although all power plants are PWR types, the intervention of different NSSS suppliers, as well as different architect engineers, has had a non-negligible effect on the training of nuclear power plant operators.

Table 1. Belgian Nuclear Plants
Main Features

	BR3	DOEL 1/2	TIHANGE 1	DOEL 3 TIHANGE 2	DOEL 4 TIHANGE 3
START-UP DATE	1962	1974-1975	1975	1982	1984
REACTOR TYPE	PWR	PWR	PWR	PWR	PWR
NSSS SUPPLIER	WESTINGHOUSE	ACECOWEN WESTINGHOUSE	FRAMACECO FRAMATOME	FRAMACECO FRAMATOME	ACECOWEN (WESTINGHOUSE)
PRIMARY LOOPS	2/1	2	3	3	3
NOMINAL POWER	10 MWe	2 x 392 MWe	870 MWe	900 MWe	1000 MWe

Evolution in Training Programs

General. Since the beginning, the need for selection, qualification and training of the power plant operator (as well as other power plant personnel) was considered as an important concern by both the utilities and the regulatory body. Nevertheless, the TMI-2 accident has had an important influence on the improvement of training programs.

Power plants started before TMI-2 accident. The nuclear power plants which are considered here are mainly the Doel 1/2 and the Tihange 1 units, since the BR3 is experimental and SENA is operated by the French utility, EDF.

The plant operators of both sites received basic training:

- o theoretical
- o practical

The practical training consisted initially in training periods on the BR3 power plant. Part of the operation personnel were trained on US simulators. Until the TMI-2 accident, and in comparison with the present situation, rather poor attention was paid to re-training, which was not systematic.

In the early eighties, the Tihange 1 unit obtained a compact simulator (simulating the Surry 1 power plant, which is very similar to Tihange 1) and they began to systematically re-train operations personnel.

No simulator was available for the Doel 1/2 units and the training effort was made more on theoretical basic knowledge (a limited number of plant personnel followed simulator training in Spain). This theoretical, classroom kind of course included important subjects such as reactor physics, reactor operation, thermodynamics and so on.

As part of the decennial revision program these utilities, encouraged by the regulatory body, are presently establishing a complete training and re-training program, including theoretical and practical courses. In matters of practical training, two different approaches were adopted:

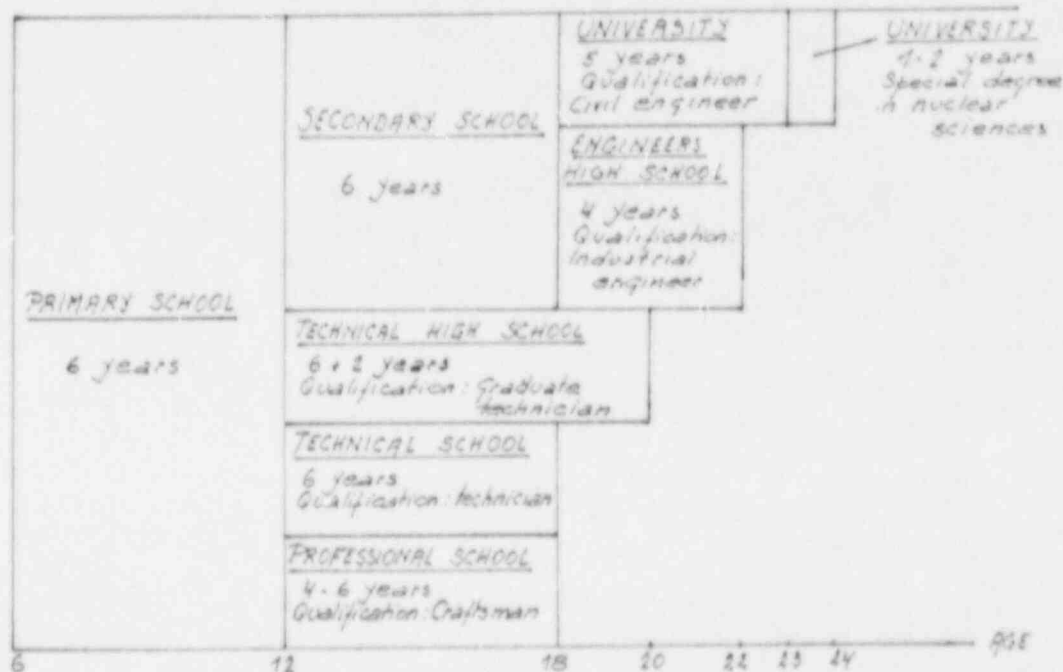
- o Doel 1/2. A full-scope simulator will be available to train and re-train the operators. Since this plant is a twin unit, the simulator will be able to fully represent one unit and its corresponding auxiliaries (eventually shared with the other unit), while the second unit will be represented into different steady-state operating conditions (full power, hot shutdown, cold shutdown, etc.).
- o Tihange 1. The compact simulator is being improved to better model the working of the different systems already represented, and to add some other important systems and subsystems. Thanks to the similarity between Tihange 1 and the other Tihange units, it will also be possible to train the operators on the full-scope simulator provided for Tihange 2 and 3.

Power plants started after the TMI-2 accident. The situation of these units (Doel 3/4, Tihange 2/3) is quite different from the older units. Indeed, taking into account the major part of the conclusions about the TMI-2 accident, the Belgian authorities imposed on the utilities to thoroughly improve their training and re-training program and, in particular, to follow the US rules and recommendations. Of course, due to differences in the education system in Belgium and in the USA, the American guidelines had to be adapted.

Qualification and experience required for power plant operators. The structure of the Belgian education system is presented in Figure 1. This figure shows only the education system which is of interest for plant operators. The qualification of the power plant personnel takes into account a combination of:

- o school education level
- o practical personal experience

Figure 1. Education System in Belgium



These minimal requirements for the different operations staff jobs can be expressed as follows:

Operation Superintendent

- o school level: civil engineer
- o experience: minimum four years in a thermal power plant, three years of which in a nuclear power plant.

Operation Assistant

- o school level: industrial engineer
- o experience: minimum two years in a thermal power plant, one year of which in a nuclear power plant.

Shift Supervisors

- o school level: graduate technician, technician or equivalent knowledge by theoretical training and practical experience
- o experience: minimum four years in a thermal power plant, two years of which in a nuclear power plant.

Operator

- o school level: technician or equivalent knowledge by theoretical training and practical experience
- o experience: minimum three years in a thermal power plant, six months of which in a nuclear power plant.

Roundsman

- o school level: technician, craftsman or equivalent
- o experience: one year in a thermal power plant, six months of which in a nuclear power plant.

In addition to these requirements, some experienced in the performed job is necessary. This is obtained by on-the-job training, leaving the candidate working together with skilled operation personnel members.

Training program. The training program is divided into two main parts: initial training and re-training.

Initial training. A very important effort was given to the initial training program. The total duration of this training period amounts to about 200 days, which constitutes a very heavy workload. This training includes theoretical training as well as practical training and is adapted in function of the initial theoretical and practical knowledge of the trainees.

The initial theoretical knowledge is assessed by examinations performed during the recruitment phase. Certain important subjects, such as health physics, safety and quality assurance programs, are not included in normal school courses.

These matters are taught by the utilities, or under their responsibility. Generally, most of the training courses are given on site, by members of the utility, specially trained for this purpose. However, some specific subjects are taught by foreign nuclear training centers such as those of Electricite de France.

A complete initial training program includes the following subjects:

- general knowledge of PWR plants
- reactor physics
- reactor operation
- thermodynamics
- reactor protection systems
- knowledge of plant systems (systems descriptions and operations)
- knowledge of plant procedures
 - normal operation
 - faulted operation
 - accident operation
- technical specifications
- training on the BWR3 power plant
- simulator operations
 - normal operation
 - faulted operation
 - accident operation

The training includes different types of teaching methods:

- theoretical classroom courses
- on-the-job training
- simulator training

As far as simulator training is concerned, the actual lack of a dedicated simulator has been resolved by sending the trainees on other available simulators as those from EDF. Since these simulators are simulating the French power plants, special courses are organized to make evident the design differences between their power plants and the Belgian ones. The same situation is encountered in case of use of the compact simulator installed in Tihange. This situation is only transitory since the Belgian authorities have imposed on the utilities the construction of simulators adapted to the specific design of the Belgian power plants. The final solution proposed by the utilities (and approved by the Belgian authorities) to give answer to this requirement will be examined later on.

Re-training. In addition to the initial training program, a further effort is made to maintain and to improve the knowledge acquired by the operation personnel. The total duration available

for this purpose is approximately equal to 5-6 full weeks per year. This re-training period is divided into several specialized sessions such as:

theoretical refresher courses on matters related to nuclear power plant operation

analyses of incidents or accidents affecting the unit or other power plants in the world

review and study of plant procedures

simulator training.

It should be noted that the Utilities, in order to provide enough time to re-train operation personnel, increased the number of shifts to seven instead of six, which is the current number in Belgian power plants.

The Use of Full-Scope Simulators -- An Original Solution

General. As already mentioned, Belgian nuclear power plants share between each other differences which make the use of one common full-scope training simulator nearly impracticable. Since the Belgian authorities had imposed to the utilities to train their plant operators on full-scope simulators, having similar operating characteristics to the trainee's plant, and original solution was proposed and approved. This solution consists of the construction of three full-scope simulators (the Doel 1/2 simulator is not exactly a full-scope simulator, but could be referred to as part-scope).

It should be noted here that the latest power plants (Doel 3/4, Tihange 2/3) were designed with so-called "second level protection systems." These systems are intended to mitigate the consequences of external events such as: complete loss of cooling water, aircraft crashes, external extended fire, gas deflagration, and so on. They are dedicated systems added to the usual auxiliary and safeguard systems, and were designed by the NSSS suppliers. As a consequence, the Westinghouse-developed second level protection systems are quite different from the Framatome-designed systems.

In addition to this situation, the Doel and Tihange power plants were built by two different architect engineers, which resulted in some differences between the two plants. All of these considerations resulted in the following adopted solution:

- o One full-scope simulator representing the Doel 4 power plant, including second level

protection systems. This simulator will be able to simulate the Doel 3 second level protection systems.

- o One full-scope simulator representing the Tihange 2 power plant, including second level protection systems. This simulator will be able to simulate the Tihange 3 second level protection systems.
- o One "part-scope" simulator representing Doel 1/2 twin units.
- o Improvement of the compact simulator actually available in Tihange.

The Doel 4 simulator. This simulator will include the following layout facilities:

- a main control room identical to Doel 4
- a second level control room identical to Doel 4
- a second level control room identical to Doel 3

The simulator will be able to function in the Doel 4 mode (with the corresponding second level protection systems), as well as in the Doel 3 mode, with the associated second level protection systems. Training and re-training of Doel 3 plant operators will be provided on the Doel 4 simulator, working in the Doel 3 mode. The second level protection systems will be available as they are in reality in the Doel 3 power plant, but the reference plant key will be operating with will be Doel 4. The differences between the basic systems of both power plants are sufficiently slight to be neglected as far as training is concerned. Except for the second level instrumentation, control and systems, all other basic parameters and systems will be those of Doel 4 plant. The main control room will also remain unchanged in case of the Doel 3 operating mode.

To make simulator training fully efficient, special courses will be provided to Doel 3 plant operators to make evident the small differences they will encounter during their training courses on the Doel 4 simulator, operating in the Doel 3 mode. The different layout design of the Doel 4 control room will also be taught.

The Tihange 2 simulator. This simulator will include the following layout:

- a main control room identical to Tihange 2
- a second level control room identical to Tihange 2
- a second level control room identical to Tihange 3

Similar to the Doel 4(3) simulator, this equipment will be able to function as well in the Tihange 2 mode (with the corresponding second level protection systems), as in the Tihange 3 mode, with the associated second level protection systems. Training and re-training of Tihange 3 plant operators will occur in the Tihange 3 mode. In the same manner as for the Doel 4(3) simulator, only the second level systems are simulated, the remaining part of the power plant being the Tihange 2 power plant with its corresponding parameters, instrumentation and control. Again, for the Tihange 3 operators, special courses will be provided to examine the remaining differences between the Tihange 2 simulator working in the Tihange 3 mode, and the real power plant.

Doel 1/2 simulator. As already mentioned, the Doel 1/2 units are rather different from the other operating units in Belgium. In particular, their "twin" characteristics, sharing several auxiliary systems between both units (such as part of the component cooling system, some safety systems such as safety injection, spray and so on) is making the use of a non-specific simulator very difficult. Furthermore, other basic characteristics such as the number of loops, the number of safety trains, increases the inadequacy. That is the reason that construction of a separate simulator was decided upon.

This simulator is intended to provide training for the Doel 1/2 operators in matters where a non-specific simulator, such as the Doel 4(3), would be ineffective. The simulation areas were, for this reason, limited to faulted and accident operation modes. Of course, even in those conditions, quite a lot of systems have to be simulated. nevertheless, systems such as the secondary systems can be simplified and are little or not simulated.

As far as the "twin" character of the plant is concerned, only one unit will be simulated, while the other will remain in a steady state operating condition, non-accidental.

The training of the Doel 1/2 plant operators will thus be provided by training courses on the Doel 4(3) simulator for the normal operating conditions (full power, hot shutdown, cold shutdown, etc.) including the corresponding transient situations. Some faulted operating conditions will also be provided on the same equipment (loss of CVCS, opening of PRZ relief valve, loss of off-site electrical power, etc.). This non-specific simulator training will be completed by training on the Doel 1/2 simulator. Special courses will be provided to examine the difference between the Doel 1/2 plant and the Doel 4 simulator.

Simulator training for Tihange 1 operators. The problem of training plant operators of the Tihange 1 plant is slightly different from the Doel 1/2 plant. Indeed, the difference between

the Tihange 1 plant and the Tihange 2 simulator are of lesser importance, since they are both three loop 900 MW PWR plants. They remain, however, too numerous to be acceptable for efficient training.

Similarly, as for the Doel 1/2 operators, the training of Tihange 1 operators will occur partly on the non-specific Tihange 2 simulator and partly on the already available compact simulator. The latter will be improved in matter of simulation models as well as in matter of simulation areas.

Special Courses will be provided to be able to train Tihange 1 operators on the non-specific simulator. This training will be completed by training sessions organized on the improved compact simulator.

Conclusion

Since the start-up of the first Belgian nuclear power plant, the situation in matter of training and re-training programs have been greatly improved. This is particularly the case for simulator training, where practically three full-scope simulators are being built. They will be fully operational by the end of 1988 for the Doel 4 and Tihange 2 simulators, and in 1989 for the Doel 1/2 simulator. This very important effort afforded by the utilities, encouraged (and sometimes imposed) by the authorities and its regulatory body will undoubtedly improve the Belgian plant operators training. This improvement will certainly improve not only plant safety, but also plant availability, which is already high in our country, reaching more than 75% capacity factor over the last two years. Both are of public interest and can be considered as a major aim for nuclear industry.

TRAINING OF NUCLEAR POWER PLANT PERSONNEL
PRACTICES IN FINLAND

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Abstract

Four nuclear power units are in commercial operation in Finland. TVO operates two 735 MW BWR units of Swedish design and IVO two 465 PWR units of Soviet design. Good availability figures have been reached during the last five years for all plants. Many different factors have been contributing to the success of nuclear power in Finland. The advanced training of the plant personnel combined with a high educational level of plant personnel is undoubtedly one of the most important factors. Another important factor has been the low turnover rate of the staff at the plant and in the nuclear industry in general. The favorable regulatory climate in Finland with open and trustworthy relations between the power companies and the authorities has also been an important contribution to the success. The paper gives an overview of the training of nuclear power plant personnel as seen from authorities', the power companies' and the research institutions' points of view.

Introduction

Four nuclear power units are in commercial operation in Finland. TVO operates two 735 (net 710) MW BWR-units of Swedish design and IVO two 365 (net 445) MW PWR-units of Soviet design. The two BWR plants are located at the Olkiluoto site on the Finnish west coast and the two PWR plants 100 km east of Helsinki. The main commissioning dates for the four plants are given in Table 1 and the capacity factors in Table 2. The plants have been described in more detail in Reference (1).

Table 1. Main Commissioning Dates of the Finnish Nuclear Power Plant Units.

	Loviisa 1		Loviisa 2		TVO I		TVO II	
Start of construction	May	1971	Aug	1972	Jan	1974	Aug	1975
Criticality	Jan 21	1977	Oct 17	1980	Jul 28	1978	Oct 13	1979
Synchronization	Feb 8	1977	Nov 4	1980	Sep 2	1978	Feb 18	1980
Full power	Apr 14	1977	Dec 12	1980	Jan 1	1979	Nov 11	1980

Table 2. Capacity Factors

Year	Loviisa 1	Loviisa 2	TVI I	TVO II
1982	87.3	77.7	79.9	84.2
1983	83.8	90.0	88.7	86.4
1984	90.7	92.9	87.2	86.2
1985	87.4	91.7	87.4	93.0
1986	88.1	81.9	94.2	91.0

The nuclear power plants were delivering 34% of the electric energy used in Finland in 1986. The demand for electricity has been growing for a couple of years (cf. Table 3) and plans to build a fifth unit in Finland had proceeded quite far in April 1986. In the present situation it is not politically possible to start the building of a new nuclear unit. Nuclear power has however not been abandoned and the discussion may be taken up again in the nineties. The increasing demand for electricity will, in the meantime, be met with coal- and peat-fired power plants.

Table 3. Electricity consumption in Finland

	1976	1978	1980	1982	1984	1986
hydro(%)	29.4	27.5	25.3	31.1	27.0	23.3
back pressure(%)	24.3	27.3	26.7	21.4	21.5	23.6
condensation power(%)	32.6	32.2	27.8	3.9	3.9	7.7
nuclear(%)	--	8.7	16.6	38.0	36.7	34.2
net imports(%)	12.8	3.6	3.0	5.5	10.5	11.0
other(%)	0.9	0.7	0.6	0.1	0.4	0.2

Finland has during the last fifty years gone through a drastic development from an agricultural to a highly industrialized country entailed by a rapid advance in the level of technical education and, as a consequence, technological knowhow in various industries. In Finland the pulp and paper together with the metal industry represents more than 70% of the total industrial volume. Presently the electronics and computer industry is the most rapidly growing field. The pulp and paper industry was built before the Second World War, the metals industry mainly after the war and the electronics and computer industry was started in the mid-sixties. Although the nuclear power plants, themselves, are based on foreign technology, the Finnish subcontractors have played an important part in building up the plants. The development of the educational level together with the industry has in Finland provided a very fruitful infrastructure for the development of nuclear power. It has

been easy to get able people to the field and they have been willing to spend a lifetime of work in their fields of expertise.

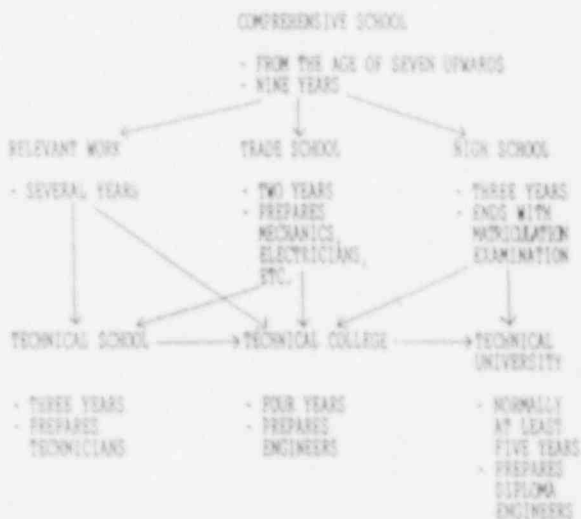
Licensing Considerations

The operational organizations of the Loviisa and Olkiluoto power plants resemble each other and they are more or less similar to the operational organizations of nuclear power plants in many other countries. Before elaborating the regulatory requirements concerning the training of the nuclear power plant personnel, it may be useful to give a brief description of the Finnish educational system, especially in regard to technical studies.

In the Finnish educational system, one can study technology at three levels and graduate as Technician, as Engineer or as Diploma Engineer. The educational system of the technical studies is presented in Figure 4. The education in a technical school is for the most part practical and it consists mainly of classroom lectures

and exercises. The education at a technical college is comparable to education at a university, even though it is more practically oriented. It is not far from the truth to say that the degree of an Engineer is on a level with a B.Sc. in the U.S.A. A Diploma Engineer's degree corresponds to an M.Sc. in the U.S.A. (Reference 2.)

THE EDUCATIONAL SYSTEM OF THE TECHNICAL STUDIES IN FINLAND



The requirements issued by the regulatory body STUK concerning the education, experience and training of the nuclear power plant personnel are presented in Reference 3. A summary of the requirements is given in Figures 5 and 6. As we can see from the requirements, a shift supervisor is required to have an Engineer's Degree in Finland, and an operator must at least be a technician.

Figure 4. The Finish Educational System of Technical Studies

The regulatory requirements concerning the retraining are also presented in the before-mentioned guide. The retraining program of the nuclear power plant personnel shall be submitted to the regulatory body annually. The implementation of the program is followed by the regulatory body by means of regular inspections made in accordance with a special program. The program and its use in the surveillance of the activities and competence of the nuclear power plant personnel is described in Reference 4. This particular inspection is performed twice a year. In these inspections the accomplished training is compared with the plans. In addition to this, the inspectors of the regulatory body perform audits of some training sessions in person.

The licensing procedure for nuclear power plant operators in Finland is presented in Reference 5. The licensing procedure includes medical examination, written examination, oral examination and the so-called verification of skill in work. The license of an operator granted by the regulatory body is valid for two years. Qualifications for a renewed license are medical examination, regular work in control room, participation in retraining and passing of an oral examination.

As a summary, one can say that the regulatory supervision of the training of the nuclear power plant personnel is based on the retraining programs and regular inspections mentioned before. The qualification of the most important personnel of the plant, that is, the control room operators, is additionally verified by the oral examinations in two year intervals. By these means the regulatory body makes sure of the high level of training practices in Finnish nuclear power plants and especially the high level of knowledge and skill of the operators of the plants.

General Principles of Training in TVO

Training is a part of the development of the company's personnel. It aims at creating, maintaining and increasing the capacity and activity of the personnel. The other parts of the training comprise making personnel proficient at their work and the company, job rotation, private studies and learning by the actual work.

The personnel should have the following basic abilities to a necessary extent:

- o adequate knowledge of the profession, i.e., own special expertise, company policy, construction and function of the nuclear power plant, commercial and industrial environment, society and nature.

Figure 5. Introductory Training Requirements for Personnel

position	Fundamentals of Nuclear Technology	Features of Facility Design	Special Courses on Facility Components	Radiation Protection	Fire Protection	Abnormal Incidents and Emergencies	Administrative Training	Course-type Practical Training	On-the-job Training
Responsible Plant Manager	F	E		E	M	X	E		
Operations Manager	X	E		X	M	X	E		
Maintenance Manager	X	E		X	X	X	E		
Technical Manager	X	E		X	M	X	E		
Operations Engineer	F	F		F	F	F	F		
Operations Co-ordinator	E	E		E	C	M	F		
Shift Leader	F	F		F	F	F	F		4 mo
Operator	F	F		F	F	F	F		1 mo
Assistant Operator	C	C	C	F	F	C	C		2 mo
Chief Work Co-ordinator	C	C		C	C	C	F		
Work Co-ordinator	C	C		C	C	C	F		
Mechanical Maintenance Foreman	C	C	F	C	C	C	F		
Electrical Maintenance Foreman	C	C	F	C	C	C	F		
Instrumentation and Controls Maintenance Foreman	C	C	F	C	C	C	F		
Building Maintenance Foreman	C	C	F	C	X	C	F		
Foreman	C	C	F	F	F	C	C		2 mo
Mechanic	C	C	F	C	F	C	C		2 mo
Safety Engineer	X	E		E	F	X	E		
Reactor Engineer	X	M		E	M	M	E		
Radiation Protection Engineer	X	M		E	M	M	E		
- " - - " - Technician	C	C	C	F	F	F	C		1 mo
- " - - " - Assistant	C	C	C	F	F	C	C		2 mo
Chemist	X	X		X	M	M	X		1 mo
Laboratory Assistant			C	C	C		C		2 mo
Training Co-ordinator	X	X		E	F	X	E		

F = a full-length course required
 C = a concise course required
 E = required to possess the knowledge contained in a full-length course or to acquire it through course attendance or some other way
 X = familiarity with the main points of subject dealt with on a full-length course required

- o adequate skills and preparedness, i.e., professional skills, civic education, mastering of data processing, creativity, leadership, ability to cooperate, knowledge of languages.
- o proper attitudes towards work, i.e., valuation of work, responsibility, willingness to cooperate, self-development and development of the environment.

In TVO, the following principles are adhered to the personnel responsibility for training. The responsibility for the adequacy of training belongs to the superior. Each person is

Figure 6. Education and Experience Requirements for Personnel

position	Basic Training	Total Working Experience (years)	Nuclear Power Plant Experience (years)
Responsible Plant Manager	MSc	10	2
Operations Manager	MSc, E	5, 10	2, 5
Maintenance Manager	MSc, E	5, 10	2, 5
Technical Manager	MSc	7	3
Operations Engineer	E	7	2
Operations Co-ordinator	-(*)	-(*)	-(*)
Shift Leader	E, T	3, 7	3, 3
Operator	T	2	1
Assistant Operator	-(*)	-(*)	-(*)
Chief Work Co-ordinator	E	5	1
Work Co-ordinator	-(*)	-(*)	-(*)
Mechanical Maintenance Foreman	E, T	5, 7	1, 3
Electrical Maintenance Foreman	E, T	5, 7	1, 3
Instrumentation and Controls Maintenance Foreman	E	5	1
Buildings Maintenance Foreman	T	5	-
Foreman	T, -	-, 10	-, 3
Mechanic	VT, -	- 2	-, -
Safety Engineer	MSc, E	3, 7	3
Reactor Engineer	MSc	3	3
Radiation Protection Engineer	MSc, E	3, 7	3
Radiation Protection Technician	T, -	-, 2	-, 2
- " - " - Assistant	-	-	-
Chemist	MSc, E	3, 5	1, 3
Laboratory Assistant	VT, -	-, 2	-, -
Training Co-ordinator	MSc, E	2, 5	1

(*) Requirements depend on responsibilities and will be specified on a plant-by-plant basis.

obliged to develop himself according to the possibilities available. Aims, contents and realization of the training have to be in close contact with the actual work. Training has to be given in order to gain deep knowledge, specialized skills and abilities, according to the demands of work and the personality of the trainees. The actual application of expert knowledge and skills involves adequate general knowledge of the duties of other personnel within the company's field of operation. The differences between individuals should properly be taken into account in training. Training should be given according to real necessities.

The duties associated with TVO's personnel training are the following: The company manager states principles and aims of the personnel training, he creates the prerequisites to the aims stated

and he supervises the activities. The training group defines the needs for the training and outlines the training programs. It also discusses the annual training program and follows the training in practice and the training results.

The training coordinator is responsible for the training programs and develops the internal training. He also supervises courses, prepares and improves the training material and takes part in the evaluation and assessment of the external courses. The superior of each line organization defines the training needs of the subordinates, plans the training and adjusts it with other activities. He also sees that each person's individual training needs are taken care of in his unit and follows the practical aspects of the training. Each person is supposed to put forward his/her own needs for training. Everyone is also responsible for actively and effectively taking part in the courses arranged, for adapting the knowledge and skills gained into practice and also for distributing the knowledge within his/her organization.

The planning of training at TVO is done by making and maintaining position-specific demand lists, individual plans, annual programs and budgets. The necessary training demands define the needs to be taken into account in the training, e.g., mastering of tasks and responsibility, authority definition, rules, securing, etc. In the individual training plans, the demands of a particular job, the former schooling and experience, the general principles and the training events arranged by TVO are taken into account. The training programs are updated annually. Changes in the personnel, need for repeated training, personnel development and changes in the company's activities are taken into account in the training plans. The training budget is made annually and is accepted together with the budget of the company. Each organizational unit, including the personnel training, prepares its own budget according to the issued instructions.

The personnel training is carried out by arranging training sessions whose instructors are either TVO's own or other (internal schooling) or by sending personnel to external courses (external schooling). Every superior takes responsibility for the training by sending subordinates to external courses. Everybody can come forward with a proposal of taking part in optional training sessions. Everyone is obliged to take care of the training of his own subordinates. The training coordinator follows systematically quality and suitability of external courses. The training group follows the training in practice and its results. The training coordinator keeps a training file and makes yearly a report of the accomplished training activities.

The licensed operators are given simulator training at the full scope training simulator in Sweden. The initial courses given

amount to six weeks and retraining is given for one week's time annually. The content of the annual retraining courses are specified jointly by the training center and plant staff taking into account operating experience from their own plant and others of the same type. The simulator used is not plant-specific as it represents the Barseback plant of earlier design as compared with the TVO plant. A description of the features of the control room of the TVO plant is given in Reference 6.

General Principles of Training in IVO

The personnel of Loviisa Nuclear Power Station consists of about 420 persons divided in the operation group (114), the maintenance group (206), the technical group (45) and the office group (45). The power plant is responsible for planning and realizing the initial and the retraining of the personnel.

The training supervisor is responsible for the training of his own organizational group and the training engineer acts as a coordinator in practice. The training is led by his own experts of which three are simulator instructors. The main part of the operation personnel's training is carried out in the on site, plant-specific full-scale training simulator.

The initial training of shift supervisors is carried out in a group of three to four engineers (process/machine) with two to three years working experience, who are hired to form a training group. The total training will take about two to two-and-a half years.

The following main points are included:

- o basic acquainting 1 week
- o lectures 8 weeks
- o supervised self study 24 weeks
- o participating in annual maintenance 8 weeks
- o shift working in different vacancies 8 weeks
- o system study 12 weeks
- o simulator training 10 weeks
- o written license examination 1 day
- o operator trainee in main control room -- more than additional training 6 months 1 week
- o oral license examination .5 day

The training of licensed operators is carried out in a group consisting of three to four of the plant's experienced (region) technicians, who already are well acquainted with the plant

layout and the auxiliary systems. The trainees will be either primary or secondary circuit operators. The training period is about a year-and-a-half to two years and the main contents are the same as for the shift supervisors. Other shift personnel are trained in groups of three to four persons employed from the outside and having a professional training and one to two years of working experience. The training is performed according to a separate program (of about six months) along with the work, under guidance of the primary/secondary circuit work instructors.

Training of other personnel is given according to individual training programs under the guidance of an experienced worker or supervisor. Additional training is given by means of external courses.

Retraining of shift supervisors and control room operators is realized in terms during spring and fall. Each term consists of five days of simulator training and two to three days of lectures (annual basis ten days simulator training and five days of lectures). The training is carried out within the day shift system. In addition they are given information about process changes, possibilities to self study and outside training, etc.

The other shift personnel are given training in the form of lectures five days per year, in addition to simulator demonstration, fire protection training, external courses and training information. The retraining of other personnel is mainly external training, but the maintenance group also gives its own internal annual training. In addition, they can also participate in the lectures given for the operation personnel.

The special features of the training at the Loviisa plant can be summarized:

- o high class initial training forms a good starting point for the plant training.
- o practice related training is given in a plant specific simulator and trainers being experts of Loviisa
- o high study motivation of the personnel
- o utilizing of events abroad for the simulator training
- o annual training for emergency situations in cooperation with the authorities
- o cooperation with other VVER-plants

Research Issues

Research and development is a precondition for developing and maintaining any high tech application. The decision to start a nuclear power program in Finland in the late sixties implied thus a considerable investment in research in the nuclear power field. In

the beginning, several groups were established directly under the Finnish Energy Commission. The groups got their funding directly from the Ministry of Commerce and Industry. In the beginning of the seventies, the groups were integrated into the Technical Research Centre of Finland. A direct governmental funding for research in the field of nuclear energy has been maintained through the years. In 1986 the governmental R&D budget for nuclear safety research was nearly \$3,000,000 in U. S. dollars.

During the years, a great variety of issues have been taken up in the field context and we discuss only those that have a specific interest from the viewpoint of training. In the early seventies principal simulators were built both for the PWR and the BWR units. The main goal for the simulation was to verify the design of the main control systems for the plants, but the simulators were also used for the initial training of operators.

Considering the training of control room operators it was clear that only a full scope simulator could provide the flexibility and efficiency needed. TVO could train their operators in Sweden but IVO had to consider their own simulator. The construction of the Loviisa training simulator was started in 1977 when IVO awarded the contract to Nokia, a Finnish computer company. VTT was involved in the project with a total effort of 15 person-years concentrating on the simulation models, the training program and the acceptance testing of the simulators. The simulator has been described in Reference 7.

By an agreement between IVO and VTT, the simulator has not only been for operator training but also for research. The research issues have been the simulation models and control room design (Reference 8). A two-phase flow model was integrated into the simulator in the early eighties and has been used in the operator training since then (Reference 9). A critical function monitoring system was tested out at the simulator as a joint project between IVO, VTT, OECD Halden Reactor Project and Combustion Engineering Inc. (Reference 10). The alarm system of the Loviisa plant has been investigated and improved on the basis of studies carried out at the simulator (Reference 11).

VTT has, since 1977, been participating in the Nordic research programs on nuclear safety sponsored by the Nordic Liaison Committee on Atomic Energy (NKA). The first phase of the program was addressing control room design, human reliability and operator training (Reference 12). The second so-called "LIT-program" considers maintenance activities, organizational issues, computer aided design, computer aided operation, experimental validation and operator training (Reference 13). A third phase of the cooperation was started in 1985 aiming at surveying artificial intelligence methods and expert systems in the support of nuclear power plant operators.

International cooperation is an important part of research. VTT has been actively engaged in the work of IAEA and OECD/NEA. In that work VTT has participated in working groups and has been arranging international meetings (Reference 14). VTT has also actively participated in the work of the OECD Halden Reactor Project and was working as a subcontractor to Nokia in the delivery of the NORS simulator (Reference 15). VTT has also been cooperating with research institutions abroad on a bilateral basis of which EPRI is one example. The Nordic cooperation funded by NKA has already been well established and has led to different spin-off projects. A bilateral cooperation with Studsvik Energy Technology has been initiated concerning the delivery of a training simulator to South Korea from Sweden.

The technical universities in Helsinki and Lappeenranta have had important roles, the education of engineers and researchers for the nuclear industry in Finland. Although there always is a problem of attracting enough young and bright students to a developing field there have been less problems in Finland than in comparison to Sweden. VTT has also had an important educational role in the respect that many of the senior engineers at the authorities and the power companies have been employed by VTT in an earlier phase of their professional careers.

Conclusions

Manpower is the most important asset of the nuclear power plants. A basic education combined with intensive training will provide a good starting point. Maintaining high motivation for additional training together with regular retraining courses will make it possible to ensure high performance of the plants. The small turnover of the staff makes it possible to concentrate on the small things in increasing the performance.

Intimate and open relations between the power companies, the authorities and the research organizations makes it possible for everyone to concentrate on the basic issues. A reliable infrastructure provided by a good educational system and well established industrial traditions make it possible to get the support needed in all situations. International cooperation and exchange of experience provide the final components for an outstanding performance.

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NUCLEAR TRAINING AND EXPERIENCE FEEDBACK IN SWEDEN

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Abstract

There are several different ways of educating and training the personnel at the Swedish nuclear power plants:

- o Centralized training in full-scale and part-task simulators.
- o Centralized education in the form of technical academic courses where computerized teaching is also used.
- o Extensive decentralized training out at the nuclear power plants, where compact simulators are also used.
- o Experience feedback forms an important part of the training.

Five performance indicators will be identified and the results will be presented. The excellent results are a good indication of the fact that well-executed education and training and smoothly functioning experience feedback give results.

Background

The Swedish nuclear power utilities realized at a very early stage that education and training of personnel at the nuclear power plants is extremely important for maintaining and improving safety. Thanks to a policy of recruiting personnel with a broad technical background and then giving them specific nuclear training and practical experience in operating a nuclear power plant, the Swedish nuclear power industry has highly competent and well-motivated personnel today. This has also resulted in a very low turnover rate, so that most of the personnel who participated in the commissioning of the nuclear power plant remain in the operating organization today.

Another important factor worth mentioning here is the close cooperation and continuing dialogue that has always existed between the nuclear utilities in Sweden, between the utilities and the suppliers and between the utilities and the regulatory authority. This has resulted in solutions that have promoted both safety and progress.

In the long run, this has also led to an excellent operating record for the nuclear power plants, as evidenced in high plant

availability and low radiation doses to personnel. Towards the end of my presentation, I will show you these results and argue that two reasons for them are well-executed education and training and smoothly functioning experience feedback.

Nuclear Sweden

The Swedish nuclear power program that was established in the national referendum in 1980 is now fully implemented. The 12 nuclear power plants have been built and commissioned and the power utilities are resolved to operate them so safely and efficiently that they will be able to persuade the politicians and the public that we should continue to make use of nuclear power. During 1986, these 12 nuclear power plants produced 50% of all electric power in the Swedish electric power network; 45% came from hydropower and the remaining 5% from coal and oil-fired power plants.

The first light-water reactor in the 12-reactor program, Oskarshamn Unit 1, was put in to commercial operation in 1972. Numbers 11 and 12, Forsmark 3 and Oskarshamn 3, went on stream in 1985. Of these 12 reactors, nine are Asea-Atom BWRs and the remaining three are Westinghouse PWRs.

The nuclear power plants are owned and operated by four utilities with a mixed ownership structure consisting of state, municipal and private stakes. Swedish State Power Board, SSPB, which accounts for 50% of all electric power production in Sweden, operates the four plants at Ringhals. The Forsmark Power Group of which the Swedish State Power Board owns 75% operates three boiling water reactors at Forsmark. Sydkraft owns and operates the two units at Barseback and OKG, in which Sydkraft owns the largest stake, operates three boiling water reactors at Oskarshamn.

The four power utilities have formed three different organizations for cooperation within different fields: SKB, RKS and AKU.

SKB stands for Svensk Karnbranslehantering AB, known in English as the Swedish Nuclear Fuel and Waste Management Company. SKB is responsible for what is known as the back end of nuclear fuel management, in other words, for management of the spent fuel and the waste that is formed.

SKB has developed a complete system consisting of a transportation system in the form of a specially designed ship, SIGYN, that transports the spent fuel to a central interim storage facility for spent fuel, CLAB, at Oskarshamn. Here the spent fuel assemblies will be stored for about 40 years, after which they will

be disposed of in copper canisters deposited about 500 meters down in the Swedish bedrock. A central repository for low- and intermediate-level waste from the operation of the twelve reactors as well as decommissioning waste is under construction at Forsmark and is scheduled to be commissioned next year, 1988.

RKS, which stands for Radet for karnkraftsakerhet, in English, the Nuclear Safety Board of the Swedish Utilities, was formed in 1980 as a consequence of the Three Mile Island incident and the subsequent Reactor Safety Study in Sweden. RKS has worked as a joint body for collaboration in safety matters. The most important areas have been experience feedback and safety analysis, emergency preparedness and quality assurance, and education and training.

AKU, AB Karnkraftutbildning, in English the Nuclear Power Training Center, was formed in 1972 to build and operate full-scale simulators. The first full-scale simulator was put into use in the mid-1970's and was a copy of Barseback Unit 1, i.e., a BWR simulator. The second full-scale simulator was a copy of Ringhals 3, i.e., a PWR simulator, and went into operation in 1977. The third full-scale simulator was taken into service in 1985 and is a copy of the two BWR reactors at Oskarshamn unit 3 and Forsmark unit 3. AKU is also responsible for some production of teaching materials.

On the 1st of January, 1987, RKS and AKU joined to form a new organization, KSU - Karnkraftsakerhet och Utbildning AB, the Swedish Nuclear Power Safety and Training Center. The principal concerns of this new organization are Training and Experience Feedback. Since both AKU and RKS have previously worked with education and training, one of the main reasons for the merger was to coordinate these resources within the same company. Another reason was to make use of the system and the know-how built up by RKS within the field of experience feedback in the training program, in other words to achieve a greater coordination of training and experience feedback.

Simulator Training

There are thus three full-scale simulators in operation at KSU today, as well as part-task simulators. KSU offers training for operators from the 12 Swedish reactors as well as two Asea-Atom BWRs in Finland.

Several types of courses are given at the full-scale simulators:

- o Basic course for student operators (6-9 weeks)
- o Retraining course for operators (1-1.5 weeks)

- o Courses for coordinating the actions of operators and duty engineers in emergency situations. (The regulatory authorities also sometimes participate.) (1 day)
- o Courses for plant management/duty engineer (0.5-1 week)
- o Introductory courses (0.5-1 week)

Special courses are also arranged in the part-task simulators.

The training consists both of simulator practice and theoretical follow-up in the classroom. KSU itself designs the courses and produces the course literature, instruction aids and any tests given in connection with the course. The retraining courses are revised each year. At least two instructors are involved in each course. Approximately half of the instructor's time is devoted to simulator work, while the rest is divided between course productions and practical study training out at the nuclear power plants.

Instructor Qualifications

Today KSU also takes care of instructor training. They recruit only personnel with a technical education and operational experience, preferably operators from the nuclear power plants. However, the role of the instructor differs from that of the operator. Besides being a good operator, the instructor must also be familiar with the possibilities of the simulator and must possess pedagogical skills.

KSU has developed a training program for instructors that includes both technical training similar to that provided at the nuclear power plants and a seven-week pedagogical training program.

Central Academic Courses

Since the nuclear power companies frequently recruited people with a broad technical background, a need arose to give them a specifically nuclear academic education. This education was at first provided internally by the nuclear power utilities and was then further developed by RKS. The following courses are given today by KSU:

- o Nuclear Engineering Grad. Course (5 weeks)
- o Advanced Nuclear Engineering for Shift Supervisors (3 weeks)
- o Advanced Radiation Protection (2 weeks)

- o Management of Radioactive Waste (1 week)
- o Reactor Core Calculations (3 weeks)
- o PRA, Probabilistic Risk Assessment (1 week)
- o Special courses, for example:
 - Earthquake course
 - PWR course

Naturally, many employees within the nuclear utilities have travelled the usual educational path via the various departments of reactor physics, reactor technology, reactor materials or nuclear chemistry at the universities and technical institutes. For them, the courses provided by the utilities have provided an updating of knowledge and, in many cases, an anchoring in reality, since these courses place more of an emphasis on practical operation and safety matters. The courses have also gradually been revised in the light of new findings from safety studies and from the work of experience feedback. In recent years, the courses have also adopted more modern pedagogical aids, such as the use of computers. This computerized training has come farthest in the advanced nuclear engineering course that is given to shift supervisors. Personal computers have been bought by the power utilities and computer programs have been developed to which the pupils are given access prior to the course and which they may take with them to the nuclear power plant after the course of their own refresher training.

Training at the Nuclear Power Plants

Besides simulator training and the central courses at KSU, extensive training is carried out at the nuclear power plants themselves.

The Swedish nuclear power utilities bear full responsibility for the competence of their personnel and design all their own training courses and tests. The authorities are given full insight into this work and the utilities must fulfill certain reporting requirements. A special Regulation on Competence system has also been developed for the three control room positions, where each individual is judged and approved. Discussions are now being held between the regulatory authority and the nuclear power utilities to expand the system to include other personnel categories as well, such as plant technicians and certain maintenance personnel. Historically, the greatest training efforts have been made in relation to operating personnel, and primarily control room operators. In recent years, however, a great deal of work has been done on developing adequate training programs for other personnel categories as well, such as maintenance personnel.

Compact simulators have been developed and marketed in Sweden. Today, all Swedish nuclear power plants have installed such simulators and they are used in the plant's internal training. They are mainly used for operator training, but have also proved useful for giving training and information on the process to other personnel categories at the nuclear power plant.

Experience Feedback

One of RKS's most important functions was to build up and operate a functioning experience feedback system. This is a system that collects, processes and evaluates information on operational disturbances and incidents in Swedish and foreign nuclear power plants and then feeds back this experience to plant operation. A computerized system has been in operation in Sweden since 1981. This system, known as the ERF system, is both a database and an information and communication system.

The Swedish nuclear power utilities were members via RKS of INPO and UNIPEDE. Today, KSU is in charge of the national system, ERF, as well as the associated international links. As a result, we are able to make more use of experience feedback in the training of operating personnel.

All daily plant status reports, reportable occurrences (LER's), reactor trip reports, Swedish and foreign incident reports are stored in the database part of the system. All reports are tagged with key words, permitting trend analysis. The information and communication part of the system enables participants to communicate and exchange information with each other. This is also the link to other international systems via which Swedish utilities can communicate with foreign utilities, such as INPO's NUCLEAR NETWORK.

Man/Machine and Human Error

With the aid of the database in the ERF system, RKS has also created a tool for early detection of negative trends in human error at the nuclear power plants. Since 1982, RKS has made an annual study of all Reportable Occurrences, Reactor Trip Reports and Incident Reports. These figures have been low by international standards, but here I would like to point out the difficulty of comparing different international studies, which can vary a great deal depending on methods and what report material is being investigated.

Performance Indicators

It is always difficult to verify tangible results of experience feedback and training. The nuclear power industry is no

exception to this rule. RKS has therefore developed a program where five different parameters were identified:

- o Energy availability
- o Reactor trip statistics
- o Radiation doses
- o Forced outages
- o Planned outages.

In addition, we have divided the 12 nuclear power plants in operation in Sweden today into different generations. The results show that we have made improvements for each generation we have put on line. A positive trend can also be discerned within each generation. I think that these results are a good indication of the fact that good education and training and smoothly functioning experience feedback give results.

Conclusions

To sum up what I have said here, we have several different ways of educating and training the personnel at the Swedish nuclear power plants:

- o Centralized training in full-scale and part-task simulators.
- o Centralized education in the form of technical academic courses where computerized teaching is also used.
- o Extensive decentralized training out at the nuclear power plants, where compact simulators are also used.
- o Experience feedback forms an important part of the training.
- o The utilities bear full responsibility for the competence of their personnel.
- o A close cooperation and continuing dialogue between the utilities and the regulatory authority.

Discussion

MR. TANGY: I have two questions about the instructor's job. In the new KSU organization, does the instructor-engineer achieve parallax in the two activities of training the staff and analyzing the operating experience feedback to training?

Secondly, among the various indicators of NPP performance, do you identify for and with the instructor those which can be directly related to the training's efficiency? This is an important aspect of instructor motivation.

MR. OLOFSSON: We hope the instructors will be more involved in experience feedback now that we have made the merger of the two organizations, RKS and AKU. Before, RKS was involved in this, but they were also giving information from this work to the instructors, and the instructors did have access to the ERF system. But now, after the reorganization, I hope the instructors will be one part of the experience feedback, also.

The other question, if instructors feel they are part of the improvements in the NPP's performance indicators -- I think they are. I always try to discuss these with them, and I think that they feel that they are really a part of the results. I think the operators out at the plants, too, think they are a very important part of these results. I can mention here that there is going on out at the power plants an effort to improve the operator's competence. During normal and calm operation, we try to stimulate the operators and give them possibilities to improve their competence. Sometimes we let them go in the daytime for some weeks to participate in some project, and then come back to the shift organization again. As I mentioned during my presentation, we have a course that is called "Advanced Nuclear Engineering for Shift Supervisors." That was the result of the discussions that were going on after TMI, whether we should include a shift technical advisor in the control room. In Sweden, we decided not to do that, but instead to give more education and training to the shift supervisor.

MR. BALDASSARI: What is the length of time for training instructors and what is the end point requirement?

MR. OLOFSSON: It was divided between that kind of course given at the power plant site and training programs given at the simulator center. It depends on where in these programs you recruit the personnel. If you recruit them from scratch, then they have to go through the training on a path from plant technician to turbine operator to reactor operator and then to shift supervisor. The four instructor courses are about seven weeks, but the entire program is several years, depending on when you come into it.

MR. LIANG: Can you describe the major factors behind the low man-rem exposures in the BWR and PWR? How much can you attribute to training and how much to regulatory requirements?

MR. OLOFSSON: It is always hard to do that. I think one point is that we have stressed, in Sweden, from the highest management level down into the entire organization, that we should keep the plants very clean. Another thing, we have had very few fuel leakages in our plants and we stress water chemistry.

TRAINING ORGANIZATION IN THE NUCLEAR
GENERATION DIVISION OF ELECTRICITÉ DE FRANCE

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Abstract

Presentation of training given to nuclear generation staff of the Nuclear and Fossil Generation Division, covering organization, general principles, instruction methods, resources, an appraisal, and prospects.

Introduction

The mission of the Nuclear and Fossil Generation Division of EDF (Electricité de France) is to manage, operate, and maintain the company nuclear and fossil-fired power plants. The Division is responsible for ensuring that these plants are always capable of meeting the power program established by the EDG Load Dispatching Division.

The Nuclear and Fossil Generation Division collaborates closely with the EDG Plant Design and Construction Group in the engineering and construction of new company plants.

As of January 1, 1987, the Nuclear and Fossil Generation Division operates 118 generating units, fossil and nuclear. It is also responsible for operating 18 gas turbine generating systems. This represents a total of 60,500 MWe of installed capacity, 43,000 MWe of which is of nuclear origin. Total output in 1986 was 255.3 billion KWh, 237.4 KWh of which was furnished by nuclear reactors and 16.9 billion KWh by fossil-fired units. This represents roughly three-quarters of total electricity production in France.

Context of the Staff Training Program

The formal aspect. Activities at our power stations are essentially divided between managing the installations and maintenance, the latter category including several specialties, such as mechanics, electricity, automatic systems, etc.

The duties involved in these activities are performed by an operating, supervision and executive staff. The personnel for these

three levels may be found by outside recruitment or by means of internal promotion. We should add that the staff may come from a thermal power plant operating on oil or coal, and they must then be retrained as a consequence.

The quantitative aspect. In the 1975-1984 period, the SPT hired an average of around 1,700 employees a year, and an average of 2,500 employees changed jobs every year. This staff growth has now come to a halt because of the closings of old production facilities that were oil- or coal-fired, and staff reconversion is becoming of increasing importance.

Organization and quality. Our organization provides a strict selection system for recruiting and job change. The choice in connection with recruiting is made on the basis of criteria relating to knowledge or skill, but also with an eye on ability in understanding or representation of physical phenomena, to get a better indication of the person's adaptability and ability to grow. After this selection process, it is not rare for only 5% to 10% of the applicants to be accepted.

An employee who has been chosen to perform a certain job is considered suitable for the position only after suitable training. A personalized training plan is drawn up by executives for each person. This training plan determines the training activities in which the employee must take part before being authorized to hold the position for which he has been selected.

General Training Principles

The nuclear and fossil generation training activities as a whole constitute its training plan or program. This plan changes constantly, as a function of employee competence, the appearance of new techniques, and the improvements in operating safety that are constantly sought. Still the general principles of the training program remain constant.

Guide plans. This domain includes:

- o Preliminary training for adaptation to the Establishment.
- o Basic technical training for adaptation to the trade.
- o Specific training for the job in question.
- o Activities aimed at maintaining knowledge and acquisition of advanced knowledge (recycling operations).

Whatever the employee's duties and origin may be, we always find these phases, with a content and a duration that vary according to the person's profile and are adapted to it.

The guide plan for training the staff of nuclear plants matches these phases with the origins of the people concerned, namely:

- o Outside recruitment corresponding to a given educational level with respect to the National Education System or the industry.
- o Reconversion, i.e., recruiting staff from other kinds of power stations (traditional thermal units or other nuclear facilities).
- o Internal promotion, i.e., recruitment of a person already at a nuclear PWR unit for a position of equal or higher level.

Preliminary training. The main objective of this phase is to familiarize the staff with their working environment, its constraints, and the company's organization and position in the nation. This preliminary training phase may be said to include essentially informational welcoming activities and some training activities relating to safety, radiation protection, work organization and quality guarantees.

Basic technical training. This essentially theoretical training aims at understanding physical phenomena involved in the industrial process represented by a nuclear power station, as well as learning its constituent elements. Hence, it deals with heat production aspects (reactor), steam production, electricity output, as well as the related physical and chemical notions (nuclear physics, thermodynamics, mechanics, electricity).

Even if the subjects dealt with are the same, whatever the group to be trained, the depth of the approach depends on the educational level and on the duties in question. For example, basic technical training for an automatic systems progression worker lasts for two weeks, while his foreman may take nine weeks.

Specific training. This phase deals with acquisition of professional habits and reactions, the reasons for these, and the consequences within the framework of the duties performed. For operators, this training phase centers on the specific study of the various systems constituting the power plant, and the study and understanding of the procedures. The use of functional simulators and of full-representation simulators is part of the operators' specific training.

Specific training for maintenance department employees is oriented primarily toward technological knowledge of equipment, the study, understanding and performance of their typical maintenance operations sequences, and the methodology and practice of breakdown service. The length of this phase is highly variable, depending on the origin and jobs of the staff concerned. It may be just a few weeks, or several months.

Maintaining knowledge and pursuing advanced training. This phase, in France called "recycling," is aimed at maintaining the staff's knowledge and experience at the highest possible level. The good availability rate in the facilities is leading to a natural decline in staff experience, because fewer special operations are being performed and normal daily tasks become automatic. The recycling activities may deal with theoretical or practical subjects. In particular, significant incidents are studied and commented on by supervisory engineers. The operators are given annual recycling on simulators lasting for two weeks. All of the "recycling" training activities offer a large degree of advanced training because of in-depth treatment of the subjects in question.

The pedagogical method. Each training phase is broken up into sessions and each session has an objective, a content, a duration, accessibility criteria, and recommended teaching method.

The chosen pedagogical method involves participation, which implies constant interchange between the instructor and the trainees, and presupposes that concrete cases or facts are taken as a point of departure to induce reflection. This means the number of trainees must be limited. The majority of our activities are intended for 12 trainees simultaneously, but a few of them, which entail the use of equipment, are confined to only 4 trainees. With such a method, abstract notions are introduced only in so far as dealing with them is justified by the structure of knowledge or by legitimate questions from the trainees.

The teaching approach may also be deductive, ranging from the simple to the complex. Audiovisual products may then be used to insist on the key points and on connections among data. This goal-oriented teaching approach is also a kind of "success pedagogy" for the employees receiving training. The progress they make in operations, the measurement of the extent to which the objectives are reached -- called evaluation -- and the substantial level of pedagogical means lead to a minimum number of failures.

The feedback from this program makes it possible to continuously adjust the content and the methods so as to make our training activities as effective as possible and ensure that they are of the highest possible quality.

Resources and Facilities Used

Training activities relating mainly to knowledge of operating nuclear facilities are carried out at three Training Centers (BUGEY, PALUEL and CAEN) coming under the E.D.F. Personnel and Labor Relations Department, and at five Training Bases of the Nuclear and Fossil Generation Division (located at nuclear site) that are more particularly responsible for initial training programs and for specific training activities.

Simulators.

- o Basic principle simulators. Two PWR simulators used at the outset of study of operation techniques enable the future operators to improve their mental view of the physical phenomena.
- o Function simulators. Twenty-two function simulators are divided into three types:
 - Chemical and volume control of the reactor (8)
 - Turbo-generator unit (7)
 - Reactor control (7)

The objective is upgrading the understanding of the operation of the most important elementary systems.

- o Full scope simulators. These simulators are valid for nuclear units in operation. There are currently seven simulators:
 - 5 for 900 MW PWR
 - 2 for 1300 MW PWR.

These simulators are used in the following ways:

Initial training for all operators -- from the level of assistant block operator to that of safety radioprotection engineers -- in the use and the understanding of the physical phenomena involved in a PWR unit in normal, incidental and accidental operation.

Advanced training for this staff in the field of electrical supply losses.

Annual recycling of this staff.

Training of "crisis teams" in connection with nuclear accidents.

Computer-Aided Training (CAT). The essential objective of computer-aided training (CAT) is to maintain the knowledge of the operation staff (from the auxiliary operator to the safety and radioprotection engineer) with respect to the circuits, their operation and instructions, and of the staff responsible for the maintenance of the control command systems of a PWR unit.

The following major topics are developed:

- o There are about 500 hours of course work on the main circuits of a nuclear facility of the 900 MW or 1300 MW PWR type, particularly dealing with: a description of the circuits, operation maneuvers, operation instructions, common operation incidents, and incidents that have occurred at French and foreign generating stations that have endangered the installations.
- o About 50 hours of course work dealing with basic knowledge of automatic devices and systems and of the control and monitoring equipment used at a nuclear facility.
- o About 15 hours of course work dealing with various subjects, such as radioprotection or fittings.

Audiovisual resources. Some simple teaching equipment (visual documents, audiovisual presentations, instruction kits, mock-ups) is made available to the teaching staff involved in national program teaching activities to offer them tools:

- o That are well-designed from the teaching viewpoint.
- o That are well-designed from the technical viewpoint.
- o That are appropriate for each type of training activity.
- o That facilitate the trainer's task of illustration and explanation.

In particular, the purpose of the instruction kits is to serve as a session guide to the many instructors who may be involved, either at the training centers and bases or at the facilities themselves, in the interest of consistency among the various training actions.

Appraisal and Prospects

The quantitative aspect. All of the training activities put together, whether centralized or local, accounted for a total of

280,000 man-days in 1985, which represents an average of nearly 12 days of training per year per employee. However, it would seem that this level of 5% of the time devoted to formalized training is a ceiling for the people and the organizations of our production facilities.

Such an effort required a substantial increase in training costs, and the weight of these expenditures by comparison with salaries is about 17%. These costs have risen faster than the training volume because of a rise in such heavy investments as the simulators and a bigger pedagogical staff (sometimes one trainer for four trainees). In the coming years, we will have to pay attention to ways of controlling these training costs.

The qualitative aspect. The kind of training that is undergoing some changes. The preliminary and basic training activities are beginning to fall off, while advanced training and recycling activities are growing rapidly. Due to the increase of knowledge, and above all of professional experience, the people who are trained have higher demands. Repetition in courses is most often considered useless, and the training program must be recast regularly in order to meet the real needs and match the employees' motivations.

We must seek training activities ensuring better feedback, and this commits us to promoting close relationships between the trainers and the users, and to seeking instructors with quality professional experience. This feedback leads us to attach even greater importance to the evaluation of the staff who have been trained, and of the training activities themselves. We must measure the extent to which objectives have been attained and verify those objectives by referring to the concrete operating needs.

Development guidelines. The company's purposes entail some priorities in the development of our training activities:

- o Maintaining competence in the operating of the installations. Better knowledge is required of safety and security rules, which must always be respected, and we need to upgrade professional abilities from the viewpoint of dealing with crisis situations. And we also need to raise the level of our staff's expertise and analytical ability.

- o Better preparation of supervisory level personnel for the "management" role. We are moving into a period of stabilization in operation of our nuclear power plants, and the human dynamism linked with start-up periods may fall off. We have to maintain such motivation and

avoid routine by greater involvement of higher-level supervisors and executives in training activities by developing mutual exchange of experience and by means of local training programs. The "spirit of enterprise" will be developed.

- o Improving our control of maintenance and operating costs. Some considerable efforts will be made to upgrade the staff's economic culture and to raise the quality of maintenance activities, which have an obvious relationship to the safety of the installations.
- o Developing the staff's ability to use the data processing tool. Training activities will have to accompany the reorganization of the Establishment's computerization program. Training work begins in the very design of the applications.

Conclusion

The nuclear and fossil generation training system has made its contribution to the successful start-up of the Electricité de France nuclear program. The vast training plan is based on:

- o Structured and monitored training of the staff for the nuclear plants.
- o Handling the bulk of the training by using our own resources and facilities to make sure the training constitutes a good response to our industrial needs, and continuously takes acquired experience into account.
- o Instruction helping the employee to progress in knowledge acquisition, while also attempting to develop an analytical turn of mind in all circumstances.

Training activities are going to change to improve our control and use of our electro-nuclear facilities.

CURRENT TREND IN ITALY FOR
TRAINING OPERATORS AT ENEL NPP'S

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Abstract

Paper describes action taken by ENEL in the field of training personnel of Caorso and Alto Lazio NPP's and anticipated future programs for the new NPP of Piemonte-Trino. Full-scope training simulators along with a fossil simulator and a computer aided training system located in the new facility of Piacenza training center are the tools provided to give excellence in training. A systematic approach is going to be implemented in order to rationalize the overall activity.

Forward

The training process for the ENEL's (Ente Nazionale per l'Energia Elettrica) nuclear power plant personnel has experienced a continuous evolution and modernization over the last 15 years. The systematic training process started in the early seventies with the preparation of the personnel for the Caorso nuclear power plant (860 MW-BWR), was improved during the eighties with the preparation of the personnel for Alto Lazio (2x1000 MW-BWRs) and will have a further evolution with the personnel assigned to the Piemonte-Trino (2x1000 MW PWRs) by the beginning of the nineties.

Training for Caorso Personnel

The Caorso NPP, located in the north of Italy near Piacenza, consists of an 840 MW GE BWR-4 unit and was commissioned in 1981. At the beginning of the 1970's, the training of the Caorso personnel was essentially based on programs and methods provided by General Electric, the supplier of the plant. In this connection GE educational materials and teachers were initially utilized for both basic and specific nuclear courses; as for the simulator, the training center in Morris (Illinois) was utilized for the first training sessions. Afterwards, once the know-how was acquired, the basic training continued independently within ENEL, organization and the training programs have been modified so as to make them more in harmony with the Italian reality.

For the simulator, owing to the various options available throughout the world, ENEL turned to other training centers in

Europe and/or in the U.S. where systems more similar to Caorso plant were available. Very recently the decision to build a plant-specific simulator for Caorso was made.

Training for Alto Lazio Personnel

The nuclear power plant of Alto Lazio, located north of Rome near Montalto di Castro, consists of two 1000-MW units each with a BWR 6, Mark 3. The order for the plant was placed by ENEL in 1974 to a joint venture constituted by GE and Ansaldo Impianti.

The initially scheduled commissioning date was 1986. On the basis of this first schedule, a program was formulated for personnel recruitment and training along with a series of actions in the field of educational aids. As a consequence, since 1979, a new training center located in Piacenza and the procedure for the acquisition of a full-scope simulator were started.

The purchase order for the simulator was assigned to a U.S. firm in 1981. The simulator design and construction had been seriously delayed due to the numerous changes in the referenced plant. These changes were caused by tightening of the governing regulation and safety criteria. The simulator was ready at the end of 1986 and its installation is complete. The simulator is now available for personnel training.

The problems encountered during the simulator manufacturing gave ENEL unique experience which deserves an "ad hoc" description. In fact, two circumstances had an influence on the project: the TMI accident and the delays which occurred in the development of the Alto Lazio design.

Impact of TMI

Soon after the simulator order, the TMI effect began. In the specific case, the critical revision of the design criteria of nuclear plants and training procedures had a strong impact on the simulator design especially as concerns three aspects:

- o The man-machine interface in the control room
- o The identification of malfunctions
- o The introduction of emergency procedures of the symptomatic type.

The control room of the original design, taken as a reference also for the simulator, had been obtained from a series of studies carried out by ENEL during 1977. Said studies had led to a

definition of a general unified architecture, also applicable to all the plants scheduled by ENEL both for BWR and PWR.

After TMI the control room design criteria had a considerable evolution. Particularly, for Alto Lazio, they forced a full re-design of the control room based on NUREG-700. These modifications had to be incorporated in the simulator design for which the definition of the preliminary specifications was in progress. The natural consequence of these actions was a delay on the project and on the procedures for the procurement of panels and instruments. Practically, the project suffered a two-year delay.

In the meanwhile, an evolution was also observed in the criteria of malfunctions identification due to the introduction of transients resulting from a more exhaustive analysis of TMI. These criteria were transferred in the simulator design with important effects in the formulation of the "Preliminary design specifications," and "Acceptance test procedures."

Finally, the adoption of emergency procedures of the symptomatic type for the reference station also affected the simulator design when it was already in an advanced stage of development. Here again, actions were taken on the model in order to allow the introduction of special scenarios during the acceptance tests, for their possible implementation in the framework of a simulated validation of the procedures themselves.

Simulator Design Versus Plant Design

In order to reach the target date of starting up the station with personnel already trained on the simulator, the simulator construction had to be well in advance of the reference plant commissioning. But since the original plant design did not include this requirement, very often the engineering data were defective or nonexistent. As a consequence, in order not to interrupt the simulator design procedure, an extensive use was made of "assumptions," or of data from other plants, or from other simulators. This caused many modifications to the simulator to have the actual station design data incorporated.

In order to follow this process of subsequent revisions and modifications, ENEL had to locate an important staff (up to a maximum of eight experts for a total of 25 man-years) at the supplier workshop in the U.S. Through this kind of direct action, it was possible to join the supplier in the revision activity and obtain a positive fall-out on the final product.

Nevertheless, it is apparent that all these actions, combined with the persisting lack of information relating to a few

systems or their components, resulted in an unavoidable perturbation in the design activities, and generated a number of discrepancies higher than that which can be observed in other similar projects. As a consequence, the test times became longer owing to the requirement to verify that the modifications introduced one after the other were correctly implemented.

In practice, the implementation of the simulator design became an activity of an experimental type, based on the continuous revision and verification of the design data, through the exchange of information between ENEL and the supplier, with an aim of obtaining a final model as close as possible to the real plant.

Furthermore, ENEL is aware that a process of revision will be necessary in the near future for aligning the simulator to the real plant. In order to meet this possibility the panel front is made up of removable plates so that revision work can be restricted only to the section affected by modification. Also, in the case of remote-control systems, any modification may be made without difficulties, since mosaic modular sets are adopted consisting of interchangeable tessera.

Today's Situation

In the course of these past years the problems associated with the development of training programs for the personnel assigned to nuclear power plant operations have increased more and more. The accident of TMI, the position of the public opinion and the general unpreparedness of newly graduated technicians to be employed in short time in industrial processes, required an improvement of the training criteria. Today the regulatory agencies are exercising more stringent controls and the plant managers want to update the training programs. They believe that training is of paramount importance for safety and, at the same time, is an investment through which plant efficiency is improved. In order to properly solve these problems, ENEL decided to concentrate the training activities in one site and to implement a systematic approach to training.

Most of the training activities for personnel assigned to nuclear power plants are performed at the new training center located in Piacenza. The improvement of training has been accomplished through three different ways.

Updating of training programs. In order to establish long term programs and at the same time to cope with the trend expressed by the licensing authority, ENEL has set up internal guidelines for the qualification of the personnel of Caorso. The same guideline criteria are going to be implemented also for Alto Lazio. At the moment the guidelines are limited to working positions with major

responsibility. For each working position the guidelines state the content of the job, the school degree level, the experience necessary to cover that position, the training curricula and the retraining criteria. The training curricula are divided in three parts:

- o basic training courses
- o specific training courses
- o on the job training (OJT)

For each course a specific plan is established which includes the objectives, the technical contents, the time length, the detailed program, the practical exercise criteria, the list of teaching aids, the certification criteria and finally the instructor qualification. The average training time is two years. The training process takes in account "quality assurance" concepts too.

Training Aids. Originally the Alto Lazio BWR training simulator, described before, was expected to fulfill also the operator training of Caorso. Recent trends to use symptomatic approach of emergency operating procedures even for Caorso, has brought ENEL to the decision to purchase for this plant a full-scope replica simulator. The procurement of the new system is now underway and every effort will be made in order to have it in operation by 1990. Furthermore, in order to fill the gap between the school and the industrial reality in which ENEL operates, great emphasis is given to provide practical experience at the first training levels during basic courses. The aim is to give to trainees a direct contact with the equipment and systems, as well as to provide the interpretation of functional logic chains and dynamic phenomena.

This program will be activated through the use of a fossil plant simulator and of plant elementary circuit mock-ups (both process and logic). The fossil plant simulator, fully made in Italy, in which ENEL had a role of architect engineer, will be installed at Piacenza training center by the end of 1987 and will be utilized in the basic training phase for the personnel assigned to nuclear plants.

Finally, in order to strengthen specific engineering aspects with high specialistic content, some educational laboratories are being developed; they will include complete remote-control equipment sets, protection devices, and complete supervision of field actuators. The areas covered by the laboratories are the following:

- o electronic, electrical equipment and associated protections
- o instrumentation and regulation
- o analogical electronic and digital electronic.

Training Organization. Recently ENEL introduced computerized instruction programs (CAI = computer-aided instruction; CMI = computer-managed instruction) in its training system, which permit an orderly formulation of the training planning as well as overall training management and lesson presentation.

The training planning is managed through the following steps:

- o analysis of training needs
- o definition of training criteria and standards
- o development of targets and criteria for the verification of knowledge
- o training development and validation
- o implementation of the courses and evaluation of the results.

Training needs are jointly analyzed by experts coming both from NPP's and from training areas with the purpose of defining criteria and standards.

Once the targets were identified for each training session, the development of knowledge verification criteria is carried out so as to ensure homogeneity of evaluation and reliability of the resulting statistical data.

Training planning and development are made by means of CMI function, which permits the trainees to be grouped by training curricula, and the courses to be structured into elementary blocks (lesson modules). These blocks constitute the elementary "brick" of the training system and they are used both on-line (by computer) and off-line (lessons in the classroom, OJT, etc.); moreover, they are designed so as to meet the homogeneity criteria as far as audio-visual presentation and ergonomic aspects are concerned.

The implementation of training courses through the CAI function is carried out mainly through an extended use of simulation systems with visual presentation on CRT's of the phenomena and through interactive exercises. A common data bank is available for helping instructors in their task during lesson design and presentation. The CAI/CMI functions are also practical tools in the hand of the quality assurance section inside the training structure in order to perform the validation of training activity. In this way, the evaluation of the results is reached with reference to the training demand, the basic requirement, and the reference standard.

As far as the training result analysis, ENEL aims to a system in which available information is structured into homogeneous areas so as to allow data processing at low costs and in short times.

The aforesaid CAI/CMI system is already designed for the purpose of managing, in an integrated way, all the technical support, including simulators and laboratories. Moreover, CAI/CMI permits the connection with the data base already available at ENEL and outside of ENEL. Particularly for the training center, the educational systems will be integrated with an internal video-transmission system, which requires the use of recording and projection means both of the conventional and advanced type. Through a special fully-digital internal circuit it will be possible to achieve on one hand an information capillary diffusion, and on the other hand the connection with a presentation system that may also utilize video-disk.

Training Programs for PUN-PWR Plants

The PUN, "Progetto Unificato Nucleare" (Standard Nuclear Project) is the reference design adopted by the Italian Government for the future nuclear power plants provided by the "National Energy Plan." The PUN nuclear power plants are twin units of 1000 MW each, equipped with a Westinghouse PWR 312, adjusted to the Italian requirements.

For PUN, ENEL decided to adopt an integrated procedure permitting the simultaneous and economic development of the following issues:

- o detailed design of the plant control room
- o design and construction of the training simulator
- o real plant and simulator operating procedures, both normal and emergency

The main stages of said activity are described by the following. The detailed design of the PUN control room will be defined through two major verification steps.

The first step will pass through full scale mock-up of the main control room. The mock-up construction will be carried out at the training center at Piacenza, and will make it possible:

- o To verify, on the basis of the preliminary operating procedures and actual flow diagrams of the plant systems, the adequacy of controls and related displays in the main control room, and/or emergency control room

and locally at the equipment; this defines the man/machine interface.

- o to optimize the synoptic presentation of the various systems in order to assist the operator to formulate the correct decision.
- o To verify the ergonomic aspects at the control panel arrangement as well as the environmental aspects of the working station.
- o to develop in the final version the significant parameters to be used in the detailed specification for the simulator and subsequently maintain a history of all impending design changes that affect the control panel procedures, and the simulator itself.
- o to establish an integrated working staff of design and operating personnel that are cognizant of all the interactive requirements of the three-pronged design, i.e., the procedures, the man/machine communications and simulator for operator training.

The second verification step will be accomplished through the plant full-scope simulator. Also this simulator will be located at the Piacenza training center, and its construction will take place after the completion of the mock-up verification program.

The simulator availability in a stage preceding the installation of the real control room permits ENEL:

- o to verify and validate the plant operating procedures
- o to further improve the control room design by eliminating any possible inadequacy and to carry out the modifications not shown by the verification on the mock-up.
- o to train, well in advance, the personnel assigned to the plant operation both for normal and emergency conditions.

The simulator will be designed by adopting flexible solutions that permit adjustments for any plant modification with a minimum of effort and redesign.

Conclusions

ENEL is convinced that intensive training is necessary for the safe operation of power plants. It also believes that its

training programs must be dynamic, not static, and that course content must be modified periodically to reflect the current equipment and regulatory requirements. In this regard, the implementation of the CAI/CMI programs is expected to give fulfillment for a systematic approach to training.

The use of centralized training facilities, with unified training courses supported by simulators provides a concrete answer to the problems related with the implementation of the "National Energy Plan."

The lesson learned from the Alto Lazio simulator project has provided ENEL with valuable experience in the field of simulator design and capabilities. This learning experience is being integrated into the PUN project control room design, its operating procedures and simulator.

TRAINING, EDUCATION AND QUALIFICATION
OF NPP OPERATING PERSONNEL IN THE NETHERLANDS

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Abstract

This paper outlines the organization and the requirements of the training, education and qualification of NPP operating personnel in the Netherlands. It describes the implementation of a formally required scheme of personnel qualification after TMI, and the current practice as developed by the training staff of both Dutch nuclear power plants. Attention is given to the specific circumstances and problems in the Netherlands, and the resulting program. The licensing criteria for control room operating personnel are discussed, including the level of government involvement. Measures are described to improve the approach to training of NPP personnel involved in safety relevant activities. Finally, some ideas are given for strategies to cope with adverse stress situations.

Introduction

The Netherlands is a country with at present two nuclear power plants in operation. Total peak load of the grid is about 5,000 MW(e) in the summer and 13,000 MW(e) in winter. The 60 MW(e) Dodewaard BWR, of General Electric design, was connected to the grid in 1970. The 470 MW(e) Borssele PWR, designed and built by Kraftwerk Union in West Germany, followed in 1973. The plant is operated by the PZEM, the Province of Zeeland Energy Company.

For the Dodewaard plant, a special operating organization was founded as a mutual cooperation by all 18 Dutch electricity-producing utilities, named the Gemeenschappelijke Kernenergiecentrale Nederland or Mutual Nuclear Power Plant Netherlands GKN. This situation is changing, and the number of electricity-producing utilities will eventually be reduced to about three to five in number.

All utilities in the Netherlands are either public companies, or private companies with a major public participation. Public participants are the provinces and/or the municipalities.

Both utilities rely for the resolution of principal safety questions upon either the original designer, the Central Electricity Research Foundation (KEMA) or other external organizations.

Because of a nuclear moratorium, no new license applications have been filed since 1973. This moratorium had an important effect on the training and manpower situation in the Netherlands. Several times there have been attempts to extend the nuclear power generating capacity. The latest attempt was aborted right after Chernobyl. Further decisions have been postponed for at least two years.

The basic reason was and still is the negative public opinion towards nuclear power in the Netherlands; the negative attitude of a large part of the society towards all persons related to the nuclear industry. It even affected the nuclear power plant personnel in their own private environments.

The aforementioned history and external influences provide an insight into the challenge of the training departments of both nuclear power plants. Their job is to train operating personnel to a very high standard, and make them reliable and preferably completely resistant to stress.

Training Programs and Regulatory Requirements

Training of plant personnel is performed by the training departments of both nuclear power plants. The role of the regulatory body was originally very limited. Traditionally, the regulatory framework provides general rules with a minimum prescriptive content. If utilities perform self-regulation at a sufficiently high level, the regulatory body is less inclined to enforce formal rules. Rules are seen as the establishment of good practices and may have some steering role. In the Netherlands, emphasis is on ensuring that correct and complete training is given, and not on the details of the program. Originally regulatory documents, like rules, guidelines or standards, did not exist in the Netherlands.

For governmental regulations, two events are of special interest -- the accidents at TMI and Chernobyl. Post-TMI measures resulted in the Netherlands in a formal rule on the training and re-training of shift supervisors and reactor operators, laid down in a document entitled: Training, Education and Qualification of Direct Operating Personnel of Nuclear Power Plants (1).

Post-Chernobyl actions will result in a document for all other personnel performing duties with relevance to nuclear safety, either as a separate document or as an amended IAEA Safety Guide.

Several reasons existed for a restricted regulatory involvement. First, the viewpoint that the responsibility for all aspects of nuclear safety should rest in principle with the

licensee, who is in any case by law entrusted with the responsibility. Second, the fact that for both Dutch plants the direct operating personnel originated for a larger part from the merchant marine, mostly as chief engineers with a longstanding experience in shift and control room work. Third, most professionals and operators are with the plants from the construction phase up to now. These people are highly familiar with most construction details and procedures. However, as is indicated, the situation is changing and more regulatory involvement is becoming a reality.

Basic Responsibilities of the (Deputy) Shift Supervisor

The job and task analyses of the shift supervisors, deputy shift supervisors and reactor operators are the basis of the assessment and training program. Essential in the Netherlands is the situation of the shift supervisor. This person is directly responsible (and authorized) for the safe operation of the plant, and the response during abnormal situations. A shift supervisor cannot be overruled in the performance of his duties. A shift supervisor is also in direct charge of the shift. Furthermore, the function of senior reactor operator does not exist in the Netherlands. Some tasks are performed by the deputy shift supervisor, e.g., keeping track of the plant status, and some by the reactor operators. However, a deputy shift supervisor is completely qualified as shift supervisor.

Basic Entrance Qualification Criteria for Candidate Reactor Operators/Shift Supervisors:

- o Age -- between 24 and 60 years. The upper limit is introduced because of the shift system and the personnel response capabilities in case of an accident. The licensees have introduced measures to cope with this requirement.
- o Education -- junior technical college level, with a minimum of two years experience in a power plant or process installation. The Dutch levels of power plant engineer, level B, or merchant marine engineer, level B, are considered to be equivalent.
- o Psycho-technical and medical exams -- a tendency exists to emphasize the psychological elements connected with stress resistance, but quantitative criteria are still lacking. In the case that a reactor operator is promoted to shift supervisor position, reliance is on judgment from superiors and human performance indicators, rather than performing a new psycho-technical test.

- o Dutch nationality -- this is not an official requirement, but thorough command of the Dutch language is required.
- o Complementary criterion for candidate shift supervisor -- education: Technical college level, power plant engineer, level C, or merchant marine engineer, level C. A minimum of two years as reactor operator on the specific power plant is demanded.

Training and Qualification Program Organization

All personnel involved in the operation of a nuclear power plant are divided into training groups, depending on the type of function or task. All groups are in principle as homogenous as possible to simplify the training requirement of each group.

Major groups are (see function in Figure 1.)

- licensed shift personnel (shift supervisors, reactor operators)
- non-licensed shift personnel
- procesengineers
- physicists
- administration personnel
- health physicists
- mechanical maintenance and repair personnel
- electrical maintenance and repair personnel
- waste department personnel
- chemical department personnel
- management
- quality assurance personnel

All personnel receive a general orientation training. This training covers general aspects of radiation, protection, industrial safety, quality assurance, emergency annunciators, and the organization of the plant. All third party personnel involved in activities in the installation receive a short introductory course on NPP elements. There is no public or privately-owned training and education instruction in the Netherlands, from which the utilities can recruit people with the knowledge and skills required for an adequate job performance in a nuclear power plant. Both utilities have to train their own perscnnel, with some assistance from external institutes (see Figure 2). Receiving education and training away from the plants probably does have the advantage of better and more undisturbed training.

The thoroughness of training for the licensed personnel and the professionals never turned out to be a real problem.

Figure 1. General Training Plan

GENERAL TRAINING PLAN


	Days	Client Trainer	Division Heads	Department Heads	Staff Specialists	Shift Supervisors	Supv. - Shift Supervisors	Field Supervisor	Trainers	Instructors	Chief Mgr. Shift	Head Quality Assurance	Technicians Licens. Mgr.	Technicians Maint. Mgr.
First information	1	*	*	*	*	*	*	*	*	*	*	*	*	*
Introduction	10	*	*	*	*	*	*	*	*	*	*	*	*	*
General info KCB	20	*	*	*	*	*	*	*	*	*	*	*	*	*
Preparation ECM-Course	10	*	*	*	*	*	*	*	*	*	*	*	*	*
ECM Course	30	*	*	*	*	*	*	*	*	*	*	*	*	*
Preparation Simulator Course	10	*	*	*	*	*	*	*	*	*	*	*	*	*
Simulator Course	40	*	*	*	*	*	*	*	*	*	*	*	*	*
Theoretical Education level 1	100			*	*									
level 2	100				*									
level 3	60					*								
Job Training in Shift level 1	100			*										
level 2	100				*	*								
level 3	100						*							
Job Training Non-Shift *	0/100	*	*	*	*			*	*	*	*	*	*	*
Nuclear Technics Course	20							*						
Fire Fighting plus	10			*	*	*	*							
Radiation Protection								*						
First Aid	4													
* Job-Training non-shift personnel may vary from 0-100 days, function dependent.														
NUMBER OF DAYS P.P.O. BETWEEN		1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111	1111111111
		221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221	221221221221

Figure 2. Location of Training Facilities

Training Locations

Table 2 indicates the various training topics and their facility locations.

TOPIC	FACILITY	Team 200	Process ECM	Aviation SIMS	Reactor ECM	ECM Site
Simulator	*					
Reactor Physics		*				
Reactor Physics				*	*	
Refresher		*	*		*	
System Modification			*		*	
Practical/Theory					*	
Emergency Shut-down					*	
Relucting machine					*	
Fire fighting					*	
First aid					*	



Low Flux Reactor at the Energy Research Center (ECN) in Princeton.

All parties involved realized that besides satisfying regulatory requirements, a comprehensive and well-structured training program would add to the efficiency of the operating personnel. Safety, as well as productivity, will increase when each person involved has the proper knowledge, experience and motivation to perform his duties adequately.

Training Program for Licensed Personnel

Reactor Operator (see Figure 3):

Basic course in plant systems	2 weeks
Radiation protection course	2 weeks
Nuclear fundamentals at the nuclear research center Petten (ECN). This includes training with a basic simulator and practical courses on the Low Flux Reactor (LFR)	4 weeks
Full scope simulator training at the Essen Power Plant School (West Germany). First course is on normal operation, starting and shutdown (note: the Dodewaard BWR recently introduced a plant-specific compact simulator).	4 weeks
Evaluation of simulator training, including comparison of plant behavior with Borssele plant (KCB)	4 weeks
Full scope simulator training course. This second course deals with off-normal and emergency conditions.	4 weeks
Evaluation of training course at KCB	2 weeks
Plant-specific training in electrical systems, logics, safety systems, operating and emergency procedures.	8 weeks
Fire fighting and first aid.	1 week
Practical on-the-job training	12 weeks
Written and oral tests (see Figure 4).	

Items such as classroom training, on-the-job training, evaluation, etc., are alternated to reach a balanced mixture of practical and theoretical lessons.

Figure 3. Training Schedule Reactor Operator

Reactor Operator Licencing

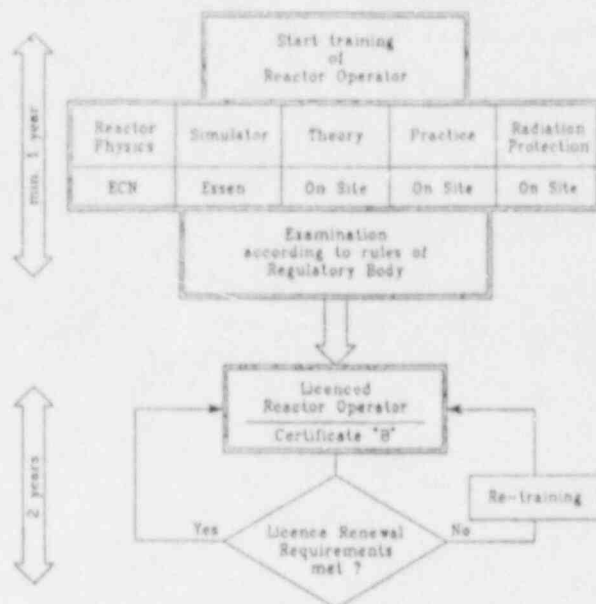


Figure 4. Examination Subjects by Regulatory Rule

WRITTEN EXAMINATION SUBJECTS FOR REACTOR OPERATOR (PAR. 29).

- A. Principles of reactor operation.
- B. Features of facility design.
- C. General operating characteristics.
- D. Instruments and controls.
- E. Safety and emergency systems.
- F. Normal and abnormal operation procedures.
- G. Disturbances.
- H. Radiation protection.

WRITTEN EXAMINATION SUBJECTS FOR SHIFT SUPERVISOR (PAR. 30).

- I. Practical reactor physics.
- J. Radioactive material handling.
- K. Specific operating characteristics.
- L. Disturbances and accidents.
- M. Fuel handling and core parameters.
- N. Administrative procedures, conditions and limitations.

Shift Supervisor (see Figure 5).

After at least two year's experience as a reactor operator, it takes another year of training to gain access to the examination. The training comprises partly the same subjects covered in the reactor operator training, but more in depth. In addition to specific courses, the elements are:

Extensive radioactive materials handling and disposal

Analysis of abnormal operating conditions

Administration

Emergency plan organization and activities

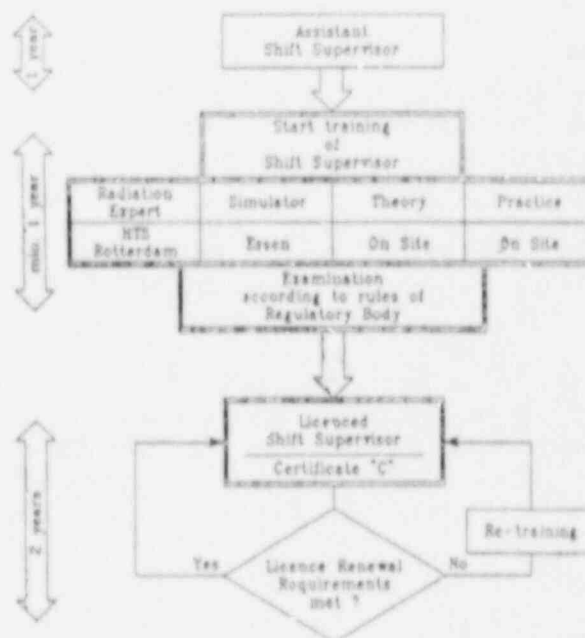
Legal limits and conditions, including reporting of violations

Status keeping of the installations

Full-scope simulator -- two extra weeks -- for emergency situations

Figure 5. Training Schedule Shift Supervisor

Shift Supervisor



At the end of the training, written and oral examinations are scheduled. For licensed personnel, retraining is a statutory requirement. In practice, other groups of personnel are also involved in re-training, such as field operators, M&R personnel (see Figure 6).

Figure 6. General Re-training Plan

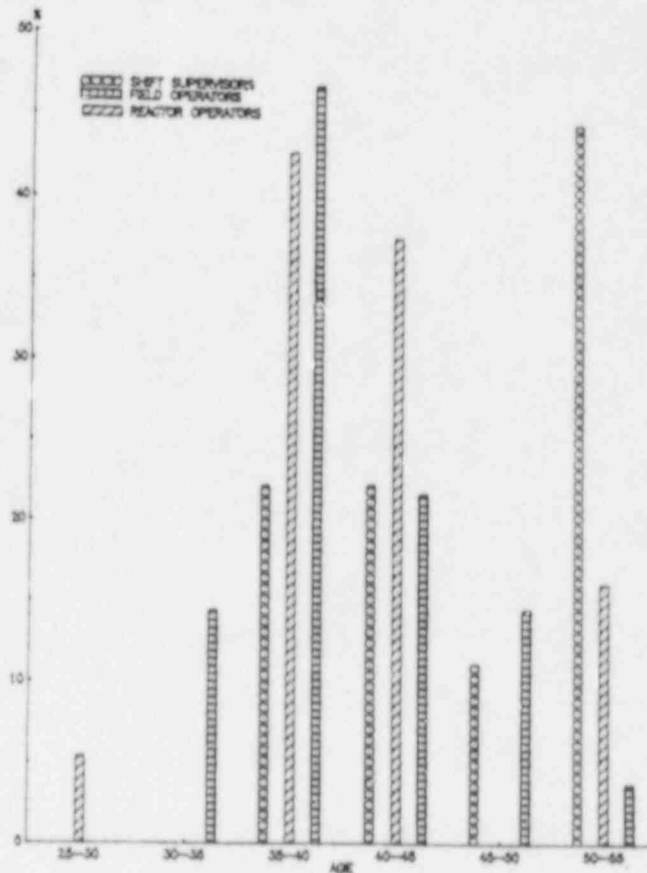
GENERAL RETRAINING PLAN		Days	Plant Manager	Division Heads	Management Heads	Shift Specialists	Shift Supervisors	Head, Shift Supervisor	Field Operator	Physicists	Instructors	Chief M&R Shop	Head Quality Assurance	Technicians Electric M&R	Technicians Mech. M&R
Refresher Course Shift Pers. (L)	5				*	*	*								
Refresher Course Shift Pers. (L)	5							*							
Refresher Course non-shift pers.	5	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Instruction Modifications	5				*	*	*	*	*	*	*	*	*	*	*
Preparation Simulator	5	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Simulator Course	5	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Emergency Plan	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fire brigade	1				*	*	*	*	*	*	*	*	*	*	*
First Aid	2				*	*	*	*	*	*	*	*	*	*	*
Miscellaneous	1				*	*	*	*	*	*	*	*	*	*	*
Total nr. of days per person per year:		15	16	16	16	19	19	18	11	15	15	5	5	15	15

Specific Problems: The training and education are affected by conditions that pose some problems in the Netherlands. Therefore, the training department receives direct support and attention from management. The specific problems are:

1. Age distribution of direct operating personnel (see Figure 7). The majority of shift supervisors are 50 or older. In a few years a gap will be manifest between this group and the rest of the licensed personnel.

2. De-motivation because of a lack of other possibilities. Most people involved entered the nuclear world with an expectation of an extended program. With only two plants, no job rotation is really possible for shift personnel and possibilities for promotion are limited.

Figure 7. Age Distribution of Direct Operating Personnel



3. All extraordinary duties place a heavy burden on the experienced personnel. Training is easily affected in these circumstances.

4. Poor responses on recruitment. Those people who qualify can get jobs in less remote areas (one vacancy: one-three responses).

5. Negative attitude of the society affects personnel in their private lives.

Strategies for Coping with Adverse Stress Situations

A few remarks about Dutch experience on adverse stress situations. Although some incidents have occurred at both nuclear power plants, they presented no real adverse stress conditions connected with emergency situations. In general, the nuclear industry is too well organized with optimum safe design and operation characteristics to be able to provide a sound statistical base with lots of data, to assess the effect of certain measures.

However, a very different group of people indeed is subjected regularly to a sort of adverse stress situation. In my country, specific task forces (ME) of the municipal police in Amsterdam have for many years been confronted with very stressful situations. A recent report (2) on the effect of stress and how to cope with it has been quite helpful. I realize that there are all sorts of stress, but some elements may be mutual.

It has been proven that specific training and education is very effective in increasing resistance to stress. Furthermore, psychological screening is helpful indeed because it selects personnel who are less prone to show primary reactions. Last, but not least, it has been found that people are more stress resistant if they know beforehand that their employer will take good care of them after stress situations.

References

- 1 License document: Rule on Direct Operating Personnel in Nuclear Power Plants: Education, Qualification and Competences (Document RT-84-019 in Dutch).
- 2 A. Slothouwer e.a. "ME and stress. An research study after the results of ME-performances related to the personal functioning of the ME-policeman" (in Dutch). Editor: Staatsuitgeverij '-Gravenhage, the Netherlands. Report ISBN 90-12053749.

CHAIRMAN'S SUMMARY

Mr. M. Grandame
Canada

This session comprised nine presentations by regulators, utility staff and a manufacturer's trainer. Outlines and descriptions of the evolution of training programs in nine countries were the primary subject throughout.

Extensive use of full-scope training simulators in many of the countries, and more extensive application of plant performance measurement systems to assess and evaluate the effectiveness of training were noted.

Key points of interest were:

- o Mr. B-G Olofsson (Sweden) indicated an interesting factor within the KSU training program. This program contains an instructor requirement that includes seven weeks of training on pedagogical principles.
- o Mr. G. A. de Vrey (the Netherlands) described the problems arising from a "no growth" situation resulting from a nuclear moratorium in that country. This has resulted in poor recruitment response, an abnormal age distribution of operating personnel, demotivation and an overall reduction in training effectiveness.
- o Mr. R. L. Long, of the GPU Nuclear Corporation (USA), identified a significant feature of his corporation's training program. The program includes periodic re-training in basic fundamentals for incumbent operating personnel, a feature not often found in re-qualification training.

SESSION 3:

INSTRUCTIONAL METHODS (I)

CHAIRMAN: Mr. A. E. Vandewalle

ACCURACY AND UPDATING OF TRAINING SIMULATORS

N. Tangy
Electricité de France
Bugey Training Centre - France

This report describes the organization taken up by Electricité de France to guarantee and maintain full scope simulators' accuracy to the level required by the training of operators, shift supervisors and engineers. The quality of the simulators is illustrated through two examples of transient: the house load operation and the break of two steam generator tubes in bi-phasic operation.

Introduction

In 1986, French nuclear electric production reached 241.4 TWh, that is to say, 70% of the total national production.

The whole of French PWR nuclear plants consists of:

- o one prototype 300 MWe unit
- o six non-standardized 900 MWe units
- o 18 900 MW(e) units representing the construction program number 1 (CP 1)
- o 10 900 MW(e) units representing the construction program number 2 (CP 2)
- o 20 1,300 MW(e) standardized units in three series (four loops PWR: first units P4, final units P'4, intermediate units H4)
- o 3 1,450 MW(e) units type under construction (four loops PWR French licensing: N4).

Those installations are operated by 1,900 confirmed technicians, executives and engineers and 1,000 technicians and plant operators.

Proper training of the NFG (Nuclear and Fossil Generation of EDF) staff has contributed in a significant way to reduce regular unavailability and human failures observed in France. In 1982, an average of 7 scrams per 900 MW producing unit and per year was recorded, 2.3 of them being the result of a human failure. In 1985, this was reduced to 3 scrams, among which 1.1 was due to human failure.

In 1986, 42% of the total 224 recorded scrams (alternator being connected to the grid or not) had a human origin. This proportion was 47% in 1985.

Nuclear training of the 2,900 operating staff comprises mainly two parts:

- o technical training on part task, full scope and physical principles simulators;
- o operation experience feedback from all the standardized plants in France and in the world.

Electricité de France owns seven full scope simulators corresponding to the different series of reactors in service:

- o 1 900 MW(e) simulator Bugey type
- o 2 900 MW(e) simulators CP 1 type
- o 2 900 MW(e) simulators CP 2 type
- o 2 1,33 MW(e) simulators P4 type

Each simulator is used for the training of operating staff and prepares them to operate in normal situations, as well as to master incidental and accidental phases of functioning, excluding operating in ultimate accidental conditions. Most of the elementary systems of each series of plants are simulated. Each pair of simulators is joined to a reference unit of the considered series.

The behavior of the plant is reproduced in real time by the simulators in such a way that a trained operator cannot distinguish between the real process and the simulated process. The simulators are continuously updated with regard to reference plants, in order to allow:

- o training evolution in connection with the modifications of the plants
- o starting training after operation experience feedback (especially in case of significant events)
- o constantly motivating the operators to train periodically.

This report describes the organization taken up by Electricité de France to guarantee and maintain full scope simulators accuracy to the level imposed by training requirements.

Simulators' Accuracy - The Principles

Construction. Training requirements are defined and established by the NFG and more precisely by the Operation, Nuclear Safety and Training Divisions. Initial specifications for the construction of the simulators are then drafted by Electricité de France in order to consult constructors.

Once it has been decided to place the order, the construction is carried out under the permanent control of two teams

of engineers, one belonging to the NFG, the other coming from the training center that is going to be equipped with the simulator. So from the very beginning of the project, the Staff Management Department who is going to be in charge of the training is associated with the realization of the simulator.

Reception and validation. The most important tests that are carried out on vendor's site, are composed of five different phases:

- o logical tests
- o general handling
- o validation tests:
 - identification
 - normal transients
 - operating incidents
 - accidental transients
- o general breakdowns
- o electrical malfunctions (losses of electrical supply)

Validation tests are carried out with the help of specialists from the NTE (Nuclear and Thermal Engineering of the Construction Group of EDF) and the NFG. Identification tests and transient tests allow control of the simulation of the process by comparison with actual situations reproduced in nuclear plants or in connection with the results of surveys and calculation codes used for the conception of nuclear plants. As an example, 49 tests of this kind have been carried out for the realization of the 900 MWe CP 2 type simulators.

Acceptance. After having carried out the reception and validation tests on the simulator, the NTE states its validity in the simulated field for the training of operators.

Detailed Conception of Training Actions and Their Evolution. Training actions specifications are established by the NFG Training Division. They take into account the recommendations of the safety authorities, the operation experience feedback from nuclear plants that has been analyzed and selected by the operation analysis section, and the advice of internal nuclear inspection.

Nuclear Training Centers that are dependent on Electricité de France Staff Management Department are the ones who are going to undertake training actions. They draft pedagogic aids from bibliographic references, technical and regulatory references, specific to the plants concerned.

Simulators Initial Quality - The Facts

The Contract. The construction specifications show the principles and characteristics of the process simulation:

- o the simulated field, that is to say, the whole of the elementary systems and of the different operating situations
- o the components and the phenomena that have to be calculated and not reproduced by repetition
- o elements and phenomena that have to be considered as reference states (initialization)
- o technical and bibliographic references

As a consequence of those specifications, the constructor must conceive an actual and accurately calculated simulation. He has nothing but the characteristics of the components and of the fundamental physical data, especially in the field of neutronics and thermohydraulics. He does not know the results of the actual tests or of the calculations for nuclear plant conception. This situation guarantees to Electricité de France a full scope simulation and the means to check it during the validation phase.

Technical References. Electricité de France gives the constructor the data concerning the elementary systems to be simulated which contain most of the technical reference:

- o role of the installation
- o conception principles
- o detailed description, nomenclature and characteristics of the components
- o operating conditions
- o instrumentation and control logical diagrams
- o mechanical diagrams
- o safety analysis
- o bibliographic references

Accuracy and Tolerance. The performances expected from the simulation are specified in terms of maximum limit of the gap between

the theoretical or actual value and the value calculated in identical conditions. In continuous operating conditions (class 1) set values must be accurate to plus/minus 0.5%. There should not be a difference of more than 1% between the other parameters and the theoretical values. In normal transient conditions (class 2) the gaps must be inferior to 10% and the tolerance on the time elapsed between the beginning of a transient and the apparition of a parameter extremum is 20%. In exceptional transient conditions (class 3) the gaps must be inferior to 20% of the variation of the considered value. The tolerance on time being the same as for class 2 transients. In all simulated transients, the curves must be identical to the ones noted on plant recorders.

One example: house load operation at full power on a 900 MWe CP 2 simulator. Document of reference: calculation of the manual house load operation at Saint-Laurent B1 after comparing the BABEL code with an actual test carried out on July 22nd, 1981. SEPTEN E-SE-TC-82-15-A.

Test on identification of house load operation at full power.

- o Goals. Compare the evolution of the main parameters given by the simulator along with the BABEL model data. Those data being themselves recalculated by the NTE from the results of the actual test carried out on July 22nd 1981.
- o Results. The most significant recordings of this test concern nuclear power and the position of the control rods, the inlet and outlet primary water temperature, the pressurizer level and pressure and the steam generator level.
- o Conclusion. During this important transient (so far as neutronics and thermohydraulics are concerned) the simulation is close to reality. The only non-negligible difference appeared when the control rods were inserted, and this can be explained by the fact that, at the time this test was carried out at Saint-Laurent B1, this unit was still piloted in black mode, whereas the 900 MWe CP 2 simulator was conceived in grey mode, so as to take the final situation of the CP 2 units into account.

Evolution of the Simulators - The Principles

Causes of evolution. Full scope simulators are paired with standardized reference units. Simulation must therefore evolve along with the modifications carried out in nuclear plants, so long as

those modifications are in connection with the simulated field or the control room hardware itself. But there are also other causes of evolution, such as:

- o the extension of the specifications concerning training on simulators, as for example taking into account the transfer of gaseous wastes by ventilation after a radioactive incident in the confinement building.
- o improvement of certain simulation models by incorporating technical progress made by constructors or the NTE, as for example the generalization of a bi-phase modelization, or the confinement building model in accidental situation.
- o operation feedback and specific operation requirements.
- o simulation anomalies recorded during training sessions.

Organization of simulators modifications -- Quality assurance. So as to maintain and guarantee full scope simulators required quality level, Electricité de France has set up an organization that relies on the responsibility of the different partners, on internal control and on the application of the quality organization handbook principles concerning simulator maintenance and training activities.

A commission of experts from the Administration Representative Standing Group checks periodically theoretical and practical staff training conditions. After studying the surveys carried out by the Institute for Health Physics and Nuclear Safety (from the Atomic Energy Commission), the Standing Group express their recommendations to Electricité de France.

On the other hand the country's safety authorities have the responsibility of carrying out external controls in training centers. They check regularly the contents of training plans as well as their correct realization.

- o Nuclear training centers play permanently an active part in the evolution of the simulators and act as supplier to the NFG. Maintenance teams work according to a convention passed with the NFG. They act on the authority of the NFG for the following missions:

participating to the reception of the simulators

correcting simulation anomalies with regard to the construction specifications

carrying out minor modifications connected with the evolution of the reference units, which do not deeply affect the models

following up the integration of more important modifications entrusted to the constructor of the simulators

general surveys and propositions about simulators' evolution according to the demands put forward by the instructors and to the remarks made by the trainees

preventive maintenance of the equipment

administration of reference documentation about simulators coming from corresponding units

Each nuclear training center works with respect for the quality organization approved and controlled by the NFG.

- o The constructor has his own quality organization and guarantees that the training equipment (delivered or modified) is in accordance with the contract passed with Electricité de France.
- o The NFG is a customer of the training centers. A technical group in charge of simulation follow up, gathers twice a year with the NFG and training centers representatives. This group:
 - analyzes afterwards the work continuously carried out by training centers
 - analyzes the surveys and requests about evolution put forward by training centers
 - decides on important interventions that have to be done and appoints responsible bodies

NFG internal nuclear inspection checks on quality organization in training centers.

- o The NTE who declared the acceptance of each simulator after construction, is asked again by a nuclear training center or by the NFG to estimate the level of accuracy of the equipment in operation:

In a systematic way at the end of the integration of an important modification.

Periodically or randomly, to ensure that a simulator has not regressed after the interventions undertaken by the training centers.

Simulators' Evolution - Two Examples

A major improvement in the simulation of the primary circuit: Bi-phasic modelization. The FRAMATOME DEFI code has been improved by a FRAMATOME, ELECTRICITÉ DE FRANCE and THOMSON joint action. The NTE carried out a complete identification operation of the new simulated field which was reliable and physically relevant after the code was integrated by the constructor.

The non regression of the simulation has been proved for normal and incidental transients. The extension of the simulated field to a certain number of situations, has been verified through accidental transient tests. That is how the limits of the model have been clearly drawn after those numerous tests:

- o Draining the low pressure steam generator tubes
- o Filling the low pressure steam volumes with water (reflooding)
- o Holding back the water in cold branches

Pedagogic aids have therefore evolved to take those limits and improvements into account. Once the limits are reached, the simulation is automatically stopped, to avoid the delivery of wrong information. The example chosen concerns the break of two steam generator tubes. The A3 procedure is then applied by the operator.

The NTE compared the simulation based on AXEL calculation with the survey made about "Behavior of the nuclear steam supply system in case of steam generator tubes break." SEPTEN-E-PE-TC-84-34
The curves show:

- o comparative evolution of primary pressure
- o comparative evolution of pressure in a damaged steam generator and pressure in a steam generator in good working order
- o comparative evolution of the levels in steam generators
- o comparative evolution of the pressurizer level
- o comparative evolution of the saturation margin.

The evolution of the different parameters are coherent, representative of the simulated accident, and consistent with the results of the AXEL calculation code.

Daily improvement on simulator's performances:
Responsibility of training center's maintenance teams. From September 1985 to September 1986, the Bugey Training Center maintenance team integrated and validated a number of 50 modifications that are classified as follows:

- o simulation anomalies: 50
- o extensions of the simulated field: 6
- o modifications of the reference unit: 16
- o different minor modifications: 8

Simulation anomalies concern mainly electric supplies, instrumentation and control. The great variety of situations created for training purposes allow discovery of those anomalies and to put them right.

Conclusion

Coming to the end of this report, we should sum up the elementary principles that explain the quality of the seven full scope simulators used by Electricité de France to train their staff, and more widely, the relevance of the training given.

An efficient organization. A customer/supplier relationship established between two distinct bodies belonging to the same firm is propitious to the constant improvement of performances. The Staff Management Department, which is in charge of the training, has a real autonomy and a great experience in the professional training trade in each and every field of activity of the firm. Training objectives and quality organization rules are imposed on the Staff Management Department by the NFG who carries out a quality control. The NTE acts as an independent expert for the customer as well as for the supplier.

Favorable circumstances:

The development of standardized French nuclear plants went along with a policy of recruitment and intensive training. From 1976 to 1986, 200,000 man-days of nuclear training were given in the centers, half of which were performed on simulators.

On a national scale, the means devoted to those activities will be stabilized, around 1990, to a team of 150 engineers and

permanent instructors in nuclear power plants and training centers and 40 simulator maintenance engineers and technicians. The multiplication of training situations carried out coherently increases the average quality of the service.

A determined policy of operation experience feedback. The NFG carries out an analysis of the significant and foregoing incidents, which is immediately transferred to the nuclear training system to integrate the results in specific objectives. Nuclear training centers are efficient vehicles for dispatching experience data among nuclear power plants. Advised and controlled both by NTE experts and NFG specialists, nuclear training centers continuously transfer the knowledge to power plant's operating staff.

INTEGRATING A SIMULATION FACILITY INTO A TOTAL TRAINING EXPERIENCE

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This paper deals with the acceptance and use of a nuclear power plant simulator from the training department's perspective. The ultimate users of the device cannot wait until delivery to plan for its implementation in the training process. Planning for use, support, and staffing must proceed in pace with the simulator construction process. This paper will recount some of the experiences and insights acquired during the process of bringing the Salem and Hope Creek simulators on-line and make recommendations on how other utilities, both within the United States and in the international scene, can be better prepared to utilize their simulators for the total training experience.

Introduction

When a utility decides that its training programs can best be served by the purchase of a plant-referenced simulator, the focus is normally on defining the scope of the project, performance characteristics, a milestone schedule for completion of the project, establishing a delivery date, and developing a testing philosophy for the product. The department that manages this project normally sees delivery, testing and acceptance as the end of the project; however, the training organization is tasked with the job of implementing this multi-million dollar training aid and integrating it into their training programs to make it a worthwhile investment. All too often the needs of establishing the training program are neglected in the frantic pace of bringing the simulator project to closure. All of the functions listed above are essential for the effective and timely completion of the simulator construction project. However, planning for implementation and use of the simulator must begin early in the cycle and cannot be left until after delivery. We will discuss three phases of planning for implementation of the simulator in the training program. Those three phases are: staff qualifications, training design and simulator support.

Phase I -- Staff Qualifications

In that the primary utilization of a simulator is in the training, qualification, and requalification of operators, the normal source for staffing the simulator would be experienced operators or experienced operations trainers. One must not overlook, however, the utilization of the simulator in training plant personnel other than licensed operators, although that is somewhat off the subject of this

paper. One cannot expect an individual, no matter how experienced in operating the plant, to be immediately effective in the utilization of a simulator to its fullest potential. The proper utilization of a simulator, or any complex training aid for that matter, requires a period of adjustment, specific instruction on the utilization of the training aid, and experience in its use. A well thought out and well-designed training program tailored specifically for potential simulator instructors is an essential part of this process. We cannot, however, stop there.

Regardless of the source of the instructor, i.e., plant operator or previously experienced trainer, emphasis must be placed on the training process and integration of the simulator into that training process. The potential simulator instructor must fully understand the principles of structured training whether we call it a Systems Approach to Training, Instructional System Design, Training System Design or some other title. The potential instructor must be coached in delivery skills utilizing the simulator, and realize that it is not a toy but a highly complex and sophisticated training aid to be used to satisfy the objectives determined by the instructor. The instructor must be knowledgeable enough not to allow a free play scenario as if it were an extremely expensive video game. The potential instructor must also be coached in the techniques of managing the classroom environment and in controlling the students to achieve the lesson objectives.

An essential part of the staff qualification is a plan for continuing training to further polish, enhance, and reinforce his/her instructional techniques. This continuing training program should be intended to not only reinforce and reaffirm the information provided in the initial training program, but it can also be used to effectively enhance the instructor's knowledge by adding new concepts, new topics or by discussing events and lessons learned by other utilities.

The last essential part of the staff qualification formula is evaluation. Each potential simulator instructor must be evaluated in his or her ability to utilize this large investment in the effective training of operators and other plant personnel. Without evaluation, one has no control over the process or the quality of the product of the training program.

It is essential that the staff for the simulator be established early in the project and their training experience begin well before the simulator is delivered for use. This will permit the simulator staff to "grow" with the simulator and become totally familiar with it before the pressure is applied to put it to use. Once the simulator has been accepted for use, it is just and reasonable for the Company to expect a return on that investment through the effective use of the machine. This cannot be

accomplished if the staff that is charged with the responsibility of utilizing this device is only assembled when the machine is ready for training.

Another benefit of the early identification and training of the staff is in feedback to the simulator project manager on concerns of simulator performance and implementation that might not be identified by the project staff. All too often, the simulator builders do not seek the cooperation and advice of the ultimate users of their project, thereby creating many compromises in the training utilization of the simulator that might otherwise be avoided.

Phase II -- Training Plan

As I stated before, the simulator is not a toy but is, in fact, a highly complex and sophisticated training aid. The instructional techniques embodied in a well-designed training program apply as well to the simulator training session as they do to the traditional classroom environment. Once the scope of simulation and the philosophy of operation of the simulator have been determined by the project group, the planning for implementation can begin. It is not necessary to wait for delivery to determine the method in which the simulator will be utilized in training. The full ISD or SAT process can and should be applied to the simulator training experience. From the task analysis developed for the licensed operator training classification, those tasks that could best be presented on the simulator must be chosen. From those tasks, the simulator staff must develop the objectives they will accomplish in the simulator training sessions and develop the training plan. The training plan, whether you call it a lesson plan, a simulator exercise guide, or something else, must identify the expected outcomes of the training session.

A major advantage of having a dedicated simulator staff who are familiar with the characteristics and experienced with the use of the training simulator is that the training session in the simulator is not altogether predictable. One must establish the expected outcome of the training session and control the student involvement to further that aim, however, the session cannot be overly structured to remove all spontaneity since many valuable experiences and lessons would necessarily be avoided. The true value of the simulator is that it will allow people to learn from their errors without disastrous outcome. This requires a highly motivated and dedicated staff to identify shortcomings and immediately correct them and then reinforce that training experience with an explanation of how, where, and why the student went wrong and why his choice of solution was not the acceptable one. On the other hand, the simulator session cannot be allowed to determine its own objectives thereby turning it into a playground instead of a classroom. The balance between overstructure and no structure is a delicate one that can only be

struck by instructors experienced with a machine, its capabilities and shortcomings. A well-trained staff can plan for this type of training experience and develop their lesson guides, plans, or exercise guides well in advance of the simulator's delivery.

A philosophy for evaluation and feedback into the training system design is an essential part of the instructional system design process. This applies equally to the simulator, but on several levels. Firstly, the direct feedback to the training development process in refining and improving exercise guides or, more fundamentally, the tasks from which they are developed is the more traditional feedback mechanism similar to that utilized in the classroom. It is essential that this process be in place and understood by all instructors in order for the training programs to be effective. This feedback mechanism must also include feedback to the classroom portion of the training on lessons learned in the simulator that might affect that training design.

There is, however, another essential level of feedback and that concerns the performance of the simulator and deviation from the referenced plant's operation. Mechanisms for handling this type of feedback must be established and must be well understood by all members of the staff involved with simulator support and utilization. We will discuss more on those mechanisms when I get to simulator support.

Another aspect essential to the full utilization of the simulator is plant involvement. The simulator cannot be established and utilized in a vacuum. While this fact is true for all aspects of the training experience, it is most crucial for the simulator. The full understanding of not only plant design and operating characteristics, but plant operating philosophy is essential for the effective utilization of the simulator. The ideal mechanism for accomplishing this is to have a member of the plant's staff serve with the training staff on a rotational basis. By making this a rotation assignment, one is always assured of having someone versed in current plant philosophy of operation available to the training staff on a full time basis. Of equal importance is the essential involvement of the plant management to the design, development, and implementation of training on the simulator. The plant operations manager must view the machine as his or her simulator in order for it to be fully effective. The feeling that the simulator is useful and valid and an integral part of the qualification process must be pervasive and must begin at the top. Without planned backing and support, the simulator will lose effectiveness and minor deviations which would otherwise be constructively discussed would become major issues.

Phase III -- Support

The third essential factor in the formula for effective utilization of the simulator is support. Support must be planned for well in advance and must be recognized as having several components. The first is the day-to-day support of keeping the simulator running. This must address everything from chart paper, pens, and light bulbs to major computer failures and requires the attention of both hardware and software personnel. A philosophy for support must be developed and implemented before the simulator is put into use. Whether that philosophy requires that the trainees or the simulator instructional staff do a portion of this work or calls for a dedicated support staff whose task is to maintain all aspects of the simulator, the thought must be applied and a philosophy must be developed or the simulator will soon degrade to the point where its usefulness and validity would be questionable.

Although most simulator projects include an initial stockage of spare parts, the budgetary impact of maintaining that stockage and of repairing some of the expensive items that can go wrong must be accounted for. The impact of just operating a simulator with no regard to upgrade to plant changes, or to the simulator's capabilities is on the order of hundreds of thousand of dollars per year. One must expect a certain mortality on computer parts, some of which are quite expensive. This also implies that a skilled and professional staff, knowledgeable in the maintenance and repair of simulation computers, is an essential factor in the formula for effective simulator use.

The other aspect of support is planning for and accomplishing upgrades to the simulator. Due to the long lead time in simulator procurement and installation and the necessity of freezing the design fairly early in the process, one must expect and plan for a fairly major upgrade of the simulator during the first year after its installation. A rule of thumb that might be applied to this is that this initial upgrade will cost approximately 10% of the initial simulator purchase. One solution to this problem might be to include the initial upgrade in the original bid package for the simulator, thereby recognizing that the upgrade is caused by the construction process. The drawback to this approach is that one becomes committed to the original manufacturer for the upgrade and the stresses and compromises necessary to bring the major project to closure could cause a strained relationship which would be exacerbated by the necessity of dealing with the same vendor for an extended upgrade.

Once the installation, initial operation, and initial upgrade are accomplished, one must expect a certain number of modifications and engineering redesign at the referenced plant which must be accounted for in the simulator. The budgetary impact of this

will vary, of course, from plant to plant, but can be expected to be on the order of half a million dollars per year just to keep the simulator valid with respect to its referenced plant. A philosophy for accomplishing this upgrade process must be developed so that a planned and reasoned approach to gathering the data necessary to support it, making necessary budgetary provisions, and planning for the management of the resources can proceed. In many cases, contractor resources are utilized to perform the majority of the upgrade work, thereby relieving the utility of the necessity for maintaining a staff that is highly qualified in a very special area, and also extremely expensive, on a year-round basis. Be that as it may, someone must plan for and monitor the performance of these upgrade consultants, and that staffing impact must be accounted for in developing your simulator support staff.

Several philosophies are in vogue for supporting simulators. At one extreme is a group of computer experts totally independent of the training staff who are responsible for performing these tasks. At the other extreme is a dedicated simulator support staff which is part of the training organization and responsible directly and solely for the maintenance and upgrade of the simulators. There are gradations of this philosophy possible whereby one might have a dedicated staff for day-to-day maintenance and an off-site project management group for upgrades. The most effective method of assuring compliance with regulations and maintaining the validity of the simulator is to have this support staff an integral part of the training staff directly and solely responsible for the maintenance and upgrade of the simulators. This is the only way that one can have the assurance that the simulator project will get the priority it deserved and requires.

Conclusion

We have seen that integration of the simulator into the training program can be a well-planned and beneficial experience if some early thought and planning is given to the ultimate use and support of the machine for its intended purpose, that is, training. It is natural and proper for the simulator project staff to see the acceptance and testing of the simulator as the end point of their project. However, the end users of the machine must be incorporated early in the process to allow them to plan for and execute the implementation of this highly effective, complex and expensive training aid into the training environment.

Discussion

MR. FRAZIER: Half a million dollars a year -- is that O&M, capital or both?

MR. SCHAFFER: Our experience has been both, however, we have not quite worked out with our financial people how we can handle it as a single project. We have experienced about two-thirds O&M and one-third capital.

MR. LONG: You say the ideal is to have an operations person be part of the training staff on a rotational basis. Have you been successful in getting operations to support that?

MR. SCHAFFER: Yes, I have. I have been fortunate that I have had very good support from both plants. In our situation, our training organization is not connected directly with the plants. We report through a different general manager to the vice-president, so there is not that close coupling you may find in some places. We have been very fortunate that both of the plant general managers and both plant operations managers have been very supportive of training and, in working with them over the past three years, we have worked out a rotational assignment where they have promoted an extra shift supervisor in both cases, and his position is in training for two years.

MR. STICKNEY: A follow-up -- when you bring these rotational people over, how do you prepare them for their instructional role?

MR. SCHAFFER: They are required to go through the same qualification process as an instructor on the permanent staff, which is a two-level course. One level is instruction techniques, which they generally need. In many cases, people we hire as instructors have previous instructional experience, and we waive that portion of it. In both cases, for our first round of rotational people, we did require the instructional techniques, the platform skills portion.

We also have a one-week course on classroom management, company-union responsibilities and rights, and managing the classroom environment, which everyone takes. Then they are placed under the direction of one of the principal training supervisors, who very closely watch all new instructors for the first month, or whatever it takes until they are confident they can handle it on their own. As it turned out, one of the people felt much more comfortable in the simulator, and he is almost totally a simulator instructor. The individual I got from Hope Creek turned into a very good platform instructor, so we have gotten a double benefit from him.

THE USE OF SIMULATIONS
IN NUCLEAR STATION FIELD SKILLS TRAINING

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Abstract

Ontario Hydro's Western Nuclear Training Centre (WNTC) carries the simulation concept of its full-scope control room simulators into its Nuclear Station Skills Training Program for its maintenance staff. The paper will briefly outline Ontario Hydro's approach to Nuclear Maintenance Training and provide examples of how simulated situations are used to train maintenance staff at WNTC.

Introduction

When I was debating with myself about what topic to discuss at this conference, I had some difficulty in choosing. The first inclination was to talk about the simulator training we do on our four full-scope real-time control room simulators the first of which went into service in 1976. However, two thoughts occurred to me:

- o What we do in control room simulator training is good but not a lot different than many others here.
- o We have been using field simulations for nuclear field skills training since the early 1960's.

I felt that a brief review of our field skills program for Control Technicians, Mechanical Maintainers and Operators might be of interest. Our approach is to provide simulations for many of the tasks our trainees will face in the stations in order to objectively test their ability to perform a wide variety of tasks. I have structured this presentation into three parts:

- o An introduction to Ontario Hydro and its nuclear program.
- o An overview of the training scheme for the major field skills areas.
- o A sampling of field simulations used in training in each of the major skills areas.

Ontario Hydro

Ontario is a province in Eastern Central Canada. It has a land area of approximately 900,000 square km and a population of about nine million people, mostly located in the southern part.

Ontario Hydro is a publicly-owned utility which operates as a stand-alone corporation. Ontario's peak electrical energy requirement in 1986 was 20,700 MWe. The total energy mix in 1986 was approximately 46% nuclear, 19% fossil-fired, 29.4% hydraulic and 5.6% other (imports, combustion turbines, etc.). By 1992 we expect the generation mix to be approximately 70% nuclear, all of which will consist of CANDU type reactors.

Our present nuclear capacity of 9,706 MWe is supplied by 16 CANDU nuclear reactors. Five more are under construction (one of these -- Bruce Unit 8 -- is critical and is expected to be declared in service soon following completion of testing).

Table 1

ONTARIO HYDRO NUCLEAR PROGRAM

FIRST UNIT I/S 1962 - 22 MWe

NUCLEAR CAPACITY I/S - February 1987

<u>Units</u>	<u>Net Capacity</u>
16	9,706 MWe + 258 MWe STEAM (electrical equivalent)

NUCLEAR CAPACITY UNDER CONSTRUCTION - February 1987

<u>Units</u>	<u>Net Capacity</u>
5	4,306 MWe

Of the total net in-service capacity, 5,561 MWe is located on the Bruce Nuclear Power Development site with 836 more soon to come. This is the site my training center serves. The Western Nuclear Training Centre is about 9,500 square meters, has two full-scope, real-time, control room simulators and a large skills training area. A similar training center serves the eastern end of the province.

At the BNPD site we have four major departments; Bruce Nuclear Generating Stations "A" and "B" each having four 900 MWe (gross) units (including steam delivery capability), the Bruce Heavy Water Plant with a capacity of 105 kg/hr of D₂O, and the Bruce Services Organization which provides centralized services for the site and radioactive waste processing and storage for Ontario Hydro.

The operations staff on site total approximately 3,300 people. With this staff we provide all normal operation, fueling, and maintenance, including maintenance during planned shutdowns.

Nuclear Training

When Ontario Hydro first entered the nuclear business back in the late 1950's some basic decisions were made regarding the reactor safety philosophy that was to be applied in designing, operating and maintaining our facilities. The five independent elements are shown in Table 2.

Table 2
DEFENCE IN DEPTH



The key one for the purposes of this presentation is comprehensive training for four major job families:

- o Operators
- o Control Maintenance
- o Mechanical Maintenance
- o Management and Professional

In this paper, I intend to cover the first three job families.

Nuclear Skills Training

From the start of its nuclear program, Ontario Hydro recognized that, given the circumstances it faced, its maintenance needs would be best met by two composite in-house trades groups - control technicians and mechanical maintainers.

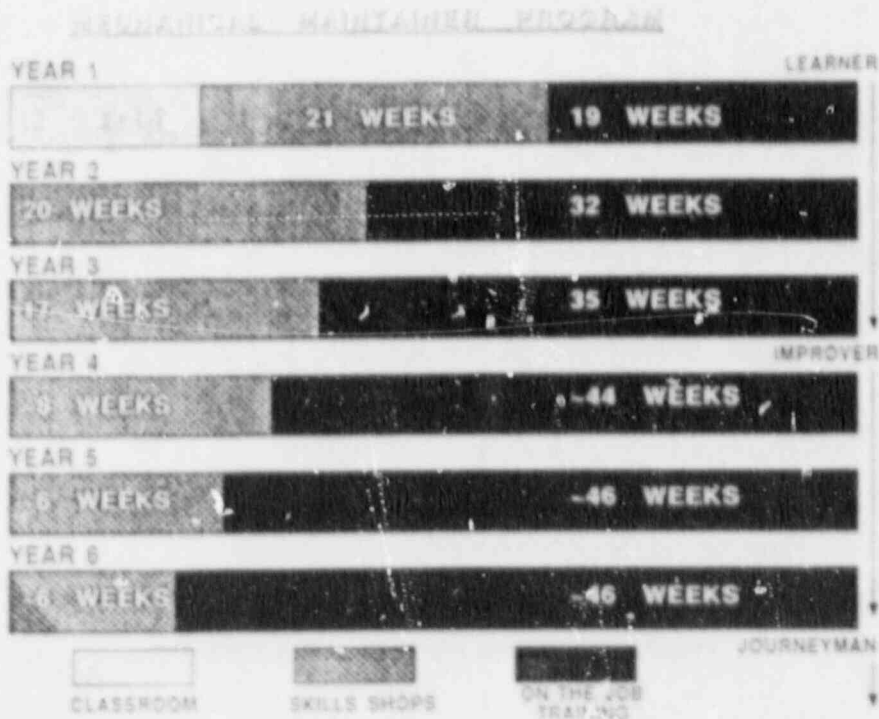
- o Control Technicians - Instrumentation
Electrical
Electronics/Computers
- o Mechanical Maintainers - Fitting
Welding
Machining

The policy of composite trades has reduced jurisdictional problem, speeded up jobs, reduced radiation dose and has allowed flexible deployment of staffing situations with varied equipment, systems and workload. Training requirements are based on a task analysis for each of mechanical and control maintenance.

Mechanical Maintenance Training Program

The mechanical maintenance program is a six-year program with an entrance requirement of high school graduation with a background in mathematics, science and some shops. As can be seen

Table 3.



from Table 3, during the initial year there are 12 weeks of classroom training which covers science fundamentals necessary for the trade, including subjects such as basic nuclear theory, fluid mechanics and thermodynamics as well as basic equipment and system principles relating to a CANDU nuclear station.

In addition, as with all the major job families, all candidates receive training in radiation protection which together with skills practice, station experience and station-specific training, will qualify all of them:

- o initially to be responsible for their own radiation protection.
- o eventually for taking responsibility for protection of others.

Following the classroom training, basic skills training is given in all the composite areas - welding, pipe fitting, machining, hand fitting and rigging. The table indicates this period as continuous for 21 weeks; however, in all years on-the-job experience and skills training is interspaced. During the period of on-the-job training, specific station systems and field checkouts are scheduled.

For the first three years, training is received in all mechanical areas. In years three to six the mechanical maintainer will specialize in fitting, welding or machining. Completion of the program gives credit for Levels 4 and 3 of a four-level program and qualifies the person as a journeyman. (See Appendix 1 for program information.)

Control Maintenance Training Program

The entry requirements are high school graduation and two years technical college or qualifications in one of the three trades -- instrumentation, electrical, electronics. The control maintenance program is similar in concept to the mechanical maintenance program (see Table 4). In year three the control maintainer will specialize in two of instrumentation, electrical or electronics. Again, completion of the program gives credit for Level 4 and 3 of a four-level program and qualifies the person as a Control Technician.

Operator Training Program. An operator requires high school graduation with advanced mathematics, chemistry and physics. Table 5 outlines the requirements with initial training being similar to that for mechanics and control technicians followed by generic skills training at the local training center.

In on-the-job training at the assigned department there is considerable emphasis on station systems and field knowledge testing. After two years of training and experience the operator, if successful, gains credit for Level 4 and becomes an assistant

Table 4

CONTROL TECHNICIAN PROGRAM

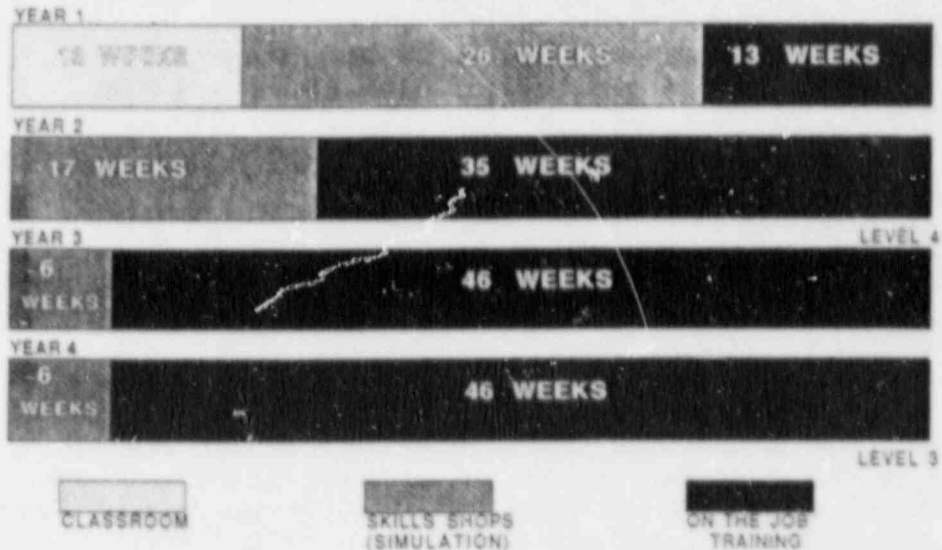
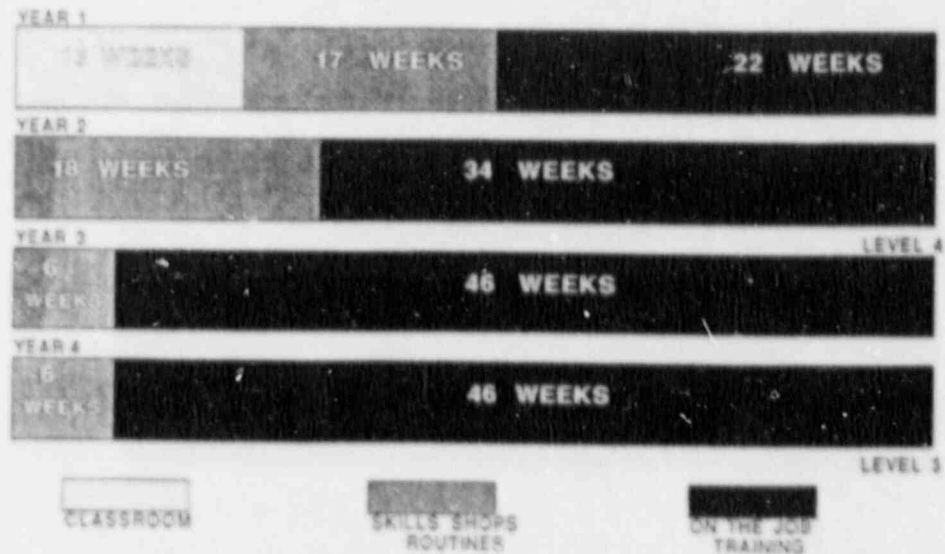


Table 5

NUCLEAR OPERATOR PROGRAM



operator. Level 3 training and field checkout when complete make the assistant operator eligible to become a second operator when positions become available.

Level 2 training involves Control Room First Operator authorization training as well as use of our full-scope control room simulators and will not be dealt with here.

The Use of Simulations

In the provision of skills training over the last 25 years, it has become clear that use of field simulations has been an important element in reliably achieving course objectives. They allow practice and testing under realistic situations, but in a controlled environment at no risk to production equipment.

Mechanical Maintenance Simulations

We administer regulatory testing for welding on site; however, it is one thing to do a weld on the bench and another to do one in our piping simulator. This simulator allows us to give practice in doing fitting and welding in realistic situations. The simulator changes shape constantly as practice needs and classes go through. The maintainer is given a blueprint and must construct the required addition to the simulator demonstrating the required skills.

In our hand fitting shop, we have an operating pump loop with horizontal and vertical pumps with mechanical seals. Trainees must take out work protection (eventually to be provided by trainee operators under proper surveillance). They must rig lifting tackle and remove and refurbish the pumps and seals, reassemble and align all to acceptable standards. In addition, we have fans, compressors and other equipment to practice skills on.

A flange testing apparatus allows the mechanic to make various types of flanged connections, (different gaskets, 'O' rings, victaulic couplings, etc.) use torquing patterns and pressure test the results.

In the machine shop, when the opportunity arises, we make spares for some station equipment and special parts to refurbish old workshop machines for use by ourselves or others. The jobs are chosen to demonstrate or practice performance in the objective testing areas including machining, heat treatment and quality testing.

Control Maintenance Simulations

In the control maintenance shop we have a considerable number of field simulations. I have chosen the following examples.

The setting of limit and torque switches on large valves is critical to production and safety. For the various main valve types on site we have operating valves in our shop. Limits are set by the normal field procedure including head set communication. We have

all main types of electrical breakers in use on site feeding the various live pieces of equipment, where possible. This gives the opportunity to work not only on live equipment such as for maintenance and set up of valve actuators, but also the opportunity for realistic breaker maintenance modules and for operator training in applying isolations on breakers such as a 13.8 kV breaker.

In our electronics shop we have operating inverters and rectifiers to troubleshoot as well as other station electronic equipment and computers. In our instrument shops we use computerized process simulators for demonstrating various concepts to initial trainees; however, hands-on skill reinforcement comes from hardware field simulations varying from a simple bubbler indication loop to an array of more complex loops involving the majority of instrumentation the trainee will come across. These loops demonstrate cascade control, feed and bleed control, three element boiler level control and a rather complex enthalpy control loop. These and others are resident on a panel and are wired through a control distribution frame to various operating field loops. We have a whole array of field equipment and controller faults we can put on these loops to simulate characteristic faults found at the stations. This allows us to realistically test the capability of more advanced students to operate, tune and troubleshoot a large variety of different instrumentation without risking station reliability or safety.

Operator Simulations

The field operators make use of a number of the operating loops in the control and mechanical shops. They learn how the equipment functions, what it does and how to operate, isolate and apply work protection. An example in the control maintenance area that the operators make significant use of is a 25 kW operating steam turbine-generator, used to demonstrate load angle and the effects of changing excitation as well and to practice synchronization techniques using systems found in the stations.

Operators can also use a reactor channel feeder pipe freezing simulator to ensure complete knowledge of techniques used in high hazard areas of the station.

Radiation Protection Simulations

All major job families receive radiation protection training as part of initial training. As well as theoretical knowledge passed on in the classroom, initial field skills are taught in a simulation area using multiple movable sources to demonstrate and test proper survey techniques with the array of instruments available.

A rubber area is set up by the trainees and is used to demonstrate control of loose contamination by using fluorescent

powder to demonstrate and test techniques used to prevent spread of loose contamination. Field experience and station-specific training is also necessary to gain full qualification as with all the other areas.

Fire and Rescue Training

Development of competent fire and rescue crews is an important part of skills training. Our graduation exercise tests the ability of the crew to protect themselves against, fight and extinguish a large petroleum-based fire fed from multiple sources. We also demonstrate safe techniques in fighting electrical fires. An electrical grid is charged to 13.8 kV and through monitoring nozzle current, we can demonstrate the protection effectiveness of the spray pattern when fighting electrical fires. Rescue techniques are demonstrated and practiced in typically awkward smoke-filled areas. These simulations are essential to developing the skills, teamwork and confidence to deal with potential emergencies in our field departments.

Conclusion

In the time allowed, I could only acquaint you with a very brief overview of our skills training program and a sampling of the simulations we use to objectively identify that a person is capable of doing a job in realistic conditions. Perhaps this has spawned some ideas. I would be happy to discuss what we do further and would like to hear what others do.

APPENDIX I

ONTARIO HYDRO NUCLEAR TRAINING PROGRAM

TABLE A - Training and Development Requirements by Position

<u>Major Family</u>	<u>Position</u>	<u>Certification Code</u>
Management and Professional	Superintendent	NTS-1A
	Shift Supervisor	NTS-1S
	Technical Supervisor	NTS-1
	Assistant Technical Supervisor*	NTS-2
	(Junior Engineer In Training)	-
Nuclear Operator	Shift Supervisor	NS-1
	Shift Operating Supervisor	NS-2
	First Operator	NO-2
	Second Operator	NO-3
	Assistant Operator*	NO-4
	(Trainee Operator)	
Control Technician	Control Maintenance Supervisor	CS-1
	Shift Mtce Supervisor - Control	CS-2
	Senior Shift Control Technician	NC-2
	Shift Control Technician	NC-3/4
	(Shift Control Technician Trainee)	
Mechanical Maintainer	Mechanical Maintenance Supervisor	MS-1
	Shift Mtce Supervisor - Mechanical	MS-2
	Foreman/Subforeman	NM-2
	Journeyman*	NM-3
	Improver	NM-4
	(Learner)	

For each position, a Certification Code identifies a set of training development requirements.

* New hires are trained for positions marked with an asterisk. Progression beyond that is based on selection for further training and promotion.

APPENDIX 1 (continued)

TABLE B - Training and Development Requirements - New Hires*

	Assistant Technical Supervisor (Hours)	Assistant Nuclear Operator (Hours)	Control Technician (Hours)	Mechanical Maintainer (Hours)
<u>Knowledge</u>				
Science Fundamentals	118	162	128	162
Equipment and System Principles	224	110	90	90
Protection (Conventional/ Radiation)	186	186	186	186
Management	52	*	*	*
<u>SKILLS</u>				
Initial Level 4 Skills	--	264	1,040	840
Common Level 3 Skills	--	*	680	1,320
Streamed Level 3 Skills	--	*	400/480**	400/920**
<hr/>				
TOTALS	580	722	2,520/2,604	2,978/3,498

NOTES: This table includes generic training common to all locations. Specific training is given at each field location in addition to that outlined here.

* The table does not include training beyond positions marked with an asterisk in Table A of this appendix.

** Depends on stream selected.

THE ROLE OF COMPACT ON-SITE SIMULATORS IN SWEDEN

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Abstract

The scope and methods for nuclear power plant training have, in the past years, been subject to great changes. In addition to the traditional methods of on-site classroom training and replica-simulator training at the training center, the use of STUDSVIK's compact on-site simulators have continuously been increasing in Sweden. The on-site compact simulators are presently used as a regular and indispensable part of the operator training programs for the Forsmark, Oskarshamn and Ringhals nuclear power stations, and the fossil power plant in Stenungsund. Also new staff categories are now subject to simulator training, and this is especially true for the maintenance personnel. New areas of application have arisen: man/machine interface development and testing, validation of new operator support systems, process analysis and prediction, incident rehearsals and emergency exercises.

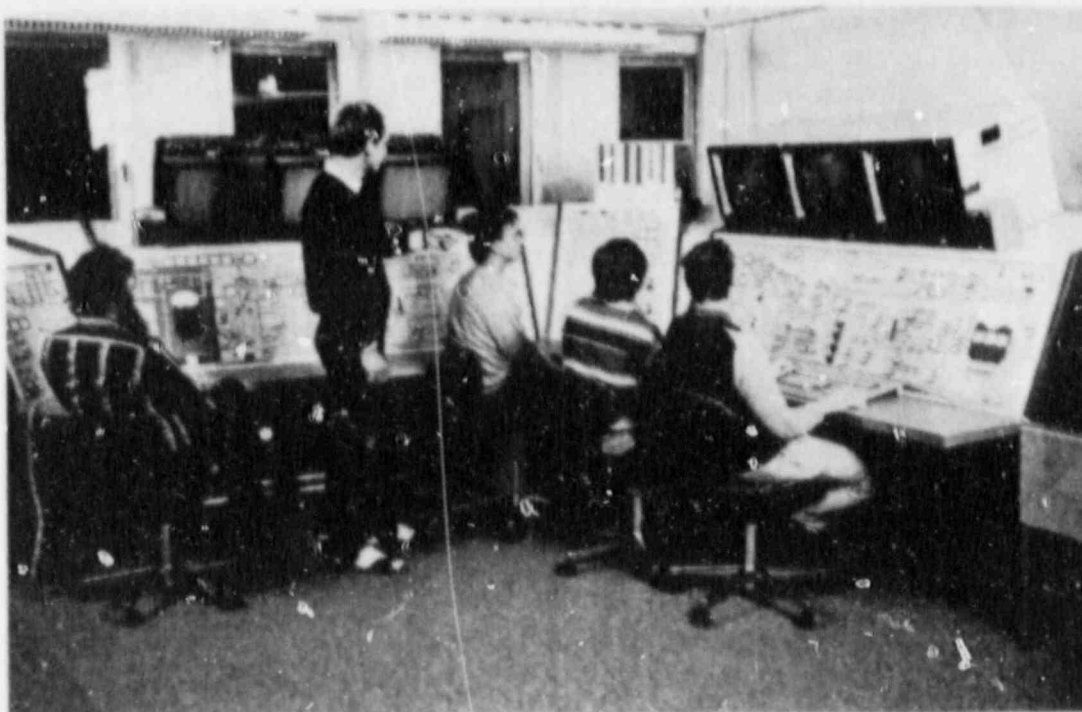
Acknowledgment: The experience of on-site compact simulator training as summarized in this report is mainly the result of contributions received from the instructors in charge, and this is gratefully acknowledged. Especially to be mentioned are: Reima Harju, Lars Sjulander and Nils Borje Jonsson at Forsmark; Hakan Andersson and Henry Sundstrom at Ringhals; Anders Morling and staff manager Anders Jervehed at Oskarshamn; and Morgan Halvarsson at Stenungsund.

The STUDSVIK Compact Simulator

The history of STUDSVIK's compact simulators goes back 15 years in time, when engineering models of the BWR and the PWR plants in Sweden were connected to simplified instrument panels, and used in training sessions as a supplement to the theoretical courses in reactor physics, process hydraulics, and nuclear plant control for operators. Since the first on-site compact simulator was installed in 1979, a remarkable development has taken place both in the scope of simulation and in the way the simulators are used. This simulator is a pioneering example of the application of a non-replica simulator.

Right from the beginning, the emphasis was laid on developing and designing the STUDSVIK compact simulators to convey a deeper understanding of the process mechanisms and the

interrelationships between the various systems. For this reason, the simulator had also to include equipment for routine operational maneuvers. Over the years a number of reports (1-3) have been presented, describing the various steps of compact simulator development and use. A typical example of the ongoing advancement is represented by the second version of the Forsmark 1/2 compact simulator, delivered in 1985 and shown in Figure 1.



TRAINING SIMULATOR INSTALLED AT FORSMARK NUCLEAR POWER STATION UNIT 1 AND 2, 1985

Figure 1

There are three specific areas in which development of the STUDSVIK compact simulator has taken place:

Software Development

The software part of the compact simulator has continuously been expanded, and today contains a plant system reproduction and fidelity which is essentially equivalent to that found in modern full-scope simulators. The expanded requirement of computer capacity has been well met by the parallel advancement of the speed and memory capacity in commercial minicomputers.

Recently an important addition to the software package was introduced. The Fuel Rod Process Simulator (FRPS) (4) is a software module designed by Studsvik for the very fast and reliable simulation of nuclear power water reactor fuel performance. It is

based on the worldwide data base that exists today and which, to a large extent, is a result of the sophisticated in-reactor fuel testing carried out at Studsvik. The FRPS may be used as an integrated part of the Studsvik compact simulator, but may also be used as an independent software package for tracking fuel rod performance under specified operating conditions. The FRPS is, thus, a tool for training, control room information and analysis of fuel management problems.

Colorgraphic Systems

The graphics system, with color VDU's connected to the scaled down instrument panels, constitute the basic divergence of the compact simulator from the full scope simulators. The signals displayed by the panel instruments represent, in general, results of complex control (mostly automatic) procedures and process responses, and the purpose of the graphic systems are to visualize most of the details of these events.

Two colorgraphic display systems can be employed, one or both of which, by the compact simulators. One is a full-graphic system developed by STUDSVIK, and the other is a semi-graphic system, developed by ASEA and comprising an advanced editing capability.

Extensive efforts have been placed in developing the organization of the display system and the layout of the various VDU pictures. The library of pictures includes displays of parameter-time-functions, trend curves, space functions (control rod positions, fuel pin expansion, a.o.), design structures, flow schemes, control schemes, logic schemes, etc., each with information which can be dynamically updated. The limits of expanding these information features cannot yet be seen.

Training Manuals

The third area of development applies to training documentation, the necessary support both for classroom and for simulator training sessions. It is the experience of the simulator instructors that a full exploitation of the simulators cannot take place, because of the time required for the preparation of the training sessions. It has been mentioned that, of the available simulator time, about 30% is allocated to course preparations and about 40% to training sessions. The residual 30% is utilized by staff members, especially the operators, who perform individual operational studies and training runs.

The utilities have carried out an intensive program for the production of textbooks and training manuals, to which STUDSVIK has also contributed. The principal aim of the on-site compact simulator, which is to facilitate a deeper understanding and

proficiency among the operator staff, does not put any constraint on the applied simulator display techniques, as would be the case if a close control room replication had to be maintained. Instead, characteristic of the compact simulator is that new training capabilities are continuously added to the system. As a consequence, new instructor support materials and training manuals have to be produced. Many years will probably still be needed before a substantial reduction of the phase lag between these two activities can be achieved.

Training Experience

The normal organization of the on-site compact simulator training by the utilities is the allocation of one (sometimes two) dedicated instructors for each simulator. The instructors have many years of experience as senior reactor operators, i.e., as shift leaders. The training requirement is based on the fact that each reactor unit is manned by seven shift groups, each group comprised of one shift leader, one reactor operator, one turbine operator and one control room technician.

The capability of the modern compact simulators in representing so many details of the systems, even in their dynamic contexts, has placed greater demands on the expertise of the instructors. However, these demands have not been met by previous requirements of instructor experience. Greater knowledge of system design and inherent system functions requires, thus, a much longer time for course preparation than would be expected.

There is an opinion among the instructors that the training on compact simulators both supplements and enhances the training on the replica simulators. It has also been speculated why not the initial training programs for operators to a much greater extent make use of compact simulators.

It is interesting to note that the early, more restricted versions of the compact simulators, like the first Forsmark 1/2 on-site simulator (installed 1980), were accepted by the operation staff as a useful tool in the initial training program, but to a lesser degree for re-training courses. The later, more advanced simulators, like the second version of the Forsmark 1/2 simulator (installed 1985) turned the attitude and instead resulted in a demand for more frequent retraining courses than the instructors, time-wise, were capable of. There exists, therefore, a threshold effect of increased simulator sophistication.

In practice, the effective time available for on-site training is limited to about seven months a year. This is due to vacations, plant revisions (re-fueling), holidays, and so on. Another administrative bottleneck in the extent of the simulator

training program is the limitation of instructor availability, even as shift leaders of the operator crews (on a loan basis) are acting as instructors for the initial training programs.

Operators with long term experience in control room work sometimes tend to fail more often. The explanation of this is probably a complex matter, but one reason seems to be the rare opportunities to perform some of the routine operations, such as start-ups and shut-downs. These procedures are intricate and require a memorization of many details. Fresh operators have the advantage of more recent training in these procedures. The present programs for re-training seem thus not to place an adequate emphasis on the exercise of this type of routine operation.

As a remedy for this inadequacy, a proposal is made that the compact simulator should be equipped with certain full-scale panels, which would allow realistic training of specific reactor and turbine operations. The suggestion has the interesting aspect of combining the STUDSVIK conceptual compact simulator with the French approach of a part-task simulator.

The procedures, during normal base load operation, to carry out regular tests of various components and system functions often give rise to reactor and turbine trips. The circumstances contributing to these undesirable events are often due to shortcomings and weaknesses in factors such as operator communication, administration procedures, control room ergonomics and personal relationships. These elements are difficult to counteract by training, when present-day simulator techniques are applied. However, in Sweden, a research program is considered aiming at harnessing this problem.

Another communication problem, which instructors are well aware of, is caused by the fundamental difference in operational approach which is exercised by the reactor operators and the turbine operators. It is the task of the instructor to bridge this inadvertency during compact simulator training sessions.

The control room operators may sometimes face difficulties in properly identifying the actual operational condition and, therefore, in correlating this with the relevant instructional procedures. The training sessions with the compact simulator have brought up this problem, and there are cases where the written procedures have to be revised as a result of these exercises.

An obvious and important result of the on-site compact simulator training as witnessed by the instructors, is that the operators have a greater certainty and self-confidence in their work in the control room, and are thus better fitted mentally to their tasks.

Results of On-Site Training

The complex nature of the nuclear plant designs and the way these normally are operated make it very difficult to correlate the impact of the compact simulator training with failure rates during operation. The statistics will always be too poor. However, in order to illustrate the tendencies, some relevant results from the use of the compact simulator in a fossil plant will be referred to.

The Stenungsund Power Plant consists of four oil-fired units, with an installed power capacity of 820 MWe. The plant is operated as a peak load station and also as a standby plant, in case of failure in the national grid or in the normal production units. The requirement of operating skill is high in this stand by plant, not least because the demand for a fast start-up often is urgent. And yet, there could be many months while the station is standing idle.

A STUDSVIK compact simulator was installed at Stenungsund in 1983. This simulator happened to be the first version of a compact simulator which combines the basic idea of a conceptual trainer with a replica formed operator's console. An extensive training program has been conducted since February 1984, and the training impact analyzed, based on one and a half year's experience. The results will be presented here.

One clear impact of the simulator training was that the accumulation of knowledge in system functions and proficiency in plant operation was speeded up considerably. The reported observation is illustrated by Figure 2, which shows that the gain

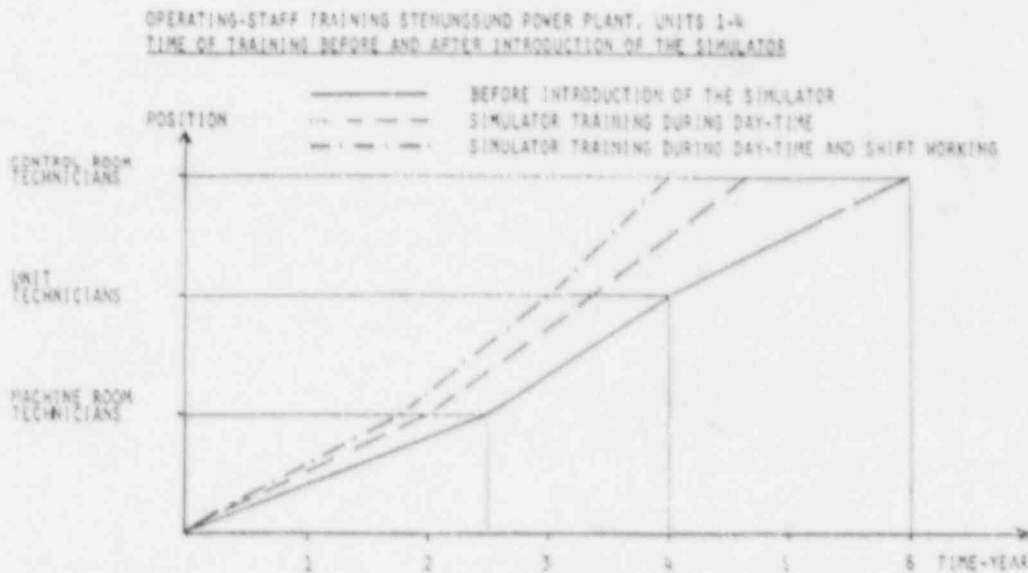
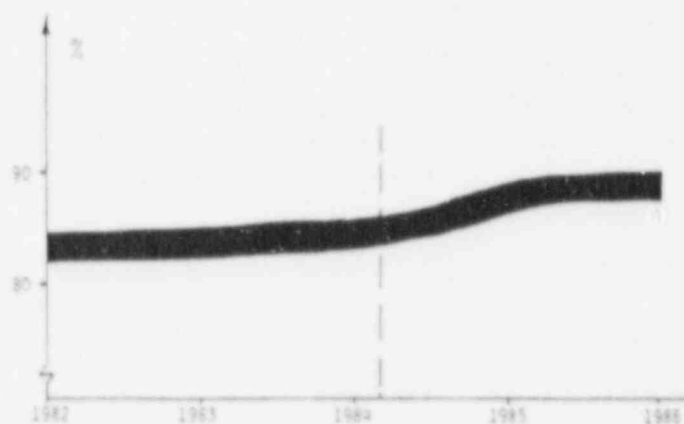
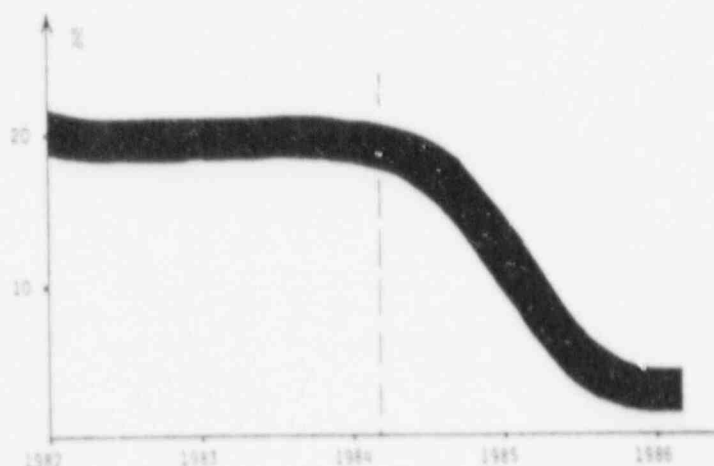


Figure 2

in time to reach the operator competence can be up to two years. The present opinion of the nuclear plant instructors is that this gain rather be used to increase the competence level of the operator, instead of shortening the training schedule. A dramatic decrease of interruptions in the nuclear plant production, caused by personal mistakes, was observed at Stenungsund, and this is shown in Figure 3. The role of the simulator training is manifest, as the training program included the compact simulator exercises from February 1984. One may note that it took one year's time to achieve the full bonus of the simulator use. The instructors at nuclear power plants confirm that they have experienced the same tendencies after the installation on-site of the advanced versions of the compact simulators. It is, however, from statistical point of view, difficult to provide this correlation.

Figure 3. Service Interruptions Caused by Personnel Mistakes

Figure 4. Availability of Operation

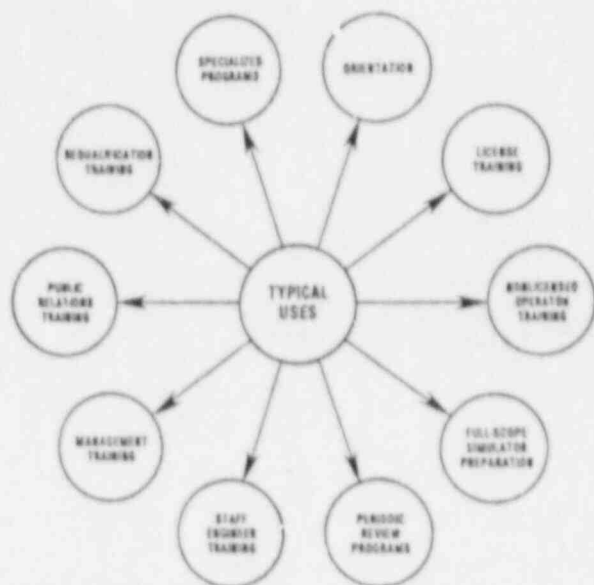


The above described decrease in unanticipated interruptions of production service has of course a bearing on the availability factor of the plant. The resulting increase of the Stenungsund plant availability is shown in Figure 4.

Application of Compact Simulators

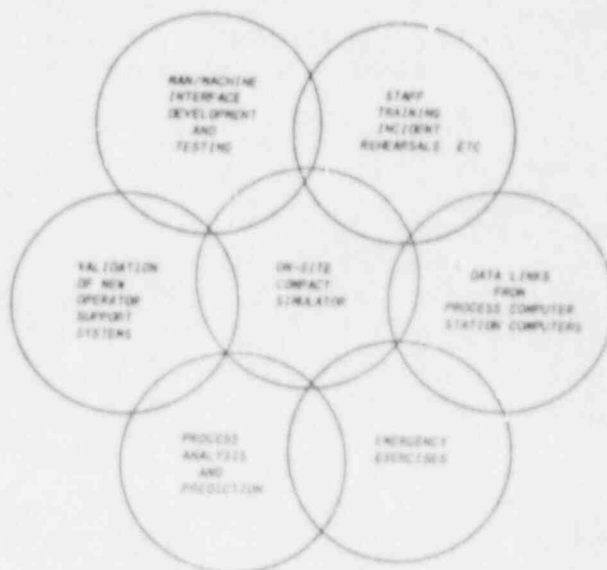
The compact simulator is not expensive, compared with a replica simulator. It is easy to handle and flexible in giving access to detailed process information. Furthermore, its aim for conceptual presentation of the systems and their functions makes it natural to expand the scope of its use. The condensed panels and display systems do not overwhelm the trainee in the way the replica simulator might do. Therefore, various forms of training can be easily implemented with the simulator, and various categories of staff may be involved. See Figure 5 for application examples.

Figure 5



STUDSVIK ON-SITE COMPACT SIMULATOR
USE IN TRAINING.

Figure 6



EMPLOYMENT OF THE ON-SITE STUDSVIK
COMPACT SIMULATOR.

The characteristics of the compact simulator, including the notable degree of fidelity and accuracy, make it well fitted for employment in a number of other areas. Many of the pertinent applications are interrelated, as illustrated in Figure 6. The main areas, apart from training are:

- * Process analysis and prediction
- * Man-machine interface development and testing
- * Development and validation of new operator support systems
- * Emergency exercises, based on initial conditions, set by a data link from the actual process unit to the compact simulator.

The above mentioned applications stand at various degrees of development and exploitation. It will be the undertaking for future meetings to discuss the experience of these applications.

Discussion

MR. HANDLEY: What is the cost of the compact simulator?

MR. BLOMBERG: It varies considerably, but ranges from \$700,000 upwards for a complete system.

MR. HANDLEY: Is this an advanced machine? Is it still part of C. E. Studsvik and is it a multiple-loop or single-loop simulator?

MR. BLOMBERG: The C. E. Studsvik is mothballed presently. So it is Studsvik alone who is marketing this. The simulator equipment has multiple loops when necessary, as it represents a full-scope software system.

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TRAINING METHODS AND FACILITIES ON REACTOR
AND SIMULATORS AT THE GRENOBLE NUCLEAR RESEARCH CENTRE

SILOETTE, TRAINING AND SIMULATION CENTRE

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Siloette is a CEA unit with a threefold vocation:

- o operation of the Siloette 100 KW pool-type research reactor
- o basic training in reactor physics for nuclear power plant operators.
- o production of nuclear power plant simulators: PWR, GCR and more generally of all types of industrial unit simulators, thermal power plant, network, chemical plant, etc.

From this experience, we would emphasize in particular the synergy arising from these complementary activities, the essential role of training in basic principles as a complement to operation training, and the ever-increasing importance of design ergonomics of the training means.

Introduction

Thanks to its three reactors, Siloe (35 MW), Melusine (8 MW), and Siloette (100 KW), the Reactors Department of the Grenoble Nuclear Research Centre has gained considerable experience in operation and use of research and materials testing reactors. It is within this general framework that the Grenoble Reactors Department has created a reactor physics training activity, based on the Siloette reactor and on teaching simulators, which has been running continuously since 1975 to cope with the increasing demand resulting from the development of nuclear power plants. (References 1, 2)

This activity is carried out in close collaboration with Electricité de France, as part of an overall training policy. Today, it has become a true training and simulation center, with nuclear and non-nuclear application. The following are carried out at the same time within a single unit:

- o operation of a research and teaching reactor
- o development and production of simulators
- o courses, lectures and practical work for training.

Siloette, Training Centre

Objectives and means. The experience acquired in neutronics and reactor physics predisposed Siloette to specializing in training in physical phenomena. This training forms a perfectly integral part of the nuclear power plant operators' training cycle, completing the reactor operation training given in the Electricité de France training centers, by training in basic principles.

Understanding physical phenomena is therefore now a very individualized objective, an indispensable basis for subsequently assimilating control actions in normal and, even more so, in abnormal situations.

In this respect, Siloette has the great advantage of having available two perfectly complementary types of training facilities.

- o The Siloette reactor. Siloette is a pool-type reactor with a power of 100 kW. The fuel used is enriched uranium in the form of aluminum-clad U-Al plates. The proportion of uranium in the U-Al amalgam varies from 22% to 26% depending on the plates. Control is by means of four Ag-In-Cd fork-type rods. The Siloette pool reactor is particularly suitable for training. This application has, in fact, now become its main activity. The fissile core remains visible during operation, and handling operations are very simple and can be directly observed by the trainees. The control panel is located inside the reactor confinement containing the pool, which enables all the operations being carried out on the reactor and the effects of the operating parameters on the neutron monitoring channels to be observed.

- o The associated simulators used for training have from the outset been designed and developed at Siloette in collaboration with EDF to meet well-defined objectives:

PWR: basic principle training
GCR: operation training

The GCR simulators (one per power plant) are the only ones in France for this type of power plant. They therefore have a much fuller role to play in training in normal and incidental operation, at an intermediate level between full-scope and basic principle simulators.

PWR Training. The courses, which last one or two weeks, are intended both for confirmed operators and for trainees whose first contact it is with the nuclear field. They comprise practical exercises on reactor and simulator. Naturally, the commentary given by the instructor is adapted to suit the audience. Each practical work session is arranged for a team of five or six trainees (limit purposely set for reason of teaching efficiency and safety conditions inside the reactor).

The following exercises are proposed on the reactor:

- o Approach to criticality:
 - seeking the critical mass by loading fuel elements
 - Seeking the critical position of the control rods
- o flux and power measurements:
 - vertical flux distribution with or without disturbances (display on a multichannel recorder)
 - transverse distribution in the mid-height plane in various media (fuel, water, aluminum, etc.)
- o reactivity measurements:
 - control rod calibration by different methods (period or reactivity meter)
 - fuel element worth measurements
 - reactivity balances

On the PWR simulators, the program, which is more flexible, is built around the following topics:

- o Cold reactor kinetics
- o Approach to criticality with search for the critical boron content.
- o Control rod and boron calibration.

Determination of the integral and differential worth of the clusters and the differential worth of the boron by means of test procedures applied to power plant hot tests.

o Temperature effects:

showing up the Doppler and moderator effects by power variation;
influence of the value of the moderator temperature coefficient on the reactor behavior;
showing up the reactor autostability;

o Contractual load variations - house load operation

load variations with and without automatic control by means of the control rods;

steam by-pass circuit studies for important load variations up to house load operation.

GCR Training:

o Normal operation:

start-up from a reference state of the reactor:

-cold state: the reactor has been shut down for more than 24 hours, decay or absence of xenon;

-hot state: xenon poisoning is taking place in the reactor due to a rod drop

load reduction for shut-down of the groups

power variation in normal operation

o Incidents:

fan failure
feed pump failure
tripping of one or two groups
thermocouple failure (control variable)
pressure sensor failure

o Accidents:

CO₂ leak - depressurization
high relative humidity
uncontrolled control rod movements
loss of blowing capacity

Appraisal of the training. The ever-increasing number of trainees attending the courses since 1975 reveals the impact this

training has had. Thus in 1986, over 600 trainees followed courses at Siloette. This training is mainly intended for engineers and technicians appointed to responsible positions in power plant operation:

- o Engineers, technicians, supervisors and foremen from Electricité de France
- o Nuclear power industry engineers (Framatome, A.C.B., Creusot-Loire, Merlin Gerin, etc.)
- o Nuclear Engineering students from Grenoble National Polytechnical Institute and from the University

Substantial efforts are also made to set up similar training courses for the benefit of engineers, technicians and students from foreign countries (Belgium, Spain, Algeria, Great Britain, Pakistan and so on).

Siloette Simulation Centre

General. The variety of the objectives pursued, from training in basic physical phenomena to control in normal or incidental situations has led us to develop different types of simulators, a few examples of which will be described here:

- o nuclear field (simulators associated with training on Siloette reactor)

PWR basic principle simulator

operation simulator for the French GCR-type power plants: St. Laurent, Bugey, Chinon

- o non-nuclear field

general oil/gas/coal thermal power plant simulator

electrical distribution network simulator

PWR simulator:

Design. The aim of these simulators being to show up physical phenomena, their design purposely favors the display means (recorders, plotting table, screen), simplifying the controls to leave the operator more freedom. Three simulators of this type have been manufactured for Siloette's own needs. A fourth was delivered in February 1987 to the Petten Nuclear Research Center in the Netherlands. Finally, a version of the simulator controlled by a fully graphic interface (DEIN) on BULL computer equips the INSTN at Saclay.

The simulator hardware configuration comprises the following main component parts:

- o a GOULD SEL 32.67 32-bit computer (throughput - 1.5 Mips) and its peripherals
- o a Computer Products RPT Input/Output System housed in the base of the desks
- o a central desk supporting the mimic panel and control-monitoring panel
- o a recording station (3-channel recorders and plotting table)
- o a graphic station comprising:
 - a high-definition monochrome graphic console
 - a high-definition color graphic console controlled by an HP320 micro-computer.
 - an instructor station

Simulation scope. The simulation program enables the operation of a PWR power plant to be studied, in real time or in accelerated time. The model used describes the essential parts of the power plant which are necessary to calculate the main physical parameters:

- o Core: one axial dimension model (neutronics and thermics) enabling control rod movements, Xenon poisoning and flux and temperature distributions to be simulated
- o Primary circuit piping: 2 loops, one of which is real
- o Pressurizer (two non-equilibrium phase model)
- o Chemical and Volume Control Circuit (simplified model)
- o Residual Heat Removal System
- o Safety Injection System (high and medium pressure)
- o Steam generator: single axial dimension model representing the different areas (feedwater supply chamber, down channel, riser, separator and dome)

- o Normal and emergency steam generator feedwater supply
- o Plane array model of the secondary circuit comprising the atmospheric steam dump, turbine-driven feedwater pump supplies, generator by-pass and supply.
- o Turbine-generator
- o Control channels:
 - Primary mean temperature regulation by control rods
 - Primary pressure regulation with heaters and spraying
 - Pressurizer level regulation
 - Chemical and Volume Control System tank level regulation
 - Residual Heat Removal System discharge temperature regulation
 - Steam generator level regulation
 - Turbine steam by-pass regulation

GCR power plant control simulator:

Design. The simulation system is based on a GOULD-SEL 32.87 computer (throughput - 3 Mips). The control desk comprises three parts:

- o the control and monitoring block, a diagrammatic representation of a GCR-type power plant desk enables the functions selected for simulation to be carried out
- o A display unit, essentially comprising a graphic terminal, for representation of internal variables or any other edited variables, selected by the operator (Doppler effect, Xenon effect, etc.)
- o The instructor's desk used for control of the simulation and introduction of the faults and incidents studied.

Four versions of this desk exist representing the four types of GCR reactor in operation at the present time:

- o Saint Laurent des Eaux
- o Chinon 2
- o Chinon 3
- o Bugey 1

Simulation scope. A list of the main models used to simulate a GCR power plant is given below:

- o Neutronics: two kinetics models are used to process power generation by the reactor:
 - one-point kinetics
 - space kinetics in 2D geometry (R,0) and (R,z) according to a layout ensuring a satisfactory representation of the power space variation phenomena.
- o core thermohydraulics: this model describes the heat transfer in the fuel cartridges (uranium, cladding) and the cooling fluid.
- o exchanger thermohydraulics: this model processes the heat transfer from the carbon dioxide to the secondary fluid for the production of steam.

Important developments are currently being undertaken to account for extended accidental possibilities.

Thermal power plant simulator. Simulation activities at Siloette have quite naturally been extended to the conventional thermal power plant field. Thus a 3-fuel power plant simulator (oil, gas, and coal) has just been produced for the Karachi Electric Supply Corporation in Pakistan.

An extremely comprehensive system is involved based on two GOULD-SEL 32.67 computers, one performing simulation, and the other being available as immediate back-up by means of a peripheral switch cabinet. The control room houses:

- o three trainee desks
- o a mimic panel
- o an instructor station
- o a line printer

The software is highly developed: it enables operators to be trained in all shutdown/startup operations and in a large number of incidental situations.

Finally, the essential feature of this simulator, which makes it a truly avant-garde product, is the care taken over the aesthetic appearance and ergonomics of its design, as far as both the desks and the software environment are concerned. In this respect, we can really talk of a new generation of simulators for which,

reliability and performances having already been successfully accomplished, utilization ergonomics becomes the determining criterion.

Network simulator. The natural complement to the thermal power plant simulator, the CEA has just perfected an electrical distribution network simulator. This comprises:

- o a GOULD SEL 32.67 computer
- o a control-monitoring desk
- o an instructor station

A version comprising one main grid station and five sub-stations is due to be delivered to the Karachi Electric Supply Corporation, but any electrical distribution network layout can be implemented by means of a software defining the elementary components, busbars, circuit breakers, disconnecting switches, transformers, generators, loads, transportation lines.

The simulator can be used either in "free operation" mode or in "pre-programmed sequence" mode.

Human factors study simulator. As part of the development of the computerized control rooms of the N4 plant series (1450 MWe), studies have also been carried out at Siloette in collaboration with the Grenoble University (LAB-SYS) on behalf of CEA/IPSN and EDF/Design and Research on man-machine interfaces. (References 3 and 4) In order to enable realistic tests to be carried out with operators in incidental situations, a simulator of the chemical and volume control circuit function of a PWR reactor has been developed. The model can be connected to two different control interfaces, a convention desk or a graphic color system.

Series of incidental tests (a different experienced operator for each test) were carried out on each of these two interfaces. They enabled the following to be drawn up:

- o design rules for control images adapted to the tasks in incidental situations
- o desk-screen comparisons related to the problems involving the interface only and those also taking account of the operator's knowledge and reasoning.

These results will be published shortly. The study is being continued with tests on a mixed desk and screen interface with teams of two operators and tests on graphic interface with an imagery of a new design to facilitate control and diagnostics in incidental situations.

Micro-simulator. The computing capacity available on the new 32-bit microcomputers (Motorola 68020 type processors) now enables them to support highly developed simulation models. by equipping them with a 19-inch graphic color screen, we can produce a "micro-simulator" with the main advantages of which are:

- o very low cost
- o no dimensional constraints or environmental requirements
- o no specific investment apart from a standard scientific computer, an HP320 or SUN110 for example
- o possibility of running other simulation models on the same hardware support.

A first PWR version has thus been produced in 1986. The computing performances are remarkable considering the low cost of the computer: real time perfectly respected, large acceleration possibilities, very high-speed image display (approximately two to three seconds). The software is modular: the complete power plant model comprises one-point axial core, pressurizer and steam generator model; it is intended for operators in the initial training stage and also for anybody wanting to get a general idea of the principles of a nuclear power plant.

More detailed separate modules of the core, pressurizer and steam generator give confirmed operators the possibility of visualizing the main neutronic and thermohydraulic physical phenomena. Finally, very great care has been taken to make the software user-friendly and the images and actuation procedures user-convenient.

Other developments. A large number of other applications are scheduled or at present being developed in as widely varying fields as fuel reprocessing, chemistry, oil refinery, conventional thermal field, nuclear safety (simulation of radiation monitoring boards for training of radiation protection personnel), and so on.

Conclusion

The originality and effectiveness of the Grenoble Reactors Department training activities is based on the equipment used (reactor and simulators).

Reactor. Over the years, the value of a Siloette-type reactor is increasingly appreciated. It is a high-performance means

of demystifying the nuclear field, has low running costs, is flexible to use (not being subject to any of the disturbances resulting from the multiplication of irradiation experiments, as is the case in a test reactor), and enables all kinds of useful activities to be developed.

The possibility of combining training activities smoothly with research, as well as physical studies based both on calculation and measurement, is also a valuable asset.

Simulators. The result of several years experience in training in close collaboration with EDF, the simulators have become irreplaceable training instruments in the field of nuclear power. They are nowadays low-cost training means, which are easy to reproduce, and flexible and relatively simple to use.

This experience can now be put to use profitably in the non-nuclear field where the range of possible applications remains very wide indeed. The roles of reactor operators, physicists, computer scientists and instructors performed by the Siloette staff constitute a very large and varied capital asset of know-how and experience enabling the training given to have both the theoretical and practical dimensions which all the trainees are looking for and appreciate.

References

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Discussion

MR. BUDNICK: You mentioned the cost of the micro-simulator, and I wonder how a utility goes about justifying the cost on a cost-versus-economics study basis? Is it possible to show a return so that you can quantify for the operators the gain that you will receive when you purchase one of these smaller machines?

MR. SIEBERT: Can we calculate how much we will save?

MR. BUDNICK: You obviously did that with your company, but from a commercial standpoint you said it was "low cost." The problem we face is justification that there is gain for our people, in a quantified way, if we purchase one of these smaller machines.

MR. SIEBERT: I think a big advantage of this machine is that it can be installed directly in the control room of an industrial power plant. So the advantage is, when operators are not completely focused on operations, they can use the training device. This would save a lot of time and the problem of trying to send operators away from the job for a week or so to a training center. Also, from the point of view of re-training and ensuring constant attention of the operators, it is very interesting to have an instrument available on site.

MR. TANGY: If I may add, as a user of micro-simulators, it is very difficult to make a cost-benefit analysis of such a device in the training frame of reference. Currently it is well known that operators may train for a week or two each year on full-scope simulators, and it is obvious that this is not enough, not so much in terms of time, but in terms of quality. One drawback of full scope simulators is that you can get too far from the basic principles of reactors. During the last two years in France, we have had significant incidents, such as criticality and dilution, which show there is a lack in our training system regarding the main, simple principles. It is difficult to bring people to a centralized training center more than two weeks a year, but it is good to have simple tools on site that can be used with the help of safety engineers and shift supervisors. So it is difficult to think in terms of cost-benefit, but we think, as users, that this type of tool is very helpful.

ARTIFICIAL INTELLIGENCE AND TRAINING OF NUCLEAR REACTOR PERSONNEL

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Abstract

Expert computer systems offer an excellent and effective means to reduce the potential for operator error, and improve plant safety and reliability. For the training field the benefits are twofold. First, the inclusion of advisory expert systems in the control environments (the physical control room and its simulator) offer a continuous source of on-the-job diagnostic training. Second, expert systems specifically designed for training are feasible for specialized license/requalification training in higher order analytical skills.

This paper consists of two parts. In the first section, the improvements for on-the-job training are examined. In the second section, the benefits for the overall training program are explored in terms of technical and educational rationales.

Introduction - The Case for Expert Systems

The application of Artificial Intelligence technologies, particularly Expert Systems, to control room activities in nuclear power plants can reduce the potential for operator error and enhance plant safety and reliability. Great quantities of numeric, symbolic, and qualitative information are handled by the reactor operators, even during routine operation. Typically our concern focuses on optimum performance for three major possibilities: emergency, abnormal (or "off-normal"), and normal conditions. Each of these conditions is defined by characteristic recognition factors, controls, and plant responses. Proper recognition, in turn, depends upon rapid analysis of a multitude of processes and systems. The sheer magnitude of the numerous process parameters and system interrelations itself poses additional difficulties. In an emergency, this can lead to information overload with a resultant deterioration of operator performance and the potential for severe consequences. In abnormal circumstances, it is the efficiency and effectiveness of the man-machine interface that is key to the

stabilization of the plant. Ultimately, the smoothness with which such stabilization can be re-established is dependent upon the facility with which available raw data can be converted to, and assimilated as, meaningful knowledge to combat the abnormality and prevent any safety degradation. Even within normal reactor operation, how well the routine data are interpreted, analyzed, and applied to physical plant evolutions and trends is an index of reliability. Expert systems can be designed to provide exact and consistent analysis for operator use for each of the above cases.

In past years, the issue of on-shift expertise has been recognized as a key ingredient to the industry goal of safe and reliable power. A host of activities in the 1980's has greatly assisted in the improvement of available data and expertise. However, a particular facet of the goal of upgrading both expertise and performance has been difficult for some plants and elusive for many. The training problem has been to find means to both improve and standardize the diagnostic abilities of different shift operating crews -- under all postulated scenarios - with regard to efficiency, rapidity, accuracy, and consistency of needed diagnoses. To provide valid, repeatable instruction in these areas, verifiable and quantifiable training techniques are required. Finding reliable diagnostic training techniques has been difficult. The elusive element of a standardized approach to event diagnosis stems from the very randomness with which actual events can occur.

To address this disparity between the established training program and actual operations, the nuclear community relies heavily upon a well defined group of training scenarios repeated regularly over the course of licensing and requalification. Such well-constructed training schedules ensure that major event categories, should they occur, will have been addressed in an analogous training scenario in the recent past. The comprehensive work involved in constructing such programs has provided valuable benefits with regard to the ability to address major postulated events. Ultimately, however, the cumulative number of scenarios and pertinent variations that can be represented in such a cyclic program are limited. Thus, for certain less severe occurrences, sequential series of events, or major event variations beyond the scope of the simulator, the field experience needed for any one event may not be available to the extent desired. As a further complicating factor, human-factors research has delineated a number of "human controller" characteristics that may further diminish timely or standardized diagnostic performance under any plant condition. For postulated cases with associated masked conditions, anomalous responses or spurious conditions, a valuable role exists for methodologies to improve the knowledge gathering process (vice simple data accumulation). Any improvements thus made can enhance the human decision-maker's ability to function at the highest levels of cognition and awareness. As previously noted, expert systems are

designed to handle knowledge gathering comprehensively and supply meaningful information. But it is as a training tool that an expert system offers an innovative solution to the diagnosis training problem. For just as a consulting expert system can evaluate raw data, a training expert system can evaluate student responses and generate relevant advice and recommendations.

Training Benefits in the Control Environment

In this section of this paper we focus upon the operational and experiential benefits to be derived from expert systems use in the control environment. (By "control environment" both the physical control room and its simulator are meant.) These are two feasible means for such use; as either independent passive consulting mechanisms or as real-time monitors via plant computer display outputs. Our emphasis will be on the former.

Expert systems designed solely as passive sources of consultation for operators have a particular training value in the control room. Not only can such devices rapidly and consistently analyze plant conditions, but they also constitute a continual source of expertise and cost-effective training for a shift crew, when called upon to do so. A recent EPRI report (Reference 1) identifies sixteen of the most important and common problems by expert systems and concludes that only certain limited areas are appropriate for development at this time because of the large effort required. However this assessment is based on a view of expert systems development as a non-integrated project. Consequently, the report does not consider the fundamental and synergistic relationship between training and expert systems. Enhanced operations is not the only realizable goal of such systems. For as the operators work with a system, there is a constant exposure to and integrated examination of bases, limits, and system interrelations. The rapidity and reasoning ability of the expert system can free the human operator from the mere sorting of data, thereby giving him time for thinking and deciding at the highest cognitive levels. Expert systems implementation then, has the capacity to yield advantages in fields aside from safety and reliability of physical plant evolutions alone (Reference 2).

One of the features that makes an expert system so compatible with training goals is its ability to explain its own reasoning for postulated conditions given to it. All supporting evidence for machine opinions about systems or events can be cited, for final evaluation and decision by the human operators. The same software mechanisms can cue suitable supplemental actions based on the exact plant status. Additionally, applicable limitations, cascading concerns, and recommendations for subsequent investigation can be displayed by the system, again with justifying explanations available. Most importantly, an expert system can be built to

"recognize" its own limitations and thus inform the user. In such a complex environment as a control room, the system can and must guard itself from giving inappropriate information. All these special characteristics are notable for their rapidity, consistency, and interactive nature. These are benefits not offered by written procedures. Consequently, expert systems, as integral parts of on-the-job operations training, offer one means to train operators not only for strict procedural compliance, but also to recognize and postulate cases where procedures may no longer apply.

It is useful to review and expand some of the mechanisms by which such augmented experiential and cognitive (diagnostic) training is attainable. As previously noted, an expert system can greatly assist in the event of information overload. The advantage to safe operations is apparent. What is also included however is the increased exposure of an operator to more numerous combinations of conditions and permutations of readings associated with certain causes. The consistency with which an expert system will analyze is all the more valuable when it is noted that patterns, trends, and the cumulative number and quality of alarms and readings can be rapidly evaluated and presented to the user with meaningful priorities chosen. Regular utilization of such a tool offers a clear means to further train an operator in the prioritizing and discriminating of control room data. Additionally, the combination of continuously available expert opinion and diagnosis, and the interaction afforded, offers great improvement in an individual operator's independent capacity to penetrate so-called masked and/or spurious plant conditions.

The effect of an implemented group of expert systems is that of having a team of experts on continuous shift, but always subordinate to the shift crew. With this type of relationship, any combination of conditions or interpretations may be postulated, that may be technologically understood but unfamiliar to a particular shift crew or shift crew member. As the shift users come to challenge the expert system, numerous items may of necessity be reviewed, such as proper interpretations and applications of procedures, good operating practices, and plant management directives (night orders, standing orders, etc.).

The effect of expert system implementation in concert with training goals is a possible means to reinforce fundamental relationship, procedural bases and limits, and cover a wider range of problem sets than is presently done. From the educational standpoint, all such activities greatly strengthen both the deductive and inductive reasoning skills of the shift team. Moreover, since a system always presents an integrated view with its supporting evidence, this calls for a continual focus on integrated, safe, and efficient operation without loss or compromise of attention to details.

Ultimately, the use of expert systems can be expected to yield other benefits such as:

- o increased attention, discipline and intellectual experience level of the operators
- o an effective reminder for key concerns in times of stress or information overload situations
- o better performance in the application, analysis, and prioritization of key parameters and trend indicators.

It is further reasonable to expect more effective use of premium simulator time ("What if?" and "Why" answers are always on hand) and to use an expert system for incontrovertible records of decisions and the bases for decisions.

Before progressing to the specific use of training expert systems outside the control room environment, it is necessary to address an important concern, that of potential over-reliance by operators on such systems. While some degree of excessive reliance is possible, the safeguard lies in an integration of expert system's use into the full training program similar to the way in which written procedures are handled. That is, operators should be trained to access the expertise of the software as another tool for diagnostics. Proper use of an expert system, just as the proper use of procedures, is a skill fostered by good instruction. But further balancing any hazard of over-reliance are those two essential features lacking in written procedures:

- o the ability to flexibly and directly explain present reasoning
- o to recognize limitations.

Expert Systems Specifically for Training

The advantages realizable from using expert systems in the control room environment provide even more appropriate and across-the-board benefits if specific training systems are considered. The cost effectiveness of the use of interactive tutorial systems within the licensing/requalification paths can be very significant. Before listing some of these advantages, it is valuable to consider the technical and educational psychology factors supporting such an addition to present plant training efforts.

The training benefits attainable from expert systems used in the control environments are largely derived from their continuous accessibility, and the manner in which it is expected that operators will want to challenge the system(s). With regard to the utilization

of these systems to license and requalification training, we invert the dialog. That is, instead of using the systems software to formulate decisions from plant parameters, we structure the expert programs to pose a situation to a student, lead him or her through a series of actions and decisions, evaluate the efficacy of those decisions, and ask him/her to diagnose or explain the final status. By then matching the trainee response to the actual conditions that result, a means to challenge and evaluate the student is thus provided.

The Technical Aspects

Such a training tool is possible because of the internal manner by which expert system software functions compared to the more traditional computer language programs (e.g., FORTRAN). Expert systems today utilize what is known as an inference engine to process near-natural language rules of analysis that consist of symbols which can be words or distinct concepts. In terms of training application, there is great significance in this structure. The symbolic processing, as opposed to programming by line commands only, allows actual concepts or intermediate analyses to be represented by symbols. Each symbol can be made accessible from any part of the program. In the final product this translates to a relatively small program for a great quantity of numeric and/or symbolic knowledge. Rules provide a direct means to set and establish interrelationships between defined symbols. Such rules can generally also be made to simultaneously consider confidence factors with regard to the validity of any individual result. The option of such confidence factors (also known as "certainty factors") allows a rule-based system to closely parallel human expertise in a given area. Examples of rules that are programmable within minutes are:

Example 1

If the reactor is in mode 1 and a reactor coolant pump trips and pressurizer level is abnormally high or pressurizer level is ever over 80% or pressurizer level is otherwise unusual or unexplained or in any case where the average coolant temperature has undergone an excessive decrease,

Then the reactor coolant pump should not be started. (This result has a 90% confidence factor.)

Example 2

If the initial conditions of the abnormal event have been given to the student, and the student decides to borate, and the boration is of sufficient amount to cause the control rods to reach their outmotion stop,

Then rods can no longer add positive reactivity and, set coolant temperature on a downward trend based on (Boron reactivity rate divided by moderator temperature coefficient) and tell the student that the "rod outmotion stop" has energized.

Both rules and defined symbols constitute the knowledge base of an expert system. Within the expert system, but separate from the knowledge base, is the inference engine, which is essentially a reasoning module that determines how each part of the knowledge base is used. The presence of the inference engine is the most significant part of an expert training system. This reasoning module is the part of the system that decides upon and selects which rules are applied and which conclusions result from the information it is given. It directs the search through and application of the knowledge contained in the expert system. The importance of this feature is that one completed knowledge base can therefore be applied to many uses, scenarios and variations, and possible student skill levels. From the standpoint of educational psychology, the large number of problem sets which such a knowledge-based system can present to a trainee is a key facilitator for learning at the highest cognitive levels. From the viewpoint of training administration and quality, knowledge-based systems can offer consistent repetition of the same training for the same student responses and yet allow interaction and tutoring on an individual basis. Effectively, an expert system can provide an inventory of smaller scope simulation experiences.

Educational Aspects

Further supporting reasons for the incorporation of expert systems into the formal training program are evident when certain specific elements of adult learning are considered in the context of the typical training program.

The learning process with which we work exhibits an inherent duality of purpose. Because of the multidisciplinary nature of our courses, we demand that a student be extremely adept at deduction. We expect and demand that successful learners be readily capable of following a sequential path of concepts to any of a number of well-definable conclusions. We refer to this trait of assembling one or more definite conclusions into a realizable goal as "inferential orientation."

For reasons of familiarity, ease of testing and the time constraints that characterize our licensing programs, the "inferential approach" is by and large the greater part of our efforts. We rely heavily on those staples of a purely inferential process: Memorization, straight-line reasoning, and quantized problems. At the same time, we also expect a student to develop

insightful skills (or inductive reasoning abilities) for the broadest range of integrated problems. We typically imbue the student with great chunks of course content, typically fundamental theory, systems, and routine operations. But historically it has been much more difficult to translate standardized techniques to the teaching of insightful skills. As a familiar example to trainers, let's consider the delivery of basic event diagnosis training. It is not prohibitively difficult to supply the basic facts, lists of symptoms, or classic appearance of any one event. More elusive are teaching and testing of the capability to diagnose the event in all probable variations, or under masked conditions and to distinguish one causal event from a field of symptoms. For the sake of discussion and contrast to the deductive inferential orientation, let us refer to the effective application of insight/inductive reasoning as "intuitional orientation."

Educational theories have helped identify the existence of potential discontinuities in the path from the lower to higher levels of cognitive thinking. However a firm model for complete cognitive training (integrating inferential and intuitional orientation throughout) does not yet exist. This does not preclude the application of effective techniques with which to get a more comprehensive and fully integrated approach in use. Nor must our objectives be attendant upon the discovery of any radically new techniques. Rather, we can focus on efficiently executing those techniques, such as expert systems, which can be made to work today.

Well-known educational principles distinctly imply elements needed to foster more integrated cognitive thinking. The variability of adult attention and interest point to the importance of timing. The necessity of goals and feedback call for immediacy and interaction for the student. We know the value of the use of "What if ...?" questions because they force a learner to examine many variations of a given situation. This is the fundamental value of the greater number of problem sets obtainable with the use of expert systems. Moreover, the adult learner's need for relevance is met by the system's ability to explain every conclusion and evaluation.

Finally, in terms of the successful and valid overall program we want repeatability for quality control and the evaluation loop, and individualization to allow for the differences in learning styles. These elements: timing, immediacy, interaction, more problem sets, repeatability and individualization, are well established factors in the success of licensing programs. Not coincidentally, a training expert system can be configured to attain each of these ends.

Now that the technological capacity and the vital functions have been covered, a generalization can be made. Briefly, a training expert system should not and cannot supplant the professionalism and

concern of a human teacher. Nor, for obvious psychological reasons, should such a system be installed as any final arbiter of a trainee's performance. Instead, such systems belong as useful adjuncts to the well-thought-out training program, to optimize instruction in light of the constraints in time, changeability, expense and demographic factors with which trainers must deal. The most appropriate foreseeable role for such systems is as part of the training method mixture used to forge that essential link between inferential and intuitional skills.

The training potential obtainable with fully implemented knowledge bases should not be dismissed as too costly in manpower or dollars. The inherent synergy with training itself greatly reduces the outlay of resources required. Unlike conventional computer language, commercially available expert systems need minimal computer expertise either to construct, update or maintain. The flexibility of the inference engines and small size required for individual knowledge bases can allow the multiple use of each expert system design effort. Work already done with models and databases at a plant need not be redone since it is possible to couple an expert system with databases and Fortran programs. And finally, the research and development costs may be greatly diminished by use of completed Job Task Analyses (JTA) as a direct source of immediately usable material for the knowledge bases.

As an aid for evaluating the educational potential of training expert systems, the diagnostic section of an overall competency list for operators, developed in the Nuclear Engineering Department at the University of Tennessee, Knoxville, is given in Appendix A. In research into training systems, these competencies are being used as minimal criteria for system performance.

Expert systems are in actual use as third party consultants in complex decision-making fields ranging from real estate law to turbine sensor evaluation and medical diagnosis. The technology is proven and due to the advent of microcomputers easily accessible and inexpensive. As a new training tool, an expert system offers the greatest improvement in total one-on-one cognitive training short of a human instructor presently available. The technical adjustments needed for a training expert system have been modeled. The advantages for higher order cognitive learning are demonstrable in terms of educational psychology and adult learning principles.

The realizable benefits to the special requirements of nuclear training stem from at least five essential areas:

- o comprehensive on-the-job training
- o translating on-shift expertise to on-shift experience level

- o direct, valid, and repeatable coaching in the key competencies of application, analysis, and synthesis.
- o training in procedural compliance, bases, limitations and such cases where procedures may no longer apply.
- o quantifiable, continuous learning of diagnostic skills.

The provable results of the use of expert systems belong in a comprehensive diagnostically oriented training program. In Appendix A are listed the specific activities of which training expert systems are capable. As an integrated part of overall training such systems are not only a promising addition to present instruction, but also a vital element of a program that seeks to train its operators to:

- o Identify problems
- o Establish priorities
- o Determine all potential causes
- o Assign reasonable probabilities
- o Develop a logical (and effective) sequence for corrective actions
- o Consider and respond to the impact of corrective actions on the plant (Reference 3).

We believe that each training department should investigate the training and cost benefits of using expert systems. A number of universities, including the University of Tennessee, are engaged in active research and applications that are directly applicable to present needs of industry. The skills are on hand. In some cases, the entire skeleton of a workable system can be purchased commercially. But it is the utility line management, who by their inquiry and interest, will decide how soon the available resources are put to work.

References

1. EPRI "Artificial Intelligence Technologies for Power System Operation," Report EL-4323, Final Report, Project 1999-7, January, 1966.
2. The link to training per se is the subject of the second part of this paper where expert systems are analyzed as more than an ancillary benefit - but rather as a proper part of a diagnostically oriented program.
3. Quoted from "Developing Teamwork and Diagnostic Skills;" Good Practice TW-503; Institute of Nuclear Power Operations; June 1985.

APPENDIX A

Diagnostic Skills

1. Distinguish between relevant and non-relevant data for a problem.
2. Organize relevant data and apply the data to a given problem.
3. Accurately determine trends in a given sequence of events.
4. Given a partial sequence of events and a set of final conditions, determine the probable causes.
5. Given a sequence of events and a resulting set of complete conditions, predict subsequent effects.
6. Describe 3-dimensional objects from 2-dimensional drawings.
7. Be able to logically justify the conclusion of a cause or effect from associated symptoms or data.
8. Given a conclusion, list and use associated supporting evidence to verify the conclusion.
9. For a given set of priorities and possible actions, list all possible actions in order of immediacy, importance, and significance.
10. For given parallel paths of supporting evidence and conclusions, group applicable evidence with all associated conclusions.
11. Demonstrate an ability to apply concepts and/or assumptions used for one conclusion to a similar but distinctly different conclusion.

Discussion

MR. BIVENS: I am Art Bivens of the AIF. Would the disturbance analysis surveillance (DAS) that the Electric Power Research Institute has been working on be considered an expert system? If artificial intelligence is so far along, how come this DAS system seems to be so far away?

MR. BUENAFLOR: Do you know anything about that specific system, Bob?

MR. UHRIG: I am not familiar with DAS.

MR. BIVENS: The disturbance analysis surveillance system is a program that would make it a lot easier for the operators to tell if they have got a problem in their plant. It diagnoses disturbances and tells you what to do.

MR. UHRIG: It sound like it should be an expert system, but I am not familiar with it, Art.

MR. BUENAFLOR: Let me go a little bit out on a limb. A similar question comes up with other applications. People who have worked in artificial intelligence as recently as six or eight years ago will say they have tried certain things and failed. A lot of that has to do with the complexity and the size of the program that were prohibitive because of the amount of computer memory (RAM) needed. Our applications at the University of Tennessee are on micro computers. If you follow the progression of computer memory to where we are now with personal computers that can have 640K to a megabyte of RAM, it is a significant change. However, the programs do not have to be that big any more. Some of the compiled programs, the machine language programs, that are on the market today can now work on machines with 640K of RAM and do very complex things that previously had to be done by programming.

A lot of the computer programs that you see as expert systems today are hard to distinguish from other programs you will see, e.g., computer-aided instruction, even the old computer-based instruction. The clearest difference from the developer's standpoint between an expert system and a very complex Fortran program you might have seen eight years ago, is that you do not have to pay as much attention to the line-by-line order of the program. You can put the information in and it is triggered when it is relevant. It makes the ease of updating and maintenance a lot simpler.

MR. UHRIG: Art, it has been our experience, and I think that of others, that when you start to build an expert system, you start with a simple project and then expand it as you check it out. I believe that this disturbance analysis surveillance system started

with a full blown diagnostic system, trying to do the complete job from day one. Our experience indicates that is not the way to go.

MR. BIVENS: After TMI, the industry came up with a safety parameter display system (SPDS), which was sort of an interim type system and it is used all over the world now. The SPDS, as I understand it, is basically an interim system which we hope someday will be replaced by DAS.

MR. UHRIG: I would simply point out that the test of the expert system using emergency procedures that EPRI is presently carrying out in Taiwan inputs to the expert system, coming directly out of the SPDS. Hopefully, this is the first step to really using the SPDS in the way that was intended, as opposed to something installed just to meet regulations.

ENHANCED LEARNING THROUGH SCALE MODELS
AND SEE-THRU VISUALIZATION

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Abstract

The development of PowerSafety International's See-Thru Power Plant has provided the nuclear industry with a bridge that can span the gap between the part-task simulator and the full-scope, high-fidelity plant simulator. The principle behind the See-Thru Power Plant is to provide the use of "sensory experience" in nuclear training programs. The See-Thru Power Plant is a scaled down, fully functioning model of a commercial nuclear power plant, equipped with a primary system, secondary system, and control console. The major components are constructed of glass, thus permitting visual conceptualization of a working nuclear power plant.

Enhanced Learning Through Scale Models
and See-Thru Visualization

In this paper I will define and expand on the concept we call the hierarchy of hands-on training devices (Figure 1). This hierarchy includes full-scope plant simulators, part-task computer-based instruction, and the new See-Thru Power Plant. All three of these training devices have a special place in the support of the learning process. The part-task computer-based instruction and the See-Thru Power Plant, however, reflect the latest technology.

The learning experience involves three basic processes: acquisition of the learning material, retention of that material, and application of this knowledge to new situations. Studies show that the average person may forget as much as 55% of the material that was presented after one week. The ability of instructional methods to maximize our students' retention and utilization of new material is a measure of instructional effectiveness.

There are two large categories into which all training can be placed:

- o that which involves instructor interaction, such as classroom lectures, on-the-job training, and plant simulators and
- o self-paced programs like videotapes and computer-based training.

I will first address the second category, self-study programs.

The effectiveness of self-paced study is largely based on student motivation. However, the very nature of this type of training can inhibit the ability of the instructor to motivate the student (which is something all good instructors do). A major pitfall of this type of training is the loss of student/instructor interaction. The more interaction that can be forced, the more effective will be the training. Computer-based training (CBT) has had widespread application in the military and now has been introduced to nuclear training programs. Early CBT was identified as "page turners," or simply a reproduction of a textbook or manual onto a cathode ray tube (CRT). Not much value was attributed to this early CBT, and users felt that vendors were simply trying to find some way to use the new ubiquitous computers. The CBT that I will discuss later in this paper is a new dimension in training and far removed from the early "page turners." As shown in Figure 1, computer-based training is the base of the training device hierarchy.

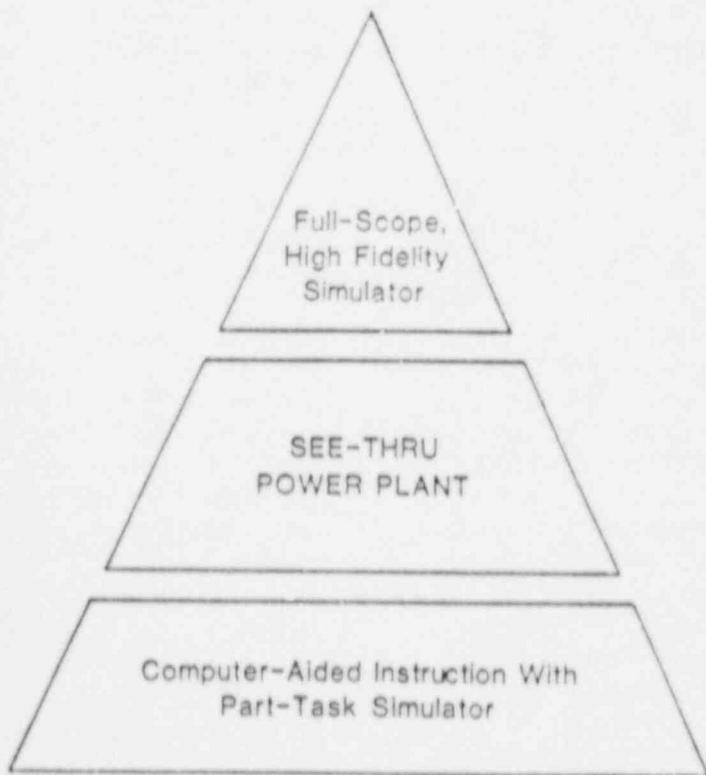


Figure 1. The Hierarchy of Hands-On Training Devices

But for now, let us go back to the first category of training, that which requires student/instructor interaction. This is by far the most often used approach. As previously mentioned, this category includes the formal classroom setting, on-the-job training, and plant simulators. Three common instructional methods (lecture, performance demonstration, and discussion) are used to facilitate student understanding. The instructors' main objectives are to simulate as many student senses as possible, to guide student activities, and to provide the opportunity for learning. For example, data show that sight may contribute 83% to learning, whereas hearing only contributes 11%. Therefore, if we restrict our teaching activity to classroom lecture, our students might lose out on 89% of the material presented. The same studies tell us that the sense

of touch can add 4% to the contributions of sight and hearing. From this we can see that an instructor employing the proper training methods can contribute as much as 98% to the learning process. This is illustrated by an old Chinese proverb: "I hear and I forget; I see and I remember; I do and I understand."

On-the-job training (OJT) is another instructor-interactive method. OJT provides the hands-on, visual, and aural stimuli. However, the student is often learning from someone who does not know the subject intimately or who does not have the instructor skills to transfer his knowledge to the student effectively. Often, OJT is performed with someone who is not a qualified instructor but merely one who has previously qualified to perform the task. The person acting as the instructor may have decided to perform the task "his own way" and will then pass this incorrect information on to the trainee.

The third method is the full-scope, high-fidelity plant simulator which is the apex of the training device hierarchy. As mentioned earlier, one aspect of learning (one of the most important for an operator, I might add) is the ability to transfer learning to new situations. The plant simulator, when properly employed by a qualified instructor, is probably the most effective method to enhance learning and retention through stimulation of the senses and student motivation. Simulators facilitate this learning transfer because they allow the instructor to produce scenarios that accurately represent real life situations as well as problem and emergency situations that call for actions and solutions identical to those demanded under actual operating conditions.

As effective as the full-scope, high fidelity plant simulator is, it is not without limitations. These simulators are costly to purchase (approximately \$10,000,000) and costly to maintain. They require a highly qualified and skilled instructor with an SRO license or certification. This instructor may have to spend months in personal training to become qualified to teach on the simulator. The students must have a high degree of knowledge of the primary plant and system interrelationships. For example, students in training for an initial Reactor Operator's license will need about a week of familiarization training on the simulator before they will be comfortable with the different control stations. Because of these limitations, the student population is often restricted to those who must have this training because of regulatory requirements. Unfortunately, this often excludes personnel whose ability to perform their jobs would be enhanced by such training, e.g., engineers and other key plant personnel who are not required to have an SRO license but need detailed plant knowledge. The complexity of the simulator presents other problems as well. Integrated knowledge takes time to develop and causes the student to focus on one problem and sometimes to miss the "big picture," e.g., TMI-2 and pressurizer water level.

Simulator mentality can also develop where students view transients and unexpected phenomena as simulator glitches instead of analyzing the situation as presented to determine whether what they saw was indeed a situation the plant would exhibit if the events were the same.

The complex and heavily regulated nuclear power industry needs to take advantage of the advanced technology available in the training market today. The days of self-paced study and dry classroom lectures as the only means of training are past. Sophisticated media exist in which training can be more effectively communicated, and these media must be utilized. Having discussed the categories of training (instructor-interactive and self-paced study), the different methods used in each category (videotapes, CBT, formal classrooms, and simulators), and some of their limitations, I would now like to address some technological advancements available to enhance or supplement these methods.

PowerSafety International has recently developed some innovative computer-assisted instructional (CAI) material that makes extensive use of part-task simulations. These part-task simulations are sections of a larger system that may be isolated and incorporated into a concentrated learning instrument. One example is the xenon/samarium simulation.

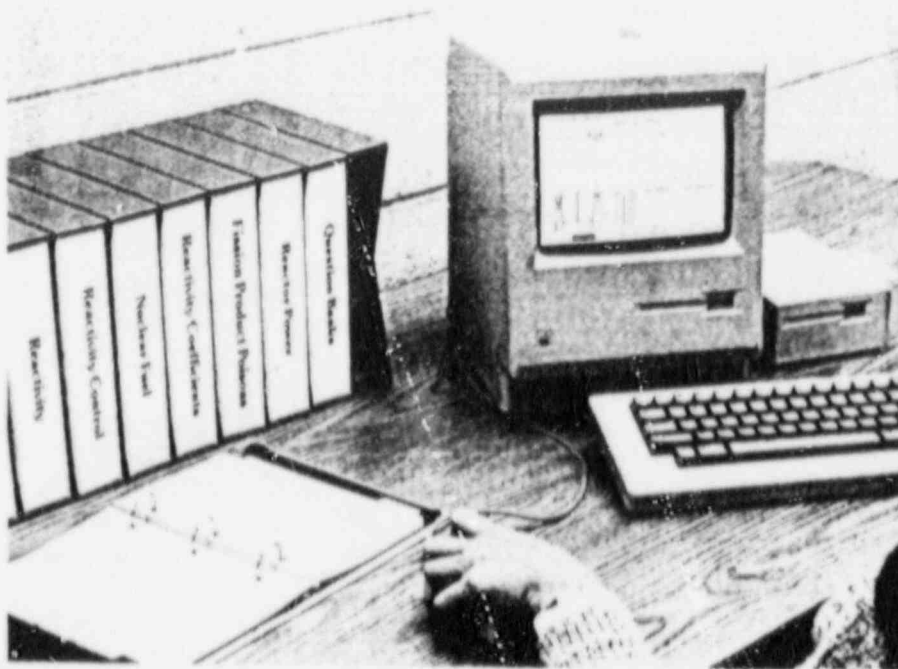


Figure 2. PowerSafety's Computer-Assisted Instruction Modules

Both xenon and samarium are fission product poisons whose concentrations in nuclear fuel are complicated functions of reactor power history. It is important for nuclear reactor operators to know how these poisons behave during reactor operations. Their behavior can be illustrated on a full-scope plant simulator; however, this usually takes four to five hours to set up, and ultimately, the instructor can only show the power histories and poison concentrations that were stored in the simulator. No real-time interactions are available, and the parameters are difficult to change.

With the xenon/samarium part-task simulation in the CAI, the complicated differential equations that determine poison concentration are solved in real time. Therefore, students are able to change power history and watch the subsequent changes in poison concentrations. They are able to interact with the simulation and to involve themselves with the simulation and thus become more involved in the learning process (see Figure 2).

The part-task simulation is a concentrated instruction on part of the system. It can free the full-scope simulator for the entire systems instruction. As a result, it is much less expensive per student than full-scope simulator training. The PowerSafety International CAI uses either Apple or IBM microcomputers and is portable and inexpensive. It also includes built-in student performance testing, extensive record-keeping, and branching to offer the most flexibility to the instructor and the student.

As a bridge to span the gap between the full-scope, high-fidelity, plant-specific simulator and the part-task simulator, PowerSafety has introduced the See-Thru Power Plant (see Figure 3). The See-Thru is a working model of a nuclear power plant. It contains all major primary and secondary system components and their associated piping, valves, instrumentation and controls. All the major components are constructed of clear Pyrex glass to permit the viewer to see water and steam during all phases of operation. Plant components and systems are structurally supported and interconnected with stainless steel piping and fixtures.

The See-Thru Power Plant components include the reactor, pressurizer, coolant pumps, core flood tank, high-pressure injection pumps and water reservoir, turbine, generator, condenser, condensate pump, ion exchanger, feedwater heater, feed pump, condenser vacuum pump, HVAC unit, and two steam generators (a once-through and a U-tube or two alike).

Critical plant parameters are monitored and displayed on the control board via digital indicators, a recorder, meters, and gauges. Monitored parameters include primary system hot leg and cold leg temperatures, pressurizer temperature, reactor water temperature,



Figure 3. PowerSafety International's *See-Thru Power Plant*

reactor head temperature, axial and radial fuel temperatures, reactor pressure, steam pressure, containment temperature, feed flow, cooling water temperature and pressure, feed pressure, feedwater heater inlet and outlet temperatures, high-pressure safety injection (HPSI) pressure, HPSI reservoir temperature, generator output, turbine speed, condenser vacuum, secondary steam temperature, power-operated relief valve and safeties tailpipe temperature, core flood tank pressure, and containment pressure.

The See-Thru can be operated in various modes and conditions including normal steady state (solid or with pressure bubble), transient, and accident conditions. Under normal full-power, steady-state operation, the plant operates at approximately 25 psi and 240 degrees F. It operates like an actual commercial reactor plant. The only thing that is simulated is the fuel; everything else is real. The heat generated in the reactor is transferred to the steam generators, which produce steam that is directed to the steam turbine/generator where an electrical output is produced. The operator controls reactor power and system pressure. System pressure can be varied by the pressurizer heater control and the spray valve control. In addition to reactor power, temperature, and pressure, the operator can control reactor coolant flow, steam generator feed flow, cooling water flow, condenser hotwell level, feedwater temperature, and safety injection flow.

In addition to demonstrating normal steady-state power plant operation, the See-Thru can demonstrate the following events:

- o Loss of feed, overfeed
- o Steam generator tube rupture
- o Steam line rupture
- o Small-break loss-of-coolant accident (LOCA)
- o Large-break LOCA
- o Main steam isolation valve closure
- o Loss of secondary heat sink
- o Stuck-open PORV
- o Loss of flow
- o Reactor trip
- o Natural circulation
- o Two-phase flow cooling
- o Loss of natural circulation
- o Loss of cooling water
- o Loss of safety system actuation
- o Loss of pressurizer heaters
- o Stuck-open spray valve

The advantages of the See-Thru Power Plant are many. It is much less expensive to purchase initially and to operate and maintain. It is less complex than a full-scope, high-fidelity simulator, allowing both the trainer and the trainee to master its operation more quickly. Also, the technical background of the instructor need only be as extensive as the student group targeted dictates.

The See-Thru offers a refreshing change in the training department's "tool box" to enhance student interest and motivation. It utilizes visual impact to reinforce the concepts being presented. The students actually see what is taking place, thereby increasing their understanding. This helps the student cement the hard-to-visualize theory.

The See-Thru provides hands-on training with immediate feedback. Except for the safety systems, it is operated in a strictly manual mode. If the student, for example, closes the turbine stop valve, the loss of heat sink will cause primary temperature to increase, which will then cause system pressure to increase. This manual control enhances the student's understanding of the theory involved and provides a better conceptualization of system interfaces and relationships. It also requires more skill on the part of the operator to keep all parameters in balance.

Because of the "see-through" concept, this training platform has unique capabilities. As already mentioned, it provides a thorough presentation of the overall power plant and all principal systems. The glass components allow the student to see the effects of different heat transfer and fluid flow principles. Therefore, not only can the student observe normal plant behavior, but he can also see what happens during transients and how to mitigate the consequences of those transients.

Finally, this unique training can benefit the entire spectrum of potential students. Everyone from the general plant employee who needs just the big picture to the engineer and manager who need more in-depth plant training all the way to the operator who wants to know more answers like "why the pressurizer appears to go solid when the power-operated relief valve opens." All plant personnel can receive valuable training on the See-Thru Power Plant. The See-Thru has also proved to be an excellent public relations tool. The inherent safety of our nuclear plants can be demonstrated. This goes a long way toward educating the public, correcting misconceptions, and relieving anxieties.

I would like to summarize by referring again to the hierarchy of hands-on training devices shown in Figure 1. This structure shows the full-scope, high-fidelity simulator at the top. It has always been the best platform available to train operators and other technical personnel. However, until recently there has been no other means of hands-on training for the vast majority of the student population. At the base of the hierarchy is placed Computer-Assisted instruction with the part-task simulations. CAI is furthest removed from the full-scope simulator in the hierarchy since it utilizes part-task simulations. These simulations are subsets of the full-scope simulations and allow for concentrated study and learning on a small part of the total system. The See-Thru Power Plant spans the gap between the full-scope and part-task simulations. This unique training device stimulates sight, hearing, and touch to enhance and reinforce the learning process. The See-Thru makes esoteric concepts understandable, so that meaningful training can be presented to learners with all levels of sophistication.

Discussion

MR. FEDAKO: I am curious about the personnel safety on using the See-Thru Power Plant. What measures are there for protecting the people using it?

MR. KELLEY: In one of the slides I showed a containment vessel around the See-Thru Power Plant. It is plexiglas with a dome on it, latched down, but also the components, themselves, are made of Pyrex which is, as you know, a very strong glass. The glass is able to withstand over a hundred pounds of pressure easily. We operate much below those levels. Even if we were to have a loss of coolant accident, which actually happened when the reactor split and dumped all the primary coolant into containment, absolutely nothing happens. The water was contained on the floor of the containment structure. It is a very safe training tool.

MR. LATONE: How much does a See-Thru Power Plant cost?

MR. KELLEY: I knew someone would ask that one. I don't want to avoid the question, but it really depends on what you want. It is like buying a car. It depends on the options. You have from a Chevy to a Cadillac. You can hang as much as you want on it. It depends on what the needs of the utility and the learning institution are. What we have found is that needs vary widely, and it really depends on what you would like to have. At the Nuclear Training Symposium next week, PowerSafety will present a discussion of the See-Thru Power Plant, including demonstrations, to allow a better understanding of how it works. We can address the cost questions then.

MR. BRUNO: What do you do to train around the problems that I think you would have with a unit that operates at such low temperatures and pressures, to train people on the thermohydraulic response? For example, if you open a PORV, what you would see on this unit would be different, I think, from what you would see in a plant because of the pressures and temperatures you are operating at. How do you get around those kinds of problems?

MR. KELLEY: Yes, there are some differences because of the pressures and temperatures we use and, as I mentioned before, it depends on your audience. If you are addressing the general public, the overall concept of what happens is more than enough. If you go into any more detail than that, you will be providing excess information. But if you are conducting training with operators, then you must take that information and apply it to the plant. That is where you need someone who has a good understanding of how the See-Thru works, as well as someone who can relate that to the real plant.

MR. BRUNO: I think you could still get into some trouble there. For example, if you teach a guy that throttling through a PORV at 25 pounds is going to give you saturated or super-heated steam, rather than a saturated mixture of steam and water that we would see in our plant, if you are teaching operators, I think you are getting close to being in a mode where you don't want to show them those kinds of things. How do you get around that if you use this for operator training?

MR. KELLEY: As you pointed out, it cannot be used for everything. The See-Thru Power Plant is like other devices. We have seen all the limitations of the full-scope simulator and the part-task simulator and all the other modes of training. So, too, the See-Thru Power Plant has its limitations. You just have to be aware of them. But I think it goes back to the instructor knowing the capabilities of the See-Thru Power Plant and knowing how the actual power plant works. He must know that. The instructor who will teach operators must know how a power plant works, or he will cause confusion no matter what his training device is.

MR. GOMOLINSKI: My question is similar. People familiar with out-of-pile experiments know that the main difficulty with the mock-up is the extrapolation to the actual plant, especially when you have two-phase flow phenomena. Because of this, it is not possible to extrapolate the phenomena to the actual reactor without using computer codes. How do you take into account this contradiction, so as not to give operators the wrong idea of reality?

MR. KELLEY: I think that is exactly what Mr. Bruno was talking about. I cannot add a lot more, except to reiterate that the person who uses the See-Thru Power Plant must understand how the power plant works. We have an individual who conducts most of our training for operators. As I mentioned, we have instructors who perform the public demonstrations and we have more advanced instructors who perform the training for operators. We have trained several operators on the See-Thru Power Plant, and they have been extremely pleased with the training, because it allows them to see some theoretical concepts that are a little hard to grasp. But it required that our instructor have a very detailed knowledge of the plant so he would know those limitations.

On another subject, earlier someone asked if B&W has done a cost benefit analysis on the See-Thru reactor. PowerSafety is a new company, a joint venture company with Babcox and Wilcox, who used to have a training division but no longer conduct training, and another company called Flight Safety International, which is probably one of the the leading training companies for the aviation industry. The two formed a new company, called PowerSafety.

The cost analysis question was addressed in one of the other papers, I believe related to part-task simulators. How can you quantify the value of training? Usually, when budgets are cut, training is one of the first targets just because you cannot quantify the return on training effort. What I can say about that is that we have seen the effect in public relations and feedback from trainees. Let me give an example.

We had a group of students who came in and they were generally very anti-nuclear. The press was there when we gave our demonstration. They called one of the students aside after the demonstration for an interview. As it turned out, the student said that before she arrived she was very much opposed to nuclear power, but because she now understood how the power plant worked, she felt more comfortable with the safety of nuclear power plants -- maybe they weren't so bad after all.

This is the kind of feedback we are getting.

MR. LIANG: Can you provide a cost figure for a system that would accomplish the purpose of allowing the student or laymen or the media to understand how a nuclear system works?

MR. KELLEY: That brings us back to the original cost question, but I will throw out a ballpark figure. The basic system, although it really is pretty advanced in design, would be about \$270,000.

AN INSTRUCTIONAL APPROACH TO INCREASE
TRAINEE LEARNING THROUGH IMPROVED
LABORATORY/SIMULATED EXERCISES

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Abstract

An area that deserves careful attention is the development and the implementation of training to prepare instructors who deliver laboratory/simulated exercises. Techniques are discussed for presenting a one day workshop to prepare instructors to conduct labs. Specific guidelines are outlined for planning a laboratory experience, preparing the training laboratory, conducting the laboratory and evaluating results and providing feedback to trainees.

Introduction

Throughout the nuclear industry there has been wide recognition of the importance of careful attention to the development of lesson plans that will be used to deliver classroom instruction. an area that has received less attention but is of equal importance is laboratory exercises* and how they can be used to reinforce classroom instruction. The objective of these labs is to provide trainees the practice and experience they need before they progress to on-the-job training. Many laboratory exercises are not as effective as they could be because of six basic problems which stem from a lack of effective prior planning. This paper will first address these problems followed by a description of the instructor laboratory skills training provided by Duke Power. The last portion of this paper will give specific guidelines for planning and conducting more effective labs.

Six Problems That Produce Ineffective Labs

Problem One: Lack of a Facility Designated
and Designed Specifically for Training

A lab may be doomed to failure if the facility must be shared with the normal daily operation of a plant. A commitment must be made to design a site specifically for training. This center needs to have dedicated technical labs that are closely tied to training and mirror as closely as possible equipment and conditions

* When the word laboratory or lab is used in this paper, it includes laboratories, shop training and simulator exercises.

in a nuclear station. Errors may occur when trainees are trained on equipment that is too different from that used in the station.

In order to provide the most realistic setting that simulates plant environment and equipment, Duke Power's Production Training Services uses five training facilities. The Lake Norman facility houses the McGuire Nuclear Station Operations Training Simulator, and Instrumentation and Electrical (I&E) and Chemistry labs. Mount Holly Training Facility houses fully equipped labs for Mechanical Maintenance (MM) and Health Physics (HP). The Oconee and Catawba Operations Training Centers house or will house simulators that are exact replicas of nuclear operations control boards at each of those sites.

Problem Two: Shortage of Proper Tools/Failure to Use State-of-the-Art Equipment

Motivation wilts in labs when tools have to be shared among groups of trainees. If equipment is not state-of-the-art and must be repaired by the instructor each time before it can be used in a lab, trainee transfer of learning to actual station conditions suffers. Sagging instructor moral may also result. Production Training Services is making every effort to keep all technical labs current. As new equipment is installed at nuclear plants, training labs are also updated.

Problem Three: Delayed Practice/Reinforcement

An example of delayed practice is having trainees complete weeks of classroom training before having them participate in the related labs. Effective instruction, on the other hand, happens when instructors use training materials that have incorporated laboratory experiences at the most appropriate places to maximize trainee reinforcement.

Problem Four: Lack of Instructor Observation Skills

This problem occurs when instructors lack training in observation skills. There is a big difference between an instructor knowing how to perform a task and having clearly in mind what the trainee should do when he/she performs the task. Trainees using their own method or procedures rather than the approved method or procedure taught by the instructor is an example of what can happen when an instructor is weak in observation skills. Another example is a situation where trainees working on teams are doing most of the work but a few stand back, for the most part, uninvolved in the exercise. Instructors need to develop a keen sense of awareness of exhibited trainee lab behavior.

Problem Five: Inadequate Demonstration/ Trainee Preparation

When a trainee cannot see an instructor's demonstration or hear the instructions, trainee error occurs. Yet trainees may be subjected to instructors demonstrating to groups too large to give all a clear line-of-sight, or instructors giving directions as an afterthought or inhibited with noise. Another indication of this problem is trainees asking numerous questions about how to proceed during an exercise. This problem occurs when little, if any, explanation was given to trainees in regard to expected behavior and performance during a lab. It can also be recognized by a lack of significant follow-up feedback being given to trainees in regard to their performance during and at the end of the lab. If trainees are to do well in a lab, they must have the opportunity to observe a model demonstration, be given information on expected behavior and performance and meaningful feedback.

Problem Six: Poor Utilization of Instructor and Trainee Time

Often a lab will have a lead instructor and instructors who assist. Too often lab time may be wasted as a result of unclear, unorganized division of labor among the instructors conducting the lab. Trainees waiting long time periods to be checked off (graded) is one indication this problem is occurring. All instructors need to understand what makes a good lab function from lecture to the actual lab, including the role each must play to prepare for and conduct a worthwhile lab.

Duke Power's Lab Instructor Training

Duke Power has addressed problems one and two by establishing quality training facilities and keeping them fully equipped. Production Training Services has averted problems three through six by providing lab instructors with training to be sure they understand how to conduct an effective, meaningful lab experience. As part of an instructor's continuing training, Production Training Services offers an eight-hour workshop to refresh, upgrade, and polish an instructor's laboratory instructional skills. This one day "learn by doing" training session for a group of five to ten instructors provides lab skills to instructors in three parts: Theory, Model/Learning Experience and Practice/Transfer.

Part I - Theory -- provides vital information and guidelines for preparing materials, preparing the class, starting, conducting, monitoring, evaluating performance, and concluding the lab. The guidelines used in this part of the training will be explained in the last portion of this paper.

Part II - Model/Learning Experience - continues with the facilitator making the training more memorable by conducting a brief lab exercise with the instructors participating as the trainees. This part reinforces Part I because now the facilitator, or an instructor the facilitator has coached, models a smoothly run lab from start to finish.

Part III - Practice/Transfer -- provides carryover for instructors. Utilizing their own lab exercise plans, perhaps one that has given them problems in the past, instructors identify weak portions in the lab plan and ways these problem areas might be improved. At first, it may be helpful to have a few individuals from the group share identified problems and have the group "brainstorm" some solutions to get the "creative juices" flowing. The last 90 minutes of the workshop should be spent with all instructors verbally sharing with the group plans made to improve their lab. They should be encouraged to be specific about the instructional technique(s) that will be used to make the lab more meaningful experience for trainees.

Requiring instructors to verbally share their plans increases the likelihood that the changes will actually be made when instructors return to their areas. To ensure the changes are made the facilitator may want to ask for actual dates by which changes will be made and then follow up at that time.

By using this training approach lab instructors should realize that effective labs require a clear understanding of the connection between classroom training and expected training outcome in the lab. The instructor should see that in order to be effective he/she must have a clear plan for the lab, execute that plan as flawlessly as possible and reinforce the intent of the lab for trainees. When this is done, trainees realize how the exercise or activity they practice in the lab relates to the work they will be expected to do once they are performing the task on-the-job.

Implementation that Insures Successful Labs

After instructors are trained to conduct labs, there are five guidelines that should be reviewed and considered each time a laboratory experience is prepared. The remainder of this paper will elaborate on these five guidelines that will produce effective labs:

- o Planning for a Laboratory Experience
- o Preparing the Training Laboratory
- o Conducting the Laboratory
- o Evaluating Results and Providing Feedback to Trainees
- o Concluding the Laboratory

Guidelines for Planning a Laboratory Experience.

When an instructor has clearly in mind the intent of the lab he/she should determine the following seven items:

- o Objectives for the lab.
- o Content in the classroom portion of the training presents all the information the trainee needs to be successful in the lab exercise.
- o Time needed for the lab.
- o Materials needed.
- o Number of opportunities trainees will have to practice before they need to demonstrate skills for a grade.
- o Demonstration to be modeled for trainees and the expected skill proficiency or acceptable standards for the finished product.
- o Process for conducting the lab:
 - o Prepare a clear outline showing how trainees' time will be spent in the lab so all participants are involved and working during the entire lab.
 - o Determine equipment restraints. If enough equipment does not exist for all trainees to do the assigned activity, plan another activity that part of the group can work on simultaneously and then have groups switch at the appropriate time.
 - o Specify responsibilities for each of the instructors assisting in the lab.

Suggestions:

-Designate two instructors to answer questions only. Assign a third instructor to be in charge of check off/evaluation of the final product.

-Use stands (or clothes pins) at each work station to hold colored cards that can be put up and taken down by trainees as needed. A red card might indicate "help needed" or "question." A white card could be "ready to be checked off."

- o Establish the level (standard) of skill proficiency trainees must exhibit.
- o Decide how lab will be introduced and summarized.
- o Determine how clear communication will be handled during the lab.

-In a noisy environment a signal needs to be established (bell, whistle, etc.) that is different from general noise to call everyone's attention.

-Instructors need to anticipate where general announcements will need to be made and make these a part of the lab lesson plan.

-For a lab that must be run by only one instructor with a large group of trainees, a brief videotape of common problems or mistakes trainees consistently make with equipment or procedures might be made for trainees to view. This would allow them to do their own trouble-shooting and perhaps find their error and continue working until the instructor has time to get to them.

- o Determine the mechanism for assuring equitable contribution of effort by participants to the exercise so all are equally evaluated.

Suggestions:

-Pair new hires with very experienced workers.

-Require trainee(s) to work with a variety of partners, not always the same person(s) to build cooperation and sharing of ideas.

Guidelines for Preparing the Training Laboratory

These are usually some items an instructor will not be able to prepare until the day before or the day of the lab. Before trainees are taken to the lab the instructor should:

- o Set up work stations.
- o Assemble equipment/materials adequate in number and quality.

Guidelines for Conducting the Laboratory

In order for lab prior planning to pay off, instructors, during the lab, must pay attention to three elements necessary for success. Instructors must:

- o Prepare the class.
- o Start the lab smoothly.
- o Monitor trainees and provide coaching when appropriate.

Preparing the Class. Before moving the class to the laboratory setting, the instructors should supply trainees with the following nine items:

- o Purpose of the lab (motivate trainees).
- o Demonstration of the exercise.
 - This may be done in a class lecture or it may need to be done in the lab.
 - It should model the exact expected behavior trainees must exhibit.
 - It should not be done by selected trainees unless they have been rehearsed and coached prior to the lab.
- o Expected behavior (conduct).
- o Safety considerations.
- o Directions for the activity in the lab.
- o Time limit trainees will have to complete the lab activity.
- o Directions for completing lab sheets or documentary results.
- o Explanations of how trainees will be evaluated (standards)
- o Assignment of working pairs (if necessary).

Starting the lab. Often an interval of time will have passed between trainee preparation and the move to the lab. A review

of classroom remarks pertaining to the lab will refresh memories and save valuable time. Instructors should restate:

- o The purpose of the lab.
- o Expected behavior.
- o Time allotted for completion of the lab activity.
- o Safety considerations.

This review should be followed by announcement of process.
Tell trainees:

- o Special/required directions.
- o Which instructors will monitor work, answer questions and which will evaluate.
- o Method to be used to call attention for general announcements.

Monitoring the Lab. Effective monitoring takes keen observation and practice. For real learning to take place, instructors need to:

- o Frequently circulate, observing trainees as they work, offering guidance, feedback, and praise when it is deserved.
- o Be aware of nonverbal language of trainees needing help but reluctant to ask. Look for confused facial expressions or no work being done.
- o Complete individual trainee paperwork documenting performance (checklist, grade sheets) in a timely, organized manner. Trusting to memory can produce inaccurate results and annoy trainees.
- o Stay on schedule and finish on time so trainees have faith in instructor's organization and a colleague's teaching schedule is not disrupted.

Guidelines for Evaluating Overall Results and Providing Feedback to Trainees

A lab has not accomplished its purpose until trainees, individually and as a group, have been told how well they have achieved the expected performance. It is not enough to simply announce or post scores. To be effective, private individual

feedback and verbal summary comments of the class's overall performance need to be given. When speaking to individuals and the entire class, point out those things that were done well along with those areas that still need improvement.

- o Tell trainees how successful they have been in accomplishing the objectives for the lab.
- o Summarize what trainees have learned and note general areas where the entire class may need to improve.

Guidelines for Concluding the Lab

To build professional habits of order and cleanliness, it is important for trainees to return the lab to its original condition. Be sure that trainees have:

- o Returned materials.

Suggestion: A responsibility of one of the instructors assisting might be to check lab equipment in and out so equipment is not put away soiled.
- o Cleaned work stations and all equipment or tools used.

Conclusion

If instructors in the nuclear industry follow the techniques outlined here, they will be better equipped to provide more effective laboratory experiences for their trainees. In addition, they will become better organized, more confident and in control of the laboratories they conduct. As a result, trainees will respond with more enthusiasm and better performance because they know what is expected and what is needed to achieve success.

Discussion

MR. WIGGIN: Would it be possible to send a training supervisor to watch one of your sessions?

DR. SALAS: Yes, we are happy to have people visit. We have had people visit in the past. Just contact me and I will tell you when we are going to do it again.

MR. BOHANON: Do you have a parallel program for instructors on the simulator?

DR. SALAS: Yes, we are developing it right now. Presently our simulator instructors attend our initial instructor training course, and some of them have gone through this workshop. We are now in the process of developing a simulator instructor skills workshop because these instructors not only need to know how to operate the simulator, but they also need to have the skills to know what to look for as trainees are working on the simulator. We should have that developed soon.

CHAIRMAN'S REMARKS

Mr. A. E. Vandewalle
Belgium

Adequate instructional methods are essential to train nuclear operators efficiently. Among them, simulators are tools which can be used in the best or the worst manner. That is one of the reasons why the CSNI meeting program group attached importance to this subject.

Mr. Tangy, describing the organization that EDF (Electricité de France) set up to guarantee and maintain full-scope simulators accuracy, insisted on the needed quality of such tools. This can be obtained thanks to a systematic approach, including every step of the construction process (contract, technical references, quality assurance, organization, etc.), as well as by standardization of nuclear programs.

Even of great basic quality, a simulator facility has to be integrated into the training department to be fully effective. This is the message of Mr. Schaffer, who demonstrated to us that it is necessary to integrate the whole construction process of simulators. That supposes timely taken actions to set up, at an early stage of the project, a training staff to follow the construction process. Implementation of the simulator has also been taken into account. All of this supposes three important phases: staff qualification, training design, and simulator support.

Ontario Hydro, in its training center, is widely using field simulation to train their personnel, as Mr. Young told us. Giving an overview of nuclear skills training for operations, control maintenance and mechanical maintenance personnel, he made evident that field simulation was an important element in reliably achieving course objectives.

Mr. Blomberg, in his presentation entitled "The Role of Compact on-site Simulators in Sweden." emphasized the actual use of compact simulators in his country as a valuable tool to supplement and to enhance the training on replica, full-scope, simulators. One clear impact of compact simulator training which was pointed out, is the gain in time to reach the operator competence, as well as significant decrease of interruptions in nuclear plant production due to personal mistakes.

The Siloette training and simulating center, presented by Messrs. Destot and Siebert, has proven to be a very efficient one. As pointed out by the authors, this would be mainly due to the combination between the use of a research reactor and several simulator types (basic, micro-simulator, etc.). Emphasis was given

to the importance of training power plant personnel outside from nuclear operation. Experience coming from the simulation of processes different from the nuclear power plant, such as thermal power plants, electrical networks has also been proven useful.

Artificial intelligence is a presently fast-growing technology. Expert systems, presented by Messrs. Uhrig and Buenaflor, can also be used with benefit in training of NPP operators. The inclusion of expert systems in the control room environment offer a continuous source of OJT diagnostic training. Expert systems are also feasible for specialized license/requalification training.

Physics of the different phenomena occurring in NPPs is sometimes difficult to understand. Messrs. Kelley and Chulick presented an interesting tool in this matter. Their See-Thru power plant complements adequately the training of nuclear operators in filling the gap between theoretical training and part or full-scope simulators. CAI (computer assisted instruction) can also be used as effective and inexpensive interactive training methods.

The full-scope simulator is undoubtedly a very good training tool. However, as DR. Salas and Dr. Oxford told us, careful attention has to be given to prepare instructors who deliver laboratory/simulated exercises. They presented useful guidelines for planning a lab experience, preparing training lab, conducting the lab, evaluating results and providing feedback to trainees.

SESSION 4:

INSTRUCTIONAL METHODS (II)

CHAIRMAN: Mr. B. Magnusson

AN INTEGRATED INITIAL TRAINING PROGRAM
FOR A CEGB OPERATIONS ENGINEER

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Abstract

This paper considers the overall training programs undertaken by a newly appointed Operations Engineer at one of the Central Electricity Generating Board's (CEGB) Advanced Gas Cooled Reactor (AGR) nuclear power stations. The training program is designed to equip him with the skills and knowledge necessary for him to discharge his duties safely and effectively. In order to assist the learning process and achieve an integrated program, aspects of reactor technology and operation, initially the subject of theoretical presentations at the CEGB's Nuclear Power Training Center (NPTC) are reinforced by either simulation and/or practical experience on site. In the later stages plant-specific simulators, operated by trained tutors, are incorporated into the training program to provide the trainee with practical experience of plant operation. The trainee's performance is assessed throughout the program to provide feedback to the trainee, the trainers and station management.

The Training Requirement

Before a newly-appointed Operations Engineer can take up his duties alongside his "experienced" shift team members in an operational AGR nuclear power station, he will undertake a program of training. The aim of the program will be to provide him with adequate skills, knowledge, and experience to enable him to carry out his duties safely, effectively and efficiently.

A detailed job analysis will provide information on what the trained engineer must be able to do and what he must know. This establishes the skills and knowledge he must have on completion of the training program. Since the majority of operational staff are professional engineers, it is possible to assume that the trainee entering the program possesses the theoretical knowledge equivalent to that gained by successfully completing a degree level course. Hence the skills and knowledge he still has to acquire can be defined and these form the basis for determining the aims and objectives of the training program.

Although the Operations Engineer has a large number of individual tasks to carry out, it is possible to identify them as being associated with a particular work area. As a reactor desk

operator in the central control room, he not only has to be competent to operate the reactor safely, he must also operate the unit and auxiliary systems with due regard for the commercial implications of his actions. The limits within which he must carry out these duties are defined in a number of comprehensive operating instructions issued by the CEGB. He has to prepare and issue documentation associated with the CEGB's Safety Rules. In the case of an emergency situation he has a number of pre-defined duties to perform detailed in the Station Emergency Handbook. In addition he has duties as a CEGB employee with respect to the country's statutory and common law.

The Process of Learning

It is apparent that the new Operations Engineer has a considerable amount of information to accumulate. The depth of knowledge he requires varies from purely recall to much higher levels of understanding. (A recognized hierarchy is knowledge, comprehension, application, analysis, synthesis and evaluation.) Real understanding cannot be said to have been achieved until he can apply his knowledge to new contexts, independent of outside assistance (Reference 1). To achieve this level of knowledge the trainee will need to experience planned periods of meaningful learning.

Learning has been defined as any relatively permanent change in an individual which results from experience (Reference 2). Factors which affect the learning process are motivation, observation, exercise, repetition and reinforcement.

For learning to be successful the trainee should want to learn. To inspire learning, the strong motives of interest and purpose should be used, with the trainer creating in the trainee a direct lively interest in the subject and a clear realization that the learning has a worthwhile purpose either now or in the future. This is done by making the trainee aware of the reason, relationship, application or purpose of the information he is being asked to learn. This may include knowledge which will need to be recalled for application at a later stage of training. It has to be remembered, however, that too much motivation may lead to anxiety and loss of performance, as can happen if the trainee tries too hard.

Observation of the target enables a person firing arrows to see what he is aiming for. In missing the bullseye he needs to observe by how much, in order to provide the feedback which will enable him to correct his aim for further attempts. Observation of the situation and especially of results enables the trainee to more clearly perceive the situation and his performance aiding the learning of what is essential. During the training program the trainee should be informed of exactly what he is expected to learn

and, to enable him to "take better aim," he should have knowledge of his results and those achieved by others. Care must be exercised to ensure the target is attainable by the trainee since feedback of apparent failure may discourage further learning by affecting motivation.

Exercise and repetition of learned facts or actions strengthen the learning and enable them to be remembered longer. Whereas simple acts are sometimes learned in a single trial, more complex acts usually require repeated exercise. Repetition is important since, if the particular learning situation does not occur again for a long time, the first learning will be lost or forgotten, whilst crowding repetitions may impair learning, follow-up is required right away for rapid learning. Thus the training program should include repetition of important acts and facts with optimal spacing if learning is to be rapid, but not impaired. Before progressing further in a subject, at a later stage in the training program, revision of important facts will be required.

In addition to repeated and well-timed exercises reinforcement of the exercise is needed to ensure retention of learning. Reinforcement is a response of the individual to the results of an activity, confirming or tending to select and establish the acts that produce desirable or meaningful sequences (Reference 2). The learner tends to eliminate responses which are not reinforced but keeps those which are reinforced by success. In the training program the trainee must be made aware of his successes, this is a further reason for him clearly understanding what is expected of him and how successful his progress has been.

The role of the trainer during the above has been adequately summarized before. "He will tell us what to do and what to expect. He will provide the equipment and watch how we use it. He may guide our movements, or perhaps let us try out a word or an action and then show us where we went wrong. He will give us hints on how to cope with the awkward parts. He will encourage us to practice and let us know whether we have improved, or how we stand up to comparison with other people." (See reference 3.)

The Overall Training Program

In order to assist the new Operations Engineer's learning process, the overall training program is broken down into modules. Some of these modules will be formal training courses at the Nuclear Power Training Center (NPTC) with the remainder being undertaken at the operator's base location. Each module, and each session within it, is designed to achieve specific objectives and takes account of the individual's then current knowledge and skills. These training modules are integrated to maximize the benefit of each, ensuring that the NPTC-based training is consolidated by practical experience on

site and that the trainee is prepared in terms of practical experience before undergoing each of the NPTC training courses. Following a decision that it is necessary to include a particular topic in the training program, it must further be decided at which stage of the program and in which module to incorporate it. This decision is based on the desirability, necessity or advantage of carrying it out at NPTC or on-site, the pre-requisite training necessary for successful learning and where in the overall training program the learned topic will be applied.

We have seen that learning is a gradual process consisting of building upon and modifying what has gone before. The building and modification are stimulated by experiences that come the learner's way. To assist in this process of learning the following are used: lecture, lesson, self-study, group study, projects, tutorials and assignments. The method chosen depends on its suitability in enabling the trainee to achieve the desired level of understanding. Copies of the aims and objectives of each NPTC course and each session within it are made available to the trainee to ensure that he is fully aware of what it is he is required to learn. NPTC course pre-requisites detailing the knowledge that the trainee is assumed to have prior to his attending a particular course are also made available. These form the aims of the previous on-site training modules. Simulation is incorporated into the NPTC courses, reinforcing theory presented or studied previously. The depth of simulation increases from micro-computer based concept simulation used during initial training courses, through generic simulation, to replica simulation used during the later courses.

Using the methods of instruction outlined above, the trainee's skills and knowledge are gradually developed during the training modules outlined below. For theoretical aspects of reactor technology and operation the particular requirement that has to be satisfied is stated along with the ideal solution. This is followed by the possible solutions, their respective advantages and disadvantages, the solution chosen, compromises made and the consequences and considerations that have to be taken into account as a result of that choice. The route followed for system operational aspects is from overall functional requirement through interrelationship of systems, detail of individual systems, control of systems, function of system components, interaction of components, control of components, to interaction and control of whole plant.

Assessment of the trainee is required to provide feedback to the trainee as discussed earlier. The results also provide feedback to the trainer which enables him to monitor the trainee's progress through the modules. Any problem areas which must be dealt with before the next module is undertaken are highlighted. The trainer can then deal with any such difficulties during the tutorial time scheduled after each assessment. Should this provide insufficient or

inadequate, further tuition is arranged to bring the trainee up to the standard required for the next module. Assessment results also provide a basis for monitoring course and training effectiveness. The method of assessment must be educationally valid or the results produced will be open to misinterpretation and provide incorrect feedback.

The assessment practices in use at NPTC are described elsewhere (Reference 4). For lecture-based courses, multiple choice, short answer and brief essay type questions are utilized. They are used in the above sequence as the trainee progress through the program, which is gradually developing his level of understanding. The questions set cover the range of topics included in the modules and hence provide a check that the session and module objectives have been met. Assessment of on-site training consists of oral questioning by direct supervisors or management. For simulator-based training, assignment reports and simulator exercises are assessed, the latter incorporating oral questioning to probe in greater depth the areas of technology, diagnosis, action and communication.

Reactor Control Training Modules

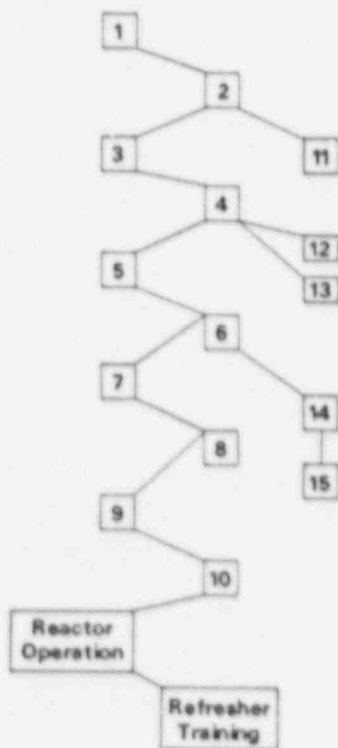


Figure 1 Integration of Initial Training Modules

The overall relationship between the individual training modules, described below, are illustrated in Figure 1. The first module is carried out on-site and concentrates on introducing the new trainee to a complex industrial site. The aim is to ensure an awareness of the procedures to be followed in the event of fire, accident or emergency and the geographical location of plant items.

The second module carried out at NPTC provides an Introduction to Nuclear Power technology. The course is principally lecture based, but use is made of micro-computer based concept simulators and a generic simulator. The concept simulators are used following lectures on nuclear and reactor physics and serve to consolidate and develop the trainee's understanding of the physical principles which are presented in the lectures. They

are designed to illustrate individual aspects of nuclear reactor operation, e.g., the effect of reactor power changes on xenon-135 concentration. Following the study of individual items, the next form of simulation used is the generic simulator. This is used to bring together the interactions of the reactor systems. In this way the effects of a load change can be demonstrated, bringing together reactivity variations due to changes in control rod position, xenon levels and temperatures both of moderator and fuel. The effect of the feedback mechanisms, due to load changes, on reactor behavior and the operator actions required to prevent reactor shutdown are demonstrated by the tutor and then investigated by the trainee as a member of a small group.

The third module is spent back on-site consolidating the information gained on the introductory course. His training aims for this period are to be able to outline basic site legislation, station and departmental staff structures, state the purpose of the station Safety Report, Operating Rules and Instructions, Safety Rules and Emergency Plan and state the location and function of particular plant items.

During the fourth module, the NPTC based AGR Design and Technology Course he will develop an understanding of the design of components and systems required for the safe and commercial operation of the Advanced Gas Cooled Reactors and associated plant. The replica simulators are used for the first time and supplement lecture presentations on such topics as the sequence to be followed after reactor shutdown and the requirements of the heat removal systems. They serve as invaluable training aids to demonstrate and re-emphasize points made in the lectures and have the benefit of simulating in real time the interaction between the various systems and the impact the operator can have on them.

On completing the fifth module back on-site, the trainee should be able to outline the requirements and procedures contained in Operating Rules and Instructions and to outline the functional capabilities of various plant items.

The off-site AGR Operational Technology Course is the sixth training module. This course aims to extend the understanding gained from the AGR Design and Technology Course and to develop a practical appreciation of operational procedures. Simulation is used to provide experience of routine plant operations using a replica interface. The simulators are used in three modes: demonstration, investigation and hands-on. The process begins with demonstrations by the tutor of reactor and plant operations during start-up, steady load and following reactor trip. These demonstrations cover operational and safety requirements during these facets of operation. This is then reinforced by the trainee using the simulator, in a small group under tutorial guidance, to investigate more fully

reactor and plant operations during start-up and after reactor trip. The trainee prepares a report based on his investigations which is assessed as part of the course. It tests his depth of understanding of the principles involved and the requirements to be met during these operations. For reactor start-up, the tutor is looking for an adequate knowledge of the various stages from shutdown to full power and the requirements to be met by protection systems, control schemes and instrumentation. In the case of post trip operation, the trainee has to demonstrate his knowledge of the plant conditions which have to be established, the design logic on which they are based and the operational sequences to be followed in order to achieve them.

During the on-site training, module number seven, that follows the AGR Operational Technology Course, the trainee must gain a detailed knowledge of the plant systems on his station. He should also know the function of all the control desk switches and the implications of their operation, the main requirement being to know the systems that are controlled from the control desk. A further area to be studied is the procedures relating to operation of the unit from the central control room.

The trainee is then ready to attend the eighth module, an Initial Simulator Operations Course. This course is designed to bring together all the systems which have been studied individually. For the first time, the trainee will be operating the simulated unit on his own or with a colleague. He is making the transition from learning about how the reactor operates to how to operate the reactor. In addition to providing further experience of routine unit operation, the replica simulators are used to provide experience of abnormal and emergency unit operation. During the course, any areas which require a greater understanding or more detailed knowledge can be identified. These will be addressed during his next period of on-site training.

This ninth module is spent mainly in the central control room and enables the trainee to consolidate, reinforce and add to his knowledge of operational procedures and the requirement to be met to ensure the safe economic operation of the reactor/unit from the control room unit desk.

The final module, number ten, is an Advanced Simulator Course at NPTC which provides practical experience of a variety of infrequent events and develops his skills in the operation of the plant. On this course the trainee will need to diagnose and take appropriate actions over a range of abnormal conditions. He is expected to demonstrate on the simulator his competence to operate the reactor and its associated systems from the control room in a safe and commercial manner. He does this during a series of exercises on the simulator with the tutor assessing his performance. Whilst a continuous assessment is made, the successful completion of

the training program relies on the trainee demonstrating his competence during the final exercises of the course. To avoid the learning process being inhibited, with its detrimental effect on progress, formal assessments are not carried out frequently during the course.

In training modules eight and ten, simulation has enabled the trainee to gain experience of unit operation under normal conditions in a time considerably shorter than would be possible on the plant. He has also been able to experience abnormal and emergency situations of varying low degrees of probability of occurrence. In both cases, the ability of the trainee to control the plant by diagnosing its state, taking appropriate actions and by communicating with other staff will have been developed. By the assessment of his performance during simulator exercises, the capabilities of the trainee have been established and the trainee will also have been able to establish confidence in his own operational capabilities.

On successful completion of this training program, all the reports on the trainee's performance will be reviewed by his departmental head at the power station who, together with other senior station staff, will undertake an authorization interview. This will assess his competence to undertake the full range of duties associated with reactor control and appropriate recommendations are formally made to the Station Manager.

Reactor Plant Training Modules

These modules are in addition to, and may be carried out in parallel with, the later modules described in the previous section.

Training to enable the trainee to demonstrate his ability to successfully discharge the responsibilities detailed in the Station Emergency Plan is carried out on site during module eleven.

The twelfth module, also based on site, provides training related to the operation of the CEGB's Safety Rules. After completion of this module the trainee should be able to state the policy, philosophy and principles on which the Safety Rules are based. In addition he should be able to describe the measures he would take when isolating a plant item from system hazards and demonstrate his ability to complete the associated documentation correctly. Successful completion of this module and a formal interview will result in his being authorized in writing to carry out defined duties in connection with the CEGB's Safety Rules.

The objectives of the site-based module thirteen are for the trainee to be able to state the procedures to be followed and demonstrate his capability to carry out duties in connection with the

local operation of the CEGB's grid system. Formal authorization follows in a similar way to that described for module twelve.

Module fourteen, the Radiological Safety Course carried out at NPTC, provides the basic training for duties in connection with the radiological aspects of the CEGB's Safety Rules.

Module fifteen carried out on site complements module fourteen to provide the trainee with local knowledge of these radiological aspects. A practical session, which is assessed, is included enabling the trainee to demonstrate his ability to interpret results of radiation and contamination surveys, specify radiological precautions to be taken and prepare the associated documentation. A formal authorization interview follows which is conducted by an independent assessor from another department of the CEGB to ensure a uniformity of standards across the board.

Refresher Training

After completion of initial training, Operation Engineers undertake refresher training programs in order to maintain and update their skills and knowledge. Whilst changes to the power station plant or to the operating procedures will require on-site training programs, they will also be incorporated into the simulator exercises which form the major part of off-site courses, attended annually at NPTC. Theory presented during initial training will be revised with a replica simulator being used by a trained tutor to enable the trainee to revise and practice plant operation under a range of normal, abnormal and emergency conditions.

Simulator Tutorial Facilities

To enable the replica simulator to be used successfully in the various stages described, it must be equipped with facilities to aid the trainee and the tutor. At NPTC tutorial formats are used on the simulators to present information in such a way as to enhance learning. In the earlier courses, they enable the principles of the area being taught to be conveyed without going into too much plant detail and so distracting the trainee with (to him at this stage) the complicated reactor desk.

Each of the tutor formats are designed to achieve a particular objective:

Firstly, they can present information not available on the station. This is because, whereas the magnitude of parameters at various nodes are calculated as part of the simulation process, it is not practicable to measure them on the power station. By presenting selected information the student can see in graphical form the effect certain operations will have on particular systems. Examples of this

are the flux shape and temperatures existing axially along a fuel channel and the water/steam, tube metal and gas temperatures existing along a boiler tube.

Secondly, the information may be presented in a way that aids trainee assimilation. This can be by combining mimic diagrams with plant parameters or showing cross-sections through plant items with the relevant plant information (Figure 2).

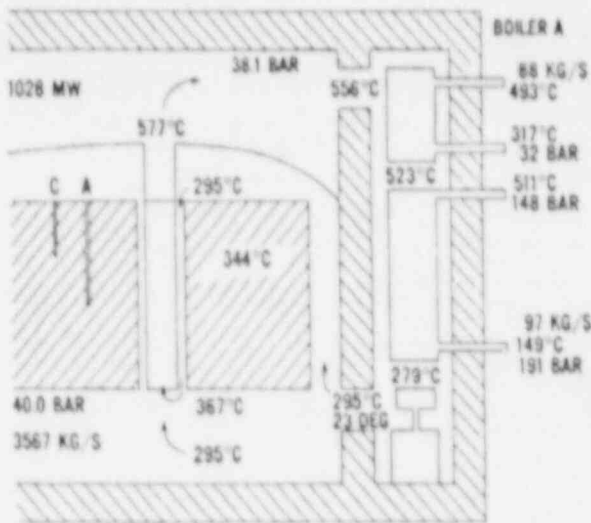


Figure 2 REACTOR/BOILER CONDITIONS

Thirdly, the visual presentation of information can aid the assimilation of a particular point which is difficult to express in words. An example of this is the use of a format to assist the understanding of the operation of a direct digital control loop.

The fourth use of tutor formats is to assist training in a particular area of operation by presenting all the information necessary for that operation together. For example, during reactor start-up, the flux levels measured on instruments with different ranges can be presented together with the various alarm and trip levels (Figure 3).

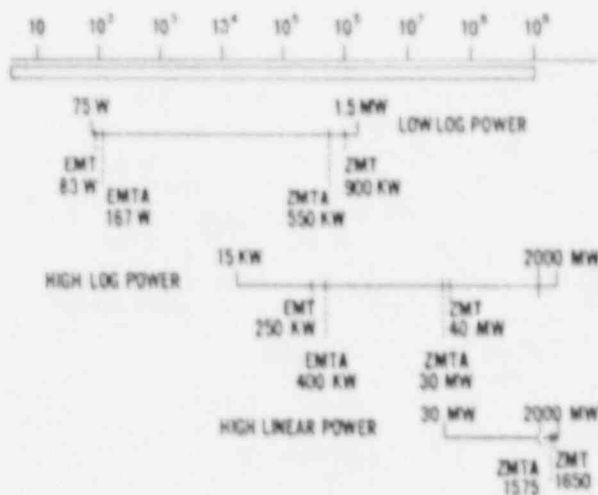


Figure 3 FLUX SAFETY CHANNELS TRIP & ALARM SETTINGS

A fifth type of tutor format allows a time history of any of the simulator model variables to be displayed. The tutor allocates one of six colors to the variable and can select scales for both the variable and time. This type of format allows the trainee to observe the effect of his and plant actions over a period of time and provides the tutor with an aid when discussing and debriefing simulator exercises.

The Simulator Tutor

The first stage of a simulator project is to identify the training requirements that need to be satisfied using a simulator, the

second stage is to design and build a simulator to meet those requirements, the final stage is to provide a trainee to use the simulator. Providing a link between these three stages is the tutor who is required to interface between the simulator, the trainee and the plant being simulated.

To enable the tutor to operate the simulator effectively and efficiently, the simulator must be equipped with "tutor friendly" facilities. He should have access to a number of defined starting points. Facilities are required to return quickly to a particular point in the event of an inadvertent operation. He should be able to send spurious alarms, instrument and switch indications. A range of realistic faults should be available so that faults on valves, controllers and control systems can be inserted. These should be capable of being inserted singly, immediately or after a time delay or as a series of faults in sequence with logical branching available. The faults should be capable of being reset automatically.

The tutor should analyze the events reported in station trip reports and the other formal documents which are issued to describe proposed changes to the plant or operational procedures. This will permit him to utilize the simulator to recreate a scenario in subsequent training programs and also to ensure that the simulator is maintained in correspondence with the plant.

A trained tutor is essential if maximum benefit is to be obtained during simulator training periods. To enable the tutor to discharge his role successfully he must have an in-depth knowledge of the simulator. He must also be thoroughly familiar with the plant the simulator represents. During training courses he will constantly bring to the trainee's attention points of detail relating to the plant which may not be immediately apparent on the simulator. The tutor must know any limitations that the simulator may have and ensure that during the training exercises, the simulator is not used outside these limits.

The tutor contributes to the development of the operator by giving guidance, pointing out strengths and weaknesses, giving credit where it is due and, by directing the training exercises, removing any areas of weakness. His input is required to ensure that areas such as those given below are incorporated into either the training exercises or are adequately discussed in the de-brief sessions (or both).

- o The operator must consider the effects of his actions on the plant, both in the short and longer term. The latter could be an economic penalty resulting from accumulated plant damage caused by a particular operation.

- o The tutor should ensure that the operator is distracted in ways that will occur in the control room, as he must learn to cope and continue to operate the plant satisfactorily.
- o The operator must be made aware of the dangers of, and an tendency he may have towards, "tunnel vision." He must be encouraged to view the system as a whole and not to focus too much attention on one aspect or he may fail to diagnose important information being indicated in another part of his interface with the plant.
- o When several faults occur, the operator must learn to allocate his priorities accordingly with the most serious, or potentially most serious, receiving the attention it deserves.
- o At all times the operator must be aware of the limitations imposed by operating rules so that by taking appropriate action, he operates within them.
- o When plant is made unavailable for service, e.g., breakdown or planned maintenance, the operator must consider the implications on continued operation. In addition, he must review the potential impact of any subsequent faults.
- o The operator should appreciate the effect of changes to the configuration of the main, auxiliary and essential electrical systems on plant operations, either directly or following a reactor trip.

A replica plant simulator allows realism to be introduced into the training of operators provided that it has been designed and built to satisfy defined training objectives and is operated by a trained tutor.

Conclusion

The processes involved in the production of electricity utilizing the heat produced by nuclear fission deserve respect - there is no room for complacency. Any adverse effects on the health and safety of the general public and employees must be minimized. Nuclear Power Stations must be designed, constructed, operated, maintained, inspected and ultimately decommissioned with techniques maximizing safety and reliability and minimizing risks.

Nuclear power stations will be controlled by operators for the foreseeable future. Training programs are required to provide a trainee with the skills and knowledge necessary to operate the plant

safely. The training program should be designed to meet defined training objectives and incorporate the factors that assist the learning process. Assessments provide feedback to the trainee and trainer enabling progress and training effectiveness to be monitored. Simulation provides a unique way of providing the trainee with experience of plant operation over a wide range of normal, abnormal and emergency conditions. By equipping the simulator with additional facilities a trained tutor can gradually develop the trainee's capabilities and confidence and assess his competence. To achieve the defined training objectives the tutor must have the capability of interfacing between the simulator, the trainee and the plant being simulated.

The CEGB has been operating commercial nuclear plants for 25 years. With the advances in technology in use at nuclear stations and available for use in training, Operations Engineer training programs have been continuously developed. This evolution will continue ensuring that nuclear power station staff receive the training they need to discharge their duties safely, effectively and efficiently.

Acknowledgments

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A CENTRALLY COORDINATED MAINTENANCE TRAINING & QUALIFICATION PROGRAM FOR A MULTI-UNIT UTILITY

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Abstract

Carolina Power & Light Company (CP&L) operates fossil, hydro, and nuclear generating plants. Included are three nuclear plant sites -- two sites are single-unit pressurized water reactors and one site is a two-unit boiling water reactor. A centrally coordinated five-year, five-level Training & Qualification Program is conducted for nuclear plant mechanics, instrumentation and control technicians, and electricians. This program consists of five levels of generic training conducted at a central training facility, five levels of site-specific training, and five levels of employee qualification based on a qualification card system. This program has obtained INPO accreditation.

Overview

Carolina Power & Light Company (CP&L) is an investor-owned utility that serves portions of North and South Carolina. CP&L operates fossil, hydro and nuclear generating plants at 13 different locations. There are three nuclear plant sites which are the Brunswick Steam Electric Plant, Southport, North Carolina; the H. B. Robinson Steam Electric Plant, Hartsville, South Carolina; and the Shearon Harris Nuclear Power Plant, New Hill, North Carolina. The Shearon Harris Energy & Environmental Center (SHE&EC), New Hill, North Carolina, serves as a central training facility.

The Operations Training and Technical Services Department, under which the Nuclear Training Section operates, is responsible for the technical training of plant personnel under the umbrella of a Training & Qualification Program. Management development type training, which includes courses in supervision, communication skills, and techniques of management, is conducted by a section of the Employee Relations Department. This paper describes a Training & Qualification Program aimed at producing a technically qualified maintenance employee.

Program Description

Carolina Power & Light Company's Training & Qualification Program (T&Q) has four major objectives. These objectives are:

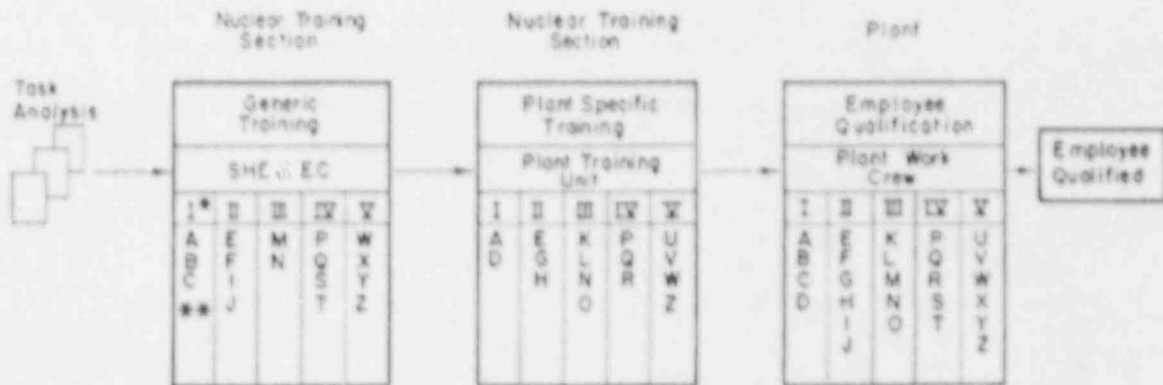
- o Train and qualify employees to competently perform job tasks.

- o Meet regulatory agency requirements for training, qualification, and documentation of qualification.
- o Achieve and maintain Institute of Nuclear Power Operations (INPO) training program accreditation.
- o Provide written tests and job performance evaluations for employee promotion requirements.

The above objectives are accomplished under the umbrella of a Training & Qualification Program. The Training & Qualification Program is divided into three major components which are generic training, plant-specific training, and employee qualifications (see to Figure 1). These major components and a description of the training organization are provided below.

Figure 1

CP&L
Central Plant & Logistics
**NUCLEAR PLANT
 TRAINING & QUALIFICATION PROGRAM
 OVERVIEW**



* I - V Represents Years Of Employment
 ** A - Z Represents Qualification Cards

Organization

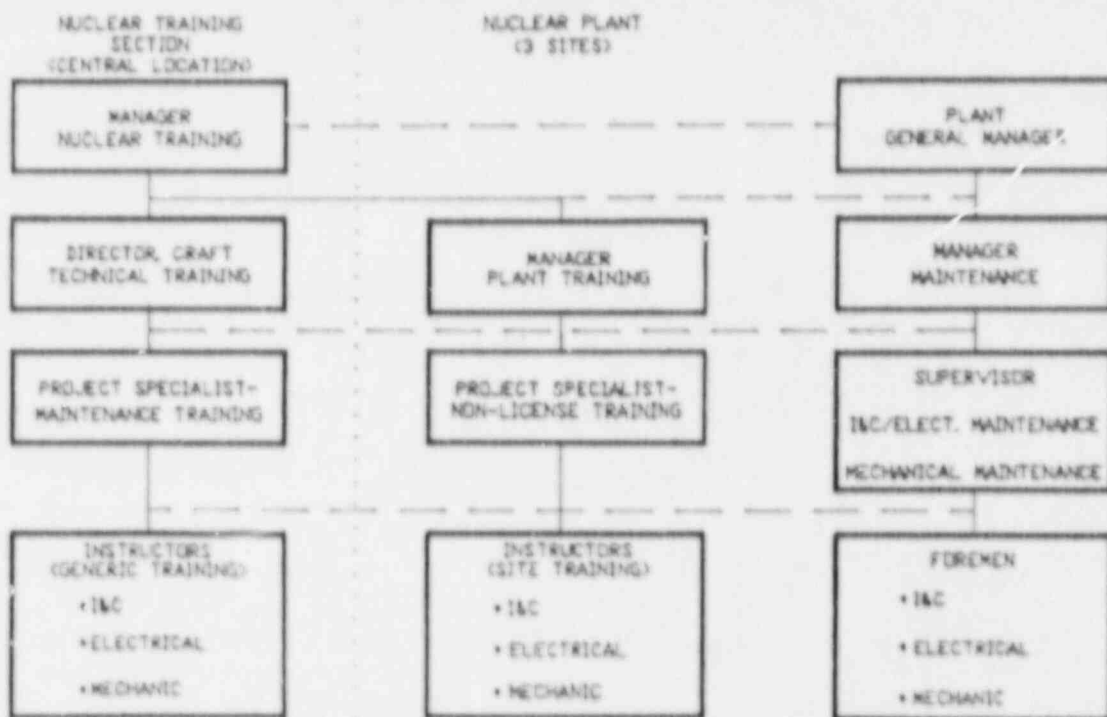
The Nuclear Training Section of Carolina Power & Light Company is organized into eight functional units reporting to a Manager - Nuclear Training. These units are:

- o Craft Technical Training Unit. This unit is responsible for generic maintenance, health physics, chemistry, and quality assurance training. This unit is located at the SHE&EC, New Hill, North Carolina, and is about geographically centered in CP&L's service area.
- o Curriculum Development Unit. This unit is responsible for program evaluation, instructor certification, and academic assistance on task analysis and lesson plan development. This unit is located at the SHE&EC, New Hill, North Carolina.
- o Nuclear & Simulator Training Unit. This unit is responsible for generic nuclear operator, shift technical advisor, and radwaste operator training and a simulator for one plant site. This unit is located at the SHE&EC, New Hill, North Carolina.
- o Plant Training Units (3). These units are responsible for the implementation of plant-specific maintenance, health physics, chemistry, operator, and general plant training. Included is the responsibility to conduct continuing/retraining lessons. This includes training on plant modifications, procedure revisions, operating experiences, and subjects in support of degraded job performance. These units are located at the Brunswick Steam Electric Plant, Southport, North Carolina; the H. B. Robinson Steam Electric Plant, Hartsville, South Carolina; and the Shearon Harris Nuclear Plant, New Hill, North Carolina.
- o Administrative Unit. This unit is responsible for budget, cost control, assistance with vendor contracts, and generic course scheduling interface with plant sites. This unit is located at the SHE&EC, New Hill, North Carolina.
- o Fossil Operator Training Unit. This unit is responsible for generic training of fossil plant operators. This unit is located at the SHE&EC, New Hill, North Carolina.

All units report to the Manager - Nuclear Training who is located at the SHE&EC, New Hill, North Carolina. The Manager ensures consistency and efficiency between each unit and provides for a common denominator at a reasonable organization level. Figure 2 provides a graphic overview of the functional maintenance training organization.

Figure 2

CP&L
 MAINTENANCE TRAINING
 FUNCTIONAL ORGANIZATION OVERVIEW



Generic Training

Generic training is divided into five levels, each of which corresponds to one year of employment. Level I is for an employee's first year of employment, Level II is for an employee's second year of employment, and so forth. Level I is for employees without work experience but who otherwise meet Company education and other employment requirements. Employees may be employed at advanced levels depending on overall education and work experience. Employment levels are determined by the employing supervisor and the Employee Relations Department. Employees employed at levels above Level I are not required to complete lower-level training unless specific needs are identified.

Generic training consists of self-study instruction, classroom, and laboratory training. This classroom and laboratory training is conducted at the SHE&EC, New Hill, North Carolina. Personnel from hydro, fossil, and nuclear plant sites participate in this training. Level I training for mechanics and electricians is self-study instruction conducted during working hours at the plant sites. This Level I self-study training consists of subjects in overall plant operations, safety, and tool use and operation. Level I training for instrumentation and control technicians consists of classroom and laboratory instructions. Level II through Level V training for mechanics, electricians, and I&C technicians consists of classroom and laboratory instruction. An average of three weeks of generic training is conducted at each level. About 60% of this training is hands-on laboratory instruction with the remaining 40% consisting of classroom lectures and discussions. The technical content of training in each level is based on qualification cards associated with that level. Generic training provides instruction on the purpose, operation, troubleshooting, maintenance, and repair of components and systems common to Carolina Power & Light Company's generating plants.

Employees are evaluated during generic training using both written and performance evaluations. A test results sheet is provided to the employee's supervisor upon completion of training. The test results sheet provides, on a pass/fail basis, an evaluation of an employee's performance on written tests for each subject taught and an evaluation of each laboratory exercise. Satisfactory completion of the written tests, 80% score or better, is one requirement for an employee's promotion.

Plant-specific Training

Plant-specific training is divided into five levels. This training is based on the qualification cards associated with a level and the content of generic training. Plant-specific training is conducted by an on-site training unit at each nuclear plant site.

Plant-specific training consists primarily of classroom and walk-through instruction. This training concentrates on site-specific procedures, systems, processes, and equipment. Written and performance evaluations are conducted for selected subjects and plant walk-throughs. About two weeks of training per level is conducted for mechanics and electricians. About four weeks of training per level is conducted for instrumentation & control technicians. A training completion report is sent to the employee's supervisor upon completion of training indicating, on a pass/fail basis, the employee's performance on written and performance evaluations. This training is in direct support of site-specific qualification card approval.

Employee Qualification

Employee qualification is accomplished through the use of a qualification card. Qualification cards are developed for key job tasks based upon a job task analysis. The qualification card is a two-part document which consists of a qualification checkout card (QCC) and a qualification card answer guide (QCAG). The QCC provides documentation of qualification. Qualification cards are signed only by plant designated employees and supervisors and not by training department personnel.

The QCC lists subordinate knowledge and/or performance tasks associated with a job task. Some QCC's list training required for qualification. Each subordinate task and required training listed on the QCC has an associated signature approval line. Employees obtain a signature by demonstrating skills and knowledge and passing training as defined on the qualification card answer guide.

On-the-job work experience leading toward employee qualification is the responsibility of the employee's foreman. The foreman assigns an employee to a work crew to gain work experience. An evaluator is recommended by the employee's foreman and approved as an evaluator by the maintenance manager. The designated evaluator should have met ANSI work experience time requirements, be qualified for on the job tasks for which he is to evaluate others, and have completed a course on the conduct of on-the-job training or equivalent.

When the employee demonstrates to the evaluator that he meets the requirements listed on the QCAG, the evaluator approves that item on the QCC. Upon approval of all items on the QCC, the employee signs the QCC indicating that he has the necessary skills and knowledge to perform the designated job task. The employee's foreman then approves the QCC card. The employee is then considered qualified on the specified job task.

Program Development

The Training & Qualification Program was developed using a systematic approach to training. Components in this approach included, in order, the development of a task analysis, development of qualification card answer guides, determination of training needs, and development of training. These components are described below.

Task Analysis

CP&L interfaced with INPO in the development of a task survey for two plant sites -- one PWR and one BWP. For the third plant site, a PWR under construction, CP&L obtained a task survey from INPO for a similar configuration plant. A plant-specific task

analysis was completed using the INPO task survey and a generic task analysis which had been previously completed by CP&L.

A Training Advisory Committee consisting primarily of a foreman from each plant site for each employee classification (i.e., mechanic, instrumentation & control technician, electrician), an academic developer, and a technical instructor from the Nuclear Training Section compiled the task analysis. A draft of the task analysis was reviewed at each plant site by personnel designated by the maintenance manager to ensure technical accuracy and sufficiency. Upon completion of this review, the task analysis was finalized and served as a basis for further program development.

Qualification and Card Answer Guides

All job tasks from the task analysis were reviewed with regard to complexity, importance to key plant systems and components, and plant training documentation. Based on this review, job tasks were selected for which to develop qualification card answer guides. QCAG's describe a job task such as the troubleshooting, disassembling, repairing, and reassembling of an air compressor. References to key plant maintenance instructions and procedures are listed. Criteria for satisfactory performance are detailed on the QCAG. Criteria were developed using the subordinate task listing under the major job function from the task analysis.

The QCAG's were drafted by a subject matter expert provided by the training section at each plant site. Drafts of the QCAG's were reviewed at each plant site by personnel designated by the maintenance manager. Upon completion of this review at each plant site, the Training Advisory Committee met to finalize the QCAG's. This process provided for both the development of plant-specific qualification QCAG's as well as generic QCAG's where the criteria was the same for all plant sites.

The qualification checkout card, a one-page document, was generated by word processing directly from the QCAG. The QCC lists the major job functions, has a signature approval line for each subordinate task, employees' signature line, and a foreman approval line. The QCC serves as the method to document employee qualification.

Determination of Training Needs

The Training Advisory Committee completed a training needs analysis for each maintenance classification. A work sheet was developed for each job task from the task analysis. This work sheet addressed whether or not the job task had an associated QCC, complexity of the job, applicability of knowledge and skills needed for job performance, and provided for the listing of training objectives. Generic training, five levels which had previously been

developed based upon a generic task analysis, was reviewed against the training needs analysis work sheet. This review served to identify any weaknesses in generic training and to specify site-specific training needs. The objectives from the training needs analysis work sheet not covered in generic training were compiled to form the basis for site-specific training lessons.

Program Implementation and Evaluation

Generic and plant-specific instruction was implemented after development and approval of training lesson plans on a scheduled basis. Training courses are evaluated with regard to technical sufficiency, accuracy, and presentation.

Implementation

Implementation of generic training is the responsibility of the Craft Technical Training Unit at the SHE&EC. This training is scheduled on a yearly basis. A proposed training schedule is developed based on projected employment levels of employees. This schedule is sent to each plant site where plant supervision selects a course level and date and assigns an employee to training classes. This information is then reviewed for class loading, finalized, and returned to each plant.

Implementation of plant-specific training is the responsibility of the training director at each plant site. A course schedule is developed in concert with employee qualification requirements and generic training prerequisites.

Evaluation

Once a year each level of generic and plant-specific training is evaluated by the Curriculum Development Unit of the Nuclear Training Section. This evaluation addresses selected job factors with regard to whether or not the employee can perform the job, where the employee learned to perform the job, frequency of performance, and whether additional training is needed. This evaluation obtains information from both employee and the employee's supervisor. Evaluation results are sent to the applicable training unit (i.e., generic and/or plant-specific) for appropriate actions on recommendations.

Each time a course is conducted, a course evaluation form is administered. This form obtains feedback from course participants with regard to course conduct and course content. As a result of this input, action items are identified that enhance the training program.

Program Coordination

The Training & Qualification Program is coordinated to ensure continuity between generic and plant-specific training. This consists of both technical and administrative coordination.

Technical Coordination

Technical Coordination of Maintenance Training is achieved by a close working relationship between generic and plant-specific instructional personnel and by controlled distribution of training materials. Generic and plant-specific instructors may meet periodically to review industry experiences, plant modifications and new equipment that may affect training needs. Copies of generic lesson plans are maintained at each plant site. Copies of plant-specific lessons are maintained at the central training facility. By having these materials available, reviews may be conducted for technical accuracy, consistency and appropriate interface.

Training Advisory Committees for each maintenance classification meet at least once a year to review generic training. This includes a review of lesson objectives, technical content, "hands on" exercises and test questions. In addition, these advisory committees provide input on new or revised work methods, new equipment and plant experiences. Additions or deletions to generic training are made as a result of this input. Revised generic training lessons are forwarded to each plant for review. Plant specific training may be revised as a result of changes to generic training.

Training courses generally consist of a series of individual lessons. Management controls are in place to review and approve changes to existing courses and/or the implementation of new courses. The Manager - Nuclear Training approves a course description sheet for each course. This course description sheet lists each lesson obtained within the course.

Administrative Coordination.

Administrative coordination is achieved by the central development of plant training instructions and Training section administrative instructions. Plant training instructions provide specific guidance on the administration and the general content of training provided at a plant site. Administrative instructions provide specific guidance for overall program administration.

Plant training instructions and training section administrative instructions are developed centrally by obtaining

direct input from plant site training personnel, plant maintenance personnel and personnel conducting generic training. Based on this input and input from regulatory agency guidelines and commitments, these instructions are drafted and circulated for review. After review and further input, a uniform instruction is generally reviewed in detail in a joint meeting of key personnel. The document is then finalized and implemented. Changes may be handled in a similar manner. Input from one site may be reviewed against commitments and needs from other plant sites. Based on this review, a change may be implemented at all sites.

INPO Accreditation

Accreditation self-evaluation reports were submitted to INPO in June 1985. These reports were for the mechanic, electrician, and instrumentation & control technician Training & Qualification Program at the Brunswick, Robinson, and Harris Plants. These reports described the nine (three programs at three sites) programs that are addressed in the paper. An INPO accreditation team visit was made to each nuclear plant site and to the SHE&EC in August 1985. As a result of an INPO accreditation board meeting in December 1985, all nine Maintenance Training & Qualification Programs were accredited.

Summary

CP&L operates fossil, hydro, and nuclear generating plants. A centrally coordinated five-year, five-level Training & Qualification Program is conducted for nuclear plant mechanics, instrumentation & control technicians, and electricians. The program consists of generic training, plant-specific training, and employee qualification based on a qualification card system. This program has obtained INPO accreditation.

Discussion

MR. BUDNICK: How much do you use self study? Is Carolina Power and Light union or non-union?

MR. PATE: We are non-union. At some levels of training, mainly for electricians and mechanics, the first level is self study. Level 1 entrance requirement is a high school diploma, and self study (of about 80 calculated hours) is fundamentals, tools and equipment. Level 2 is classroom training.

MR. LONG: How do you handle back-fit in your work force?

MR. PATE: When we implemented this five-year program several years ago, we faced the problem head on. We started the actual classroom training on a two-shift operation and basically ran

everybody through the program. People who come to us now with previous experience can be fit into the program. Based on their previous experience, it may require that they go back and take previous levels of training.

MR. FIDAGO: Are your people task-certified at each individual level throughout the five year period.

MR. PATE: Yes, they are individually task qualified.

COMPUTER-ASSISTED TRAINING FOR DIAGNOSIS
AND INCIDENT SITUATIONS

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Abstract

A presentation of Computer-Assisted Training (CAT) and of its place in training the staff of nuclear power stations, the resources used, the objectives, the courses now being developed, an assessment, and the growth prospects.

An Historical Note

Ten years ago, nuclear facilities were very limited, but in the meantime, some 32 900-MW PWR units and 9 1300-MW PWR units have been put into service, requiring some very substantial training arrangements and programs relating to start-up, control and maintenance of the installations, with a constant concern for improving quality and safety.

Thus, as early as 1979, the staff growth and the increase in the technical level of facilities led the Nuclear and Fossil Generation Department (known as "SPT" from the French initials) of Electricité de France (EDF) to study the use of a new kind of teaching tool intended to solve the tricky problem of maintaining knowledge and know-how at the desired level.

Computer-assisted training (CAT) seemed, a priori, a suitable approach to dealing with that problem. But, to ensure that CAT constituted an effective approach to the objective in question, the program was preceded by the following:

- o A search for CAT software. The market was very limited at the time, and the choice fell in the IMG product (Instruction Module Generator) of the IBM firm.
- o A feasibility study (from the end of 1979 to March 1980), carried out with the help of 15 employees of the departments concerned with control of nuclear facilities.
- o A "life-sized" test (from July 1981 to June 1982) on five nuclear power stations involving 700 people. This

experiment made it possible to improve the module writing by taking user reactions into account.

An analysis of the results of this test, which the users considered satisfactory, led the SPT in 1982 to extend the use of computer-assisted training to all nuclear installations.

Resources Used

Equipment. The courses are catalogued on a central computer of the I.B.M. 3033 type, and are accessible from terminals installed at the nuclear units, in training rooms, control rooms, etc., thus enabling the nuclear facility control staff to enjoy access to the various courses 24 hours a day. There are now more than 100 terminals at the nuclear installations.

Staff used in developing and managing the courses. Development is in the hands of seven engineers who work, the bulk of the time, as a pluri-disciplinary team in working out the course scenarios. A pluri-disciplinary team generally consists of a trainer or some other person with complete knowledge of the subject in question, several future users, and the engineer in charge of the course development. Course input into a computer, management and maintenance of the system are the task of three operators.

This organization ensures constant dialogue (electronic mail) between designers and users, through the intermediary of the terminals. The result is excellent follow-up on the courses, which are immediately supplemented and corrected as a result of the users' observations.

Content and Structure of the Courses

Four major topics are distinguished:

- o Elementary systems. These courses deal with the various circuits of a nuclear power station and describe:

- their role

- their geographical locations

- the ordinary maneuvers involved in operating them

- particular technical points about the various organs

the monitoring-control system and related regulation systems

how the units are put into and taken out of service

common operating incidents, their consequences, and how to behave if they occur.

These various courses cover practically all of the basic instruction blocs:

basic technical training
joint technical training
operations training

These courses are given at training centers providing training in the techniques and the operation of nuclear installations. They are developed for the different nuclear levels involved in operating 900-MW and 1300-MW PWR, allowing for the special features of certain nuclear facilities.

Five course libraries are in use:

three for the 900-MW level:
900 CP1-CP2
900 BUGEY
900 FESSENHEIM

two for the 1300-MW level:
1300 P4
1300 P'4

Each library contains around 120 course hours. At present, some 500 hours are in use out of the scheduled 600, as the 1300-MW level is not yet finished. These courses, which have been the basis of computer-assisted training for keeping knowledge up to par, are divided into four levels. Each level is particularly intended for a certain category of control staff, from a roundsman to a bloc chief -- but it is accessible to all.

- o Logic and automatic systems. An initial part of the courses deals with the basic principles of automatic devices and systems, and includes many exercises. The following are found in this part:

Notions of binary logic (equation establishment and simplification)

The JK-RS scales

Numeration

Microprocessors

These courses are intended for general use, and their structure is aimed at a twin objective:

Serving as a prerequisite for attendance at certain training sessions.

Maintaining knowledge after such sessions.

A second part of the courses deals with specific automatic control systems of nuclear power stations of the 1300-MW type, and is intended for technicians of the automatic systems maintenance departments. The following topics have been or are being developed:

The "CONTROBLOC" programmable automatic control system, designed specially to meet monitoring-control requirements.

The SPIN system (standing for built-in numerical protection system) based on microprocessors

The RGL system (Cluster Regulation Logic) ensuring processing of the cluster control logic.

These various courses represent about 50 training hours.

o General topics

Radiation protection. The different radiation protection training courses have been synthesized at the level of the most important knowledge, and account for about ten course hours. These courses are intended for the whole staff of nuclear generating stations, and are used primarily in recycling.

Fittings. These courses constituted a general approach to the various types of taps and valves found at the installations. A description of them indicates the ways of identifying them, the different kinds of problems that may arise in connection with handling, and the precautions to

be taken. These courses, intended for anybody who might be called on to handle valves, account for about five course hours.

- o Incidents. This library surveys a certain number of incidents that have occurred at French and foreign power stations. Two kinds of incidents are developed:

Those that might endanger the safety and security of the installation. In this case, a delicate analysis is made of the warning signs and the consequences, recalling and explaining to the operator who might be faced with this situation the steps to be taken quickly.

Incidents not affecting safety, but having an effect on installation availability. This portion deals with incidents resulting from improper handling and the rare incidents which are rather difficult to analyze and delay the start-up of a tranche.

This fast-growing library represents about 20 course hours, and deals with about 15 incidents. These courses are intended only for operating staff, from the operator to the safety engineer.

The teaching approach is different from the one used in the other courses. It calls more on reflection, and the instruction developed on the basis of the incident refers often to instructions, physical principles and the knowledge required for operating the installations generally.

These courses are among the most highly appreciated ones, as they call in an initial phase on practical knowledge before getting into the kind of theoretical knowledge that is indispensable for understanding the phenomena in question.

Uses of the Courses

Because of their structure and the possible assistance they offer when the student does not know the answer, the courses can be used in ways going beyond the initial goal of knowledge maintenance, and can be employed in self-training.

Some actions are in progress to introduce CAT in master courses given at certain training centers (such as Gurcy-le-Chatel) in order to determine, on one hand, whether CAT can constitute an

interesting supplement to present teaching methods, and on the other hand, the way of introducing use by the trainers as well as the trainees.

The extent of use of computer-assisted training at the nuclear facilities from 1982 to 1986 is indicated by the following figures:

1982	15,500 hours
1983	19,600 hours
1984	23,350 hours
1985	18,138 hours
1986	18,230 hours

For a pair of 900-MW PWR units, use can vary from 1,000 to 500 hours a year, representing for the population using CAT an average of 10 to 20 hours per year per student. The CAT users' statistics have slightly regressed since 1984 and are now stabilizing. The major reason is the end of the development of the French nuclear program and the diminution of various job applications of the staff.

Prospects

Within the framework of present CAT activities, growth prospects are based primarily on:

- o Incidents
- o Explanation of general operating rules
- o Instructions relating to accidents
- o Automatic devices and systems

Some developments involving video discs coupled with CAT are being studied in the field of valve maintenance and fuel loading and unloading.

A completely new product, which can be considered as computer-assisted training, is being developed, combining:

- o Real time simulation
- o An expert system providing an analysis, after the exercise, of the operator's actions.
- o CAT of the type now used, ensuring a theoretical explanation of the physical phenomena involved.

This new kind of pedagogical tool consists of two microcomputers of the IBM PC AT 3 type, doped up by the addition of a 32-bit GOULD microprocessor.

- o The real time process is being developed by THOMSON CSF (France).
- o The expert system is being developed by FRAMENEC (France).
- o The software used for the control room environment, ONSPEC, is a product developed by HEURISTICS (USA)
- o The explanation of the physical phenomena involved will be developed by the team in charge of production of the present CAT courses.

The first part of the project, real time simulation, will be operational in March 1988, and the second and third parts in the course of the same year.

The process being developed concerns a rupture in the tubes of a steam generator, with installation control in accordance with the accident procedure until a safe level is reached.

Other processes will be installed, with the goal of intensifying operator training at each nuclear tranche:

- o in certain tricky phases of accident management.
- o in normal operating phases that very often cause emergency stops.

It is planned for the course libraries of the current CAT program to be operational with this new instruction tool so as to have a complete and very powerful self-training tool available at each nuclear tranche.

Discussion

MR. SIDAGO: What is the motivation for the operators to take computer-assisted training courses?

MR. TANGY: I'll answer on behalf of Mr. Cordier. Motivation of personnel, in general, has been linked to career considerations. As you know, there has been a great development of careers in EDF staff during the last ten years. As that levels off, we may have to re-motivate the staff on CAT training. You saw the small degrees in 1984, which can be attributed to the diminution of careers and the stabilization of the staff. But we think many things are missing now in our nuclear training program, and CAT could be a positive influence.

VIRGINIA POWER'S COMPUTER-BASED INTERACTIVE Videodisc TRAINING:
A PROTOTYPE FOR THE FUTURE

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Abstract

Virginia Power has developed a system and internally produced a prototype for computer-based interactive videodisc (CBIV) training. Two programs have been developed using the CBIV instructional methodology: "Fire Team Retraining" and "General Employee Training (practical factors)." In addition, the company developed a related program for conducting a videodisc tour of their nuclear power stations using a videodisc information management system (VIMS).

Introduction

For many years the nuclear power industry and nuclear training have been on the leading edge of technological progress in many areas. In keeping with this surge, Virginia Power began exploring effective uses for available technology linking microcomputers to videodiscs. It is well known that both systems have many positive aspects when operated individually and even more attributes when operated in concert. This paper describes two applications that have been developed for internal training and public information that effectively use these systems.

Background on Computer-Based Interactive Videodisc Training

While most people are familiar with computer-assisted instruction (CAI), few have experience with interactive video. The distinction between traditional CAI and interactive video is critically important and readily apparent. CAI is a text-based instructional system. Although some graphic capabilities exist in CAI, learning ultimately relies on the written word. The student is told about some problem and about its solution.

Computer-based interactive videodisc (CBIV) training technology is an image-based multi-media system. It teaches by showing the trainee what must be done and telling him how to do it. With the right software, the learner can explore the course, have a chance to exercise his new skills and receive immediate feedback and tailored tutorials on his progress.

At the heart of a CBIV system is the marriage of the latest microcomputer technology with a videodisc player. Together the two create an intelligent and highly interactive video training system.

Using current interactive video technology, trainees can simulate their way through a wide variety of training problems, ranging from technical skills to management training. The viewer can interact with what he sees on the screen, and interrupt the video to ask a question or to detect some problem, as well as to change the course of events in some way. The trainee's activities can be entirely self-paced and should require no experience with computer or video systems. In fact, the keyboard is often not used and the student merely touches the screen to interact with the system.

Computer-based interactive videodisc training technology offers trainers many benefits. Some of these are listed below:

- o It provides a high degree of consistency in the training program, alleviating problems of instructor variability.
- o It provides a high degree of training reliability through feedback to trainers concerning student performance.
- o It provides a means of delivering training in accordance with trainee's individual needs, thus alleviating scheduling and pacing problems.
- o It can provide a means of delivering high quality training at a greatly reduced cost when compared to a classroom alternative in certain situations.

There are also a number of advantages of CBIV from the trainee's perspective:

- o It is self-pacing.
- o It is self-scheduling.
- o It provides immediate and intelligent feedback.
- o It is an active learning method.
- o It has game-like appeal.
- o It provides visual clarity.

System Description for Computer-Based Interactive Videodisc Training

After a review of hardware and software delivery systems available, a decision was made early in 1984 to use the expertise and equipment recommendations of Interactive Training Systems, Inc. (ITS), of Cambridge, Massachusetts, USA. This company provided

excellent support and assistance in determining the specific software and compatible hardware needed to develop CBIV training programs in-house and to implement the pilot test.

As with any computer technology, the development of CBIV training programs depends upon software to bring to life the potential created by particular combinations of hardware. An interactive video training program requires that the computer controlling the training session be able to switch intelligently from video material to computer-generated screen menus.

In a typical training session, the trainee will view a section of video material, during which time he can stop the video action by touching the screen. If he stops the video action, he will be presented with a screen which either poses a question, explains that this is not a problem area, or provides some other form of information. The flow of the lesson is affected by many factors such as: the trainee's prior knowledge or experience; learning style; whether the trainee interrupts to take action or to ask a question; and the trainee's response to questions prompted by the program. The training system must be sophisticated enough to alter the video and text content of the lesson, depending upon the responses of the trainee.

The ITS authoring software system, called AUTHORITY (TM) met this requirement and was selected in mid-1984. The AUTHORITY (TM) authoring system is an English-based menu-driven system. The sequence of video scenes and menu screens can be thought of as the "logical flow" of the lesson. The purpose of the authoring system is as follows:

- o To create or define the segments of video and text material, called "scenes";
- o To build or link scenes into a network of inter-connected screens, called a "maze"; and
- o To save this maze in the data format which can then be read by the operating system software to produce an interactive training session.

A scene is the fundamental unit of material which is presented to the student at one time. Scenes are divided into the following three major groups:

- o Video Scenes
- o Text Scenes
- o Other Scenes

A video scene consists of a segment of videodisc material. The segment has a beginning point (or "frame") and an ending frame. As a video scene is being played, the student has two ways of leaving the scene. He can either touch the screen or do nothing (that is, view the scene until it reaches its final frame). There are also two sub-types of video scenes: action scenes and pause scenes.

A text scene consists of text material which is displayed on the screen by the computer. Text scenes provide the means for displaying questions, answers, explanations, hints, or coaching. There are several ways in which a student can interact with a text scene and there are several possible ways in which a student can exit from a text scene.

Other types of scenes are those which the trainee never views directly, but which control access to other scenes.

The hardware required for each workstation consisted of the following components:

- o IBM personal computer, 256k memory (later upgraded to 384k), 2 disk drives.
- o high resolution RGB color monitor
- o ITS-2002 interface controller (later upgraded to a 3100 interface controller)
- o light pen
- o touch sensitive screen
- o videodisc player, Sony LDP 1000 with remote control capability
- o interface cabling and connectors

In addition to the workstation hardware, a software station license from ITS was needed for development.

The 1984 costs for hardware, software, and licenses for five workstations was \$75,000. Additional workstations were available at a cost of approximately \$13,000 each.

Description of Prototype

While procurement and acquisition of hardware and software was taking place, the project leader and his assistant received training on the ITS authoring system and began designing the prototype. After narrowing the possible prototype program topics to

three, a final choice was made to develop and produce a CBIV program which would provide refresher training to company power station fire team members. The goal was to refresh team members with the basic concepts of fire behavior and the proper selection and use of portable fire extinguishers. Based upon an observation of video footage of a fire in progress, the trainee would develop an appropriate strategy, or sequence of events, for extinguishing the fire. Specifically, this sequence of events included the following:

- o Properly identifying the classification of the fire.
- o Properly identifying the stage of development of the fire.
- o Identifying appropriate fire extinguisher types.
- o Detailing appropriate fire extinguisher utilization procedures.

Each trainee completing the twenty-minute program would accomplish the following objectives:

- o Define the four elements of the fire tetrahedron.
- o Identify the three stages of fire development.
- o Identify the four classes of fire.
- o Identify six types of fire extinguishers.
- o Describe the basic characteristics of extinguisher utilization.

The program was to be used initially to prepare fire team members for their next retraining class, resulting in less class time being needed. This would allow for more time to be spent with instructors conducting field training exercises/evolutions.

The major milestones associated with this project included the following:

- o Program Design
 - storyboarding
 - flow charting
 - scripting

- o Program Production
 - video production/shooting
 - video editing/post-production
 - authoring
 - premastering to 1" master tape
 - disc pressing
 - program assembly and testing
- o Program Implementation
 - pilot testing
 - program adjustment
 - program replication

It should be noted that video production and post-production support was provided to the project by another department within the company. Several services were required that were beyond the internal capabilities of the company, such as, audio talent for "voice overs", premastering from 3/4" to 1" videotape, and videodisc production.

Selected costs related to this project are listed below:

o Trainee workstation, including	
ITS 3100 upgrade	\$12,500
o Annual license	1,500
o Initial cost per program	14,500
o Additional copies per program	20

The fire team retraining program was piloted and successfully demonstrated an effective instructional component/supplement for this training area. A second program, "Practical Factors," for use with General Employee Training has also been developed and implemented since that time.

The decision on whether or nor CBIV is an appropriate medium for training delivery is a very important one, and one that can determine the cost- and training-effectiveness -- the success -- of the program. Several criteria have been identified by Helgerson for determining the applicability of CBIV to a training situation.

- o The trainee audience is large.
- o The trainee audience is physically and/or geographically dispersed.
- o A subject matter expert is unavailable.

- o The material is inherently visual.
- o The disc content is inappropriate for live staging.
- o The demonstration equipment is not available.
- o The content includes extensive variations.
- o The trainees have varying levels of experience and skill.
- o The content is relatively stable or extremely vital.
- o The content is used repeatedly. *

By applying such criteria to a proposed CBIV project, a training organization will be better able to make choices early in the design phase of the project to determine if CBIV is the best medium for training.

Future applications of CBIV being considered by the company involve a related project called the Videodisc Information Management System, which is covered in the second part of this paper.

Background on Videodisc Information Management System (VIMS)

Many of today's advances in learning technology have grown from 1960's and 1970's research projects at universities and institutions of higher learning throughout the world. Funding for some of this research in the United States has come from such government agencies as the Defense Advanced Research Project Agency (DARPA) of the Department of Defense. One such project was started and funded around 1978 to combine television capabilities with the power of the computer in a "user friendly" environment. The Massachusetts Institute of Technology of Cambridge developed the concept under direction of Dr. Nicholas Negroponte. This effort demonstrated a capability which achieved the combination; it was called "surrogate travel," "vicarious travel," or "interactive movies." It was a technological breakthrough; however, practical use of this concept demanded further refinement in computer software and hardware.

* Linda W. Helgerson, "What to Focus on When Selecting a Videodisc System," Performance and Instructional Journal, Vol. 25, No. 7, (1986), 6-10.

Around 1980, DARPA awarded a contract to a private firm to refine the concept through use of microcomputers, videodisc, and multiple prototype applications. The intent was to test the use, data acquisition procedures, production methods, indexing logic, and ease of use. This highly successful project demonstrated an exciting and practical integration of the microcomputer and videodisc into a system that delivers quick and reliable access to vast quantities of visual information.

Many applications of this concept began to emerge. One example is the CBIV training system described in the preceding section of this paper. Another is the Videodisc Information Management System (VIMS) developed by Utah-based E&G Services, Inc. VIMS was developed as a cost-effective, easy-to-use system that makes an audio-visual information data base available to the operator by its visual information organization, electronic access and data base integrity. It has been described as an "electronic book" or electronic filing and retrieval system.

System Description for Videodisc Information Management System (VIMS)

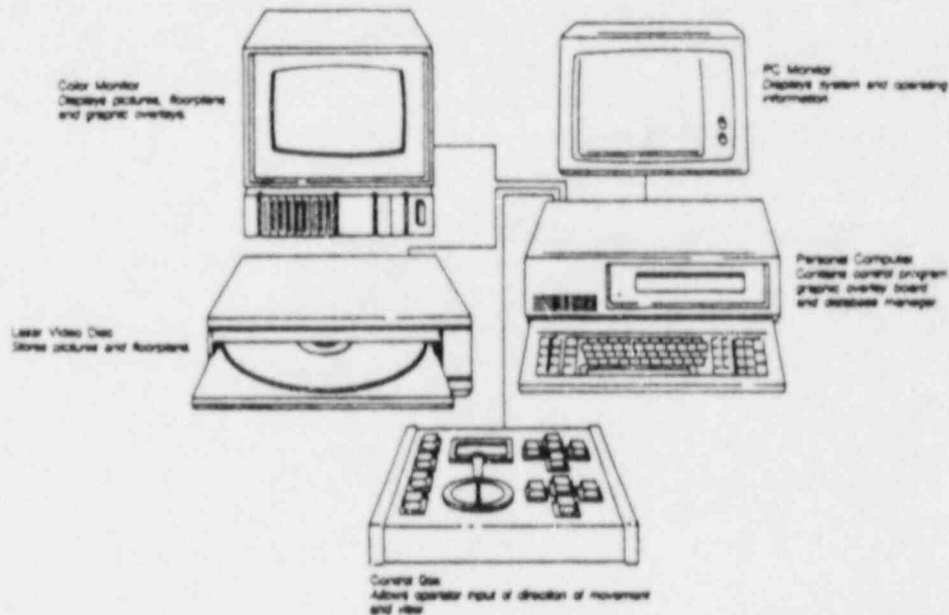
Today, VIMS is a state-of-the-art, computerized photographic data base management system that provides immediate access to actual color pictures of photos, maps, engineering drawings and related text information.

Basic hardware components include an IBM PC-XT or PC-AT computer with a 20 MB hard disk drive and 360K floppy drive, microkey overlay board, Pioneer laserdisc player, Sony Trinitron color monitor, monochrome monitor and card, and an EG&G access control unit. (See Figure 1 for a layout diagram). The software packages are DOS 2.0 or higher, Dbase III plus, and the VIMS programs which are proprietary to EG&G. All items, excluding the access control unit and VIMS programs, are off-the-shelf and can be purchased through various suppliers.

The microcomputer controls retrieval and display of videodisc-stored information on the color monitor while simultaneously displaying descriptive text, and a dynamic orientation graphic on the monochrome monitor. The orientation graphic shows the operator's current location, his position relative to significant features, his viewing direction, and special data, and other available information. VIMS also allows one to select a picture from the videodisc and overlay computer-generated descriptive information, labels, or graphic symbols on the same screen. Utilization of the system is with the access control unit, comprised of several pushbuttons and a joystick, or the computer keyboard.

Ease of maintaining the application data base is important. This includes additions and/or changes. The data base consists of

Figure 1



Hardware Configuration

both the pictures stored on the laserdisc and data files stored on the hard disk. Changes cannot be made to picture on the laserdisc. The VIMS programs make use of the overlay system to allow changes to be noted on any picture. One should overlay a pointer with descriptive text or graphically draw the change on the picture. Once some predetermined number of changes occurred, the associate pictures can be re-shot and a new laserdisc produced. The data files are changed using Dbase III plus, which are then converted to VIMS compatible file.

Videodisc Information Management System Application.

Applications for use with the VIMS are limited only by the imagination. Virginia Power chose to use this medium to photodocument our two nuclear power stations. Station floor plan drawings are used in mapping the areas to be shot. Areas are divided into paths. Each path is walked and methodically photographed at approximately two-and-one-half foot intervals, looking forward, backwards, left, right, up-forward, up-backwards, and details. Viewing an area in each direction can then be simulated.

Photodocumentation is not just a picture book of all major equipment, piping, facilities, and control panels, but literally a surrogate tour or video tour of the entire plant. For example, you can "video walk" to a location in the plant, locate a piece of

equipment, walk past or around it, and see its relationship to the surrounding area. While viewing the video walk on the color monitor, the monochrome monitor displays a line graphic that shows the travel path immediately ahead and behind the operator's current location. The graphic is constantly updated as the user moves through the area. At any time during the tour pushing a button on the control unit will display a floor plan map with a blinking cursor indicating the current location.

A quicker method to access a picture would be to type in the name, mark number, or equipment location in the plant. The random access nature of the laserdisc will display any picture and related information within approximately three seconds. Each picture has its own unique frame number on the disc. This allows all kinds of relationships within the computer database.

Imagine...photos...computer...data base...virtually the whole plant at your fingertips for...training planning...emergency planning...presentations

At your desk...in the classroom...in the auditorium... in the plant...at corporate headquarters...in the engineering office

Available to...instructors...operations and maintenance personnel...engineers...management...public relations personnel

An integrated plan is being developed for using VIMS. This plan will:

- o Support the ALARA program, reduce the number of planning trips for work in radiation areas.
- o Support the quality of maintenance teams. VIMS will be used to video locate equipment and view work areas during job pre-planning.
- o Support operations, engineers, and others for pre-planning outage work inside of containment.
- o Be used as a communication tool for:

Management discussions
Public and media briefings

In conclusion, applications for the Videodisc Information Management System will evolve as the system is used. Photodocumentation of the Surry Power Station has been completed. Currently, nine systems are in use, one each at the nuclear training

center, corporate headquarters, and engineering office, and six in the plant. Photodocumentation of the North Anna Power Station began in February of this year. Plans are to master a laserdisc halfway through the shooting and put systems in place in June with the final disc issued at the end of the year. Implementing VIMS is part of Virginia Power's commitment to excellence.

Bibliography

Helgerson, Linda W., "What to Focus on When Selecting a Videodisc System", Performance and Instruction Journal, September 1986, pp 6-10

Interactive Training Systems, Inc., AUTHORITY (TM) - The definitive authoring tool for effective courseware design.

Discussion

MR. LIANG: I do see a lot of exciting application potential here. In emergency planning, we often run into tremendous problems in estimating the access time in the accident environment or search/rescue. Now, with these video pictures, since every frame is taken about two feet apart and you have the estimated distance and a clock on the screen, can you estimate (instead of zooming up and down like Superman) for normal workers suited up and proceeding at a normal pace, how much time it would take to reach a specific spot in the plant and then get out again?

MR. ADAMS: I would say yes. One of the things you can do is vary the speed with the joystick, and you could apply a timing algorithm there. We can generate/rechange that algorithm such that it gives some semblance of a person walking normally with equipment. Now when you run the joystick, it steps pictures through variably at a certain speed. There is another program, that I don't have here. It used to be that you could hold the joystick "full out" and it would only walk you so fast. That is the one for that application. It is a normal two-and-a-half foot step that depends on the size of the individual. That is approximately what it is, and I believe you can do that. It would be an interesting application.

MR. LIANG: That would be very helpful for the designer. For example, the primary shield wall penetration design is usually finished after the wall. The penetration is cast, the designer is given this picture, and this visualization of the area would be of tremendous help in shortening the time for design.

MR. SEICLER: Have we turned this over to our corporate engineering group yet?

MR. ADAMS: Engineering called me yesterday and said their system had arrived. When I get back I will put it together for them. So engineering was one of the groups chasing me before we released the system. They wanted one installed because they had come over prior to the Unit 2 outage in October last year, and were looking at some of the places where they had to start doing some design changes in the containment. They were using what we had in place in the system already, looking at some of the areas.

MR. SEIGLER: Coming out of engineering and construction, it is nice to have engineering chasing after operations!

MR. BALDASSARI: Can you give us a figure on the ratio between time of preparation of the lesson and its implementation? That is, for an hour of lesson, how many hours are needed to prepare the slides, assemble them and so on?

MR. ADAMS: The actual field work involved me and two photographers. The photographers traded off with a camera unit, and when they weren't with the camera unit, they were doing a spreadsheet type record management system. The importance behind this is knowing what your data is. We worked to complete a two-unit power station. We calculated about eight weeks of time, shooting two weeks in a session, for ten hours a day, six days week. We were able to shoot everything we wanted to catch in that power station, even climbing ladders, just to get up and look at one snubber on the side of the shield wall. Two weeks is about all the time a photographer is good for, energy-wise. Again, your limiting factor is getting into the containment and shooting. Basically we had to shoot around the plant outages. If you were to sit down and plan out a program, say, spend two weeks a month, you would spend two weeks on the pictures. They go back. They send the photography off for conversion to one-inch tape. They put information into the database, which might take about a week's worth of work. I would say that, if you could get into your containment buildings and get access to all the areas in a relatively short period of time, then in six months you could go from start of shooting to having a system in operation. That's considering that Murphy does not get in the way as he has with us.

DEVELOPMENT OF A TRAINING ASSURANCE PROGRAM

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Abstract

The nuclear industry has made a significant commitment to improve training through the implementation of accredited performance-based training programs. Senior management expects that human performance will improve as a result of significant resource allocations. How do we know if training is effective in achieving improved human performance? Florida Power and Light Company is developing a Training Assurance Program to track indicators of training performance and future trends. Integrating the company's Quality Improvement Program processes with systematic training processes is resulting in personnel functioning in a proactive mode and increased customer satisfaction with training performance.

Introduction

The Impetus

Nuclear power utilities and their customers expect safe, reliable, quality performance from their nuclear plants and personnel. With the notorious accident that took place on March 29, 1979, at the Three Mile Island (TMI) nuclear plant, doubt was cast on the safety of nuclear power as a viable energy option for our nation. The lessons learned from TMI were numerous, "but in the end, employee training emerged as the largest single target for improvement. The general consensus among both government and industry investigators was that existing training in the nuclear industry was inadequate in scope, inconsistent among nuclear power plants, and insufficiently regulated." (Reference 1) This conclusion initiated a series of activities that culminated in the establishment of the National Academy for Nuclear Training. The Academy "focuses and unifies the training activities for the nation's nuclear utility industry and serves as a vehicle for excellence in nuclear training. (Reference 2) The academy is supported and administered by personnel from the Institute of Nuclear Power Operations (INPO), who manage the industry-wide training accreditation effort.

Accreditation: A Resource Commitment

The Accreditation process requires a significant commitment of human and financial resources. A survey of member utilities conducted in 1986 by INPO demonstrates the increase in resources used

to improve and sustain training performance (Reference 3). The survey reports the number of employees who completed initial training programs at 51 of its 55 member utilities has increased 40% from 1984 to 1985. Facilities dedicated to nuclear training purposes increased 45% over those in use the previous year. Total training staff, both permanent and contractor, now exceeds 4,700 industry-wide. Florida Power & Light Company (FPL) has experienced this growth as well.

Florida Power & Light Company is committed to achieving accreditation and improving human performance through the implementation of performance-based technical training programs. FPL's "senior management expects that human performance improvement will result from this significant resource allocation" (Reference 4). Unfortunately, training is not the only factor influencing improved human performance. "In fact, it is difficult to provide a statistically valid correlation between training enhancements and improved performance. Consequently, most utilities have few, if any, training performance indicators" (Reference 5).

Achieving our Vision

FPL's Nuclear Training Department is seeking the identification of indicators of effective training performance. Through the development of a Training Assurance Program, we expect to gain an in-depth understanding of the effectiveness of our Nuclear Training System. We expect to gain insight into future trends and issues through enhanced communication with internal customers and external organizations that impact our survival. Once fully developed and implemented, a set of quality indicators will track training effectiveness; trending and a standardized process will provide for continuous improvement. It is expected that FPL personnel will transition to a proactive mode and become leaders in the industry, thus achieving our FPL corporate vision:

During the next decade, we want to become the best managed utility in the United States and an excellent company overall and be recognized as such.

This vision is a product of FPL's comprehensive Quality Improvement Program and is FPL's long term goal.

Quality Improvement Program

Quality at FPL

The nuclear operation at FPL has been dramatically affected by the implementation of the company's Quality Improvement Program (QIP). This program supports the Nuclear Energy Department's teamwork focus and "hands on" philosophy. Quality at FPL is defined

as conformance to valid requirements. Figure 1 depicts the three components of QIP and the four principles that support its underlying foundation.

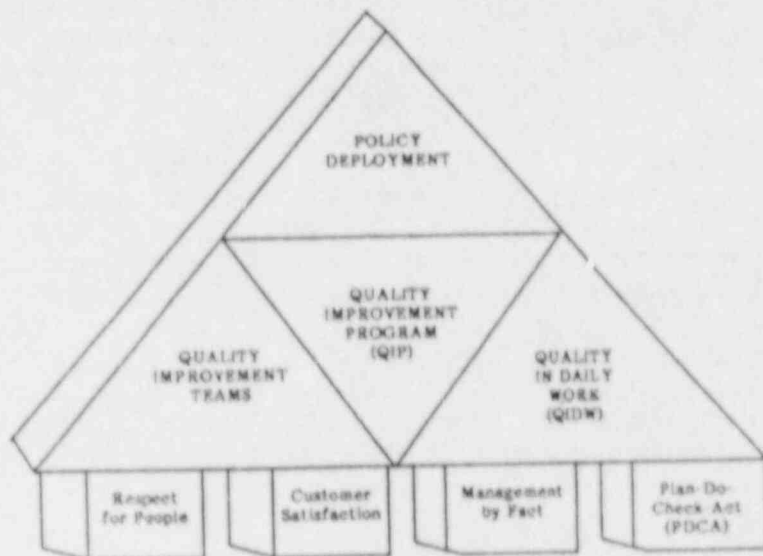


Figure 1 Quality Improvement Program

QIP Principles

The four principles supporting our QIP are:

- o Respect for people. Our management style is to keep people informed, train every individual to perform at the very best level, help people communicate, delegate responsibility and authority to attain individual accountability and to create a sense of purpose in the work place.
- o Customer satisfaction. Our customers are stockholders, regulators, ratepayers and FPL departments. The purpose of QIP is to ensure that customer needs and reasonable expectations are satisfied.
- o Management by fact. Data provides the objective means for problem analysis, measurement of performance and follow-up corrective action.
- o P-D-C-A. Essential for any improvement in performance, the continual PLAN-DO-CHECK-ACT cycle provides focus on improving the current methods. The training system is a manifestation of the PDCA concept.

QIP Components

The three components of QIP are:

- o Policy Deployment
- o Quality in Daily Work
- o Quality Improvement Teams

Policy Deployment is top management's method for providing focus to corporate efforts in a few selected areas to produce breakthrough improvements in performance. Each FPL department establishes short- and mid-term performance objectives, then selects projects to achieve the performance objectives. Corporate resources (people and money) are allocated through this process. The Nuclear Energy Department short- and mid-term objectives are selected to support corporate objectives which are targeted to accomplish the corporate visions.

Quality in Daily Work (QIDW) emphasizes quality performance of all accountabilities to meet customer needs. QIDW incorporates lessons learned from past experience through the application of a rigorous process. QIDW focuses on the establishment of control systems for each work process (PLAN). These systems define the process objectives and output indicator(s), determine the work flow, identify process indicators, targets and limits, and specify accountable individuals for critical steps in the process. Control systems are implemented on a trial basis (DO), monitored (CHECK) and refined (ACT) before becoming the "standard" quality control practice.

Quality Improvement Teams promote teamwork, problem-solving skills and organizational learning. The QI team structure includes functional teams at the local workplace, cross-functional teams involving various FPL departments, task teams assigned to solve a specific problem, and management lead teams. These teams use a structured problem-solving process, analytical techniques and QIP concepts to solve and manage problems and identify improvement opportunities. These elements of QIP provided the process and the motivation for our Training Assurance Program.

Conceptualizing a Training Assurance Program

An Initiative and Its Inputs

The Training Assurance Program (TAP) was developed as a means of staying in communication with the many organizations that impact the management of our Nuclear Training System. The external organizations include the Nuclear Regulatory Commission (NRC), INPO, and the Florida Public Service Commission (FPSC). We recognized that we were in a reactive mode with these groups because they know where they are going and we don't. When we responded to audits and evaluations, we were often working on last year's list of issues.

TAP is an initiative to help us become proactive. Key questions that TAP attempts to answer are:

- o What are the issues impacting training?
- o Why are the issues important?
- o Who is the driving force behind the issues?
- o When will the issue impact FPL?
- o Where does it appear the issue will lead FPL?
- o How will FPL respond to the issue and meet the corporate vision in so doing?

The Training Assurance Program has five inputs:

- o senior nuclear management's (plant and corporate) concerns and priority issues in the training area
- o current events in our industry and their future impact on training
- o changes (actual or proposed) from influential organizations (NRC, INPO, FPSC, etc.)
- o company events inside and outside the nuclear department that may impact training
- o training activities and good practices at other utilities and industries

Processes and Phases

TABLE 1. TRAINING ASSURANCE PROGRAM - DEVELOPMENT SCHEDULE

PHASE	COMMENCE DATE
I. Training Assessment	August 1985
II. Training Review Group	May 1986
III. Evaluating Training Effectiveness	December 1986
IV. Communication - Interaction Model	August 1987

The processes used to develop TAP are the FPL QIP processes and applicable training and educational research and evaluation processes. TAP is being developed in four distinct phases as outlined in Table 1. Each phase provides input to the next, although some development of each phase is coincident. As the phases are

implemented, we incorporate the PDCA principle to further develop the elements of our training assurance process.

The four phases include:

- o Training Assessment - an assessment conducted to determine the current status of training against all known criteria.
- o Training Review Group - the establishment of training review teams that continually assess training activities.
- o Evaluating Training Effectiveness - the evolution of an innovative evaluation process to monitor the effectiveness of training performance

- o Communication - Interaction Model - the building of a model for enhancing communication and interaction among internal and external entities that results in mutual support and a common purpose.

Products and Output

The products of TAP include:

- o a proven set of techniques used to continuously improve training communication and to track future trends
- o an assessment process that monitors training performance indicators, identifies improvement opportunities, and tracks corrective action plans.

The ultimate output of TAP is a training system that functions in a noticeable proactive mode resulting in observable improved human performance at FPL's nuclear power plants.

TAP Phase I: Training Assessment



Figure 1 Forces Affecting Nuclear Training

Initiating TAP

TAP was initiated in recognition of the myriad of internal and external forces that were affecting the status quo of the nuclear training function. Figure 2 illustrates some of the activities, events, standards, criteria, changes, expectations, and commitments that have placed nuclear plant training in a dynamic and vulnerable state (Reference 6). The training assessment was selected as the first phase because we needed to ensure we had a valid data base from which to develop subsequent phases of the program. FPL was also experiencing an aggressive regulatory environment at one of its nuclear plants. Thus, the pilot training assessment was performed at that plant.

The pilot was conducted by a task team with members from the Quality Assurance and Training Departments. The team's objective was to determine the status of training in this dynamic training environment. The team planned to identify the various valid requirements, assess and describe the current status of nuclear training and identify opportunities for improvement. A resulting summary report would be presented to plant management for disposition, who would lead corrective action efforts to achieve a new proactive status quo (Figure 3) (Reference 7).

The Pilot Assessment

The first activity of the team was to plan the assessment approach. Table II outlines the Assessment Team's plan. Assessment criteria were based on licensing requirements, regulatory commitments, site administrative procedures and guidelines, INPO guidelines, NUREG's and other regulatory documents and reports, previous NRC Training Assessment reports of FPL and other utilities, QA audits and INPO plant and accreditation evaluations. Ninety-one (91) reference documents were used to formulate over 700 questions that reflected specific, detailed criteria. The team members were thorough in their approach so as to maximize the potential for achieving excellence. The questions were incorporated into criteria checksheets and used for data

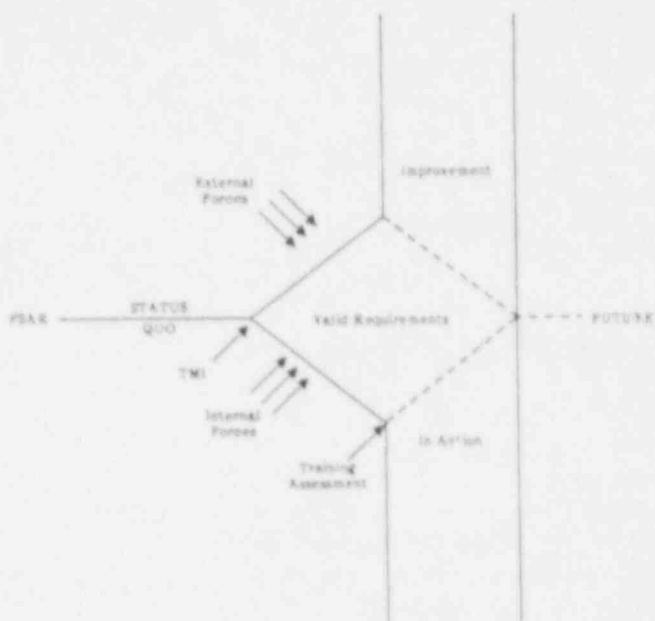


Figure 3 State of Nuclear Training

collection. The training activities assessed included those within the Nuclear Training Department and those accomplished by other plant departments. Table III lists the 27 areas that encompassed the scope of the first assessment. Extensive documentation was reviewed, many activities were observed and over 30 personnel were interviewed during the two-week on-site data collection period.

Team members, as well as those with whom they interfaced during the on-site visit, learned about various valid requirements and the plant training function. Strengths were recognized and acknowledged and opportunities for improvement identified and discussed. The plant exceeded or met the criteria for approximately 75% of the questions. In the final assessment report,

TABLE II TRAINING ASSESSMENT PLAN

PLAN: (Assessment Team)	Clarify purpose of assessment Identify criteria base Gather and review information Determine scope of assessment Select criteria Develop check sheets Identify documentation to review Identify personnel to interview Finalize dates to conduct assessment Prepare schedule for data collection
DO: (Assessment Team/ Training Staff)	Collect assessment data Analyze data Draft report sections Team member review/edit report Compile draft report Review with training/plant management Review and issue final report Maintain backup data
CHECK: (Plant Training Department/ Training Staff)	Review and synthesize results Check current activities against observations Identify appropriate areas of improvement
ACT: (Plant Training Department)	Prioritize improvement opportunities Analyze root causes/seek solutions Develop corrective action plans Implement plans/solutions Track improvement

165 specific improvement opportunities were identified and discussed, some of which were duplicated due to the report format. While no direct violation of regulatory requirements was uncovered, 48 of the items were given high priority.

Acting on Results

Training department personnel systematically evaluated each improvement opportunity for validity and required corrective action. A Training Tracking System (T-Track) was established to track assignments and action taken on each opportunity. Many items are becoming the focus of QI team efforts using the QI problem-solving process or QIDW. Many plant personnel are involved in evaluating the opportunities and implementing corrective action. The QA department is using their computerized commitment tracking system (C-Track) to monitor the high-priority items. The corporate nuclear training staff is monitoring progress on the entire scope of the assessment for senior management. To date, almost all of the opportunities have been incorporated into the Training System and many lessons have been learned.

Lessons Learned

Some of the lessons learned include the necessity for teamwork, a wholistic approach and records retention. Teamwork and open communication between all personnel concerned (i.e., Training, QC, QA, Licensing, other plant groups, corporate staff, NRC) is imperative to efficiently work on incorporating improvements. A wholistic approach involving the cross-checking of various systems is needed in order to totally close out an item so that it does not

TABLE III SCOPE OF TRAINING ASSESSMENT

ASSESSMENT AREAS	
1.	Non-licensed Operator Training
2.	Hot License Training
3.	Re-qualification of Reactor Operators
4.	Shift Technical Advisor (STA) Training
5.	Instrument and Control Training
6.	Electrical Maintenance Training
7.	Mechanical Maintenance Training
8.	Chemistry Training
9.	Health Physics (RPM) Training
10.	Technical Staff/Manager Training
11.	General Employee Training
12.	Quality Assurance Training
13.	Quality Control Training
14.	PC/M Training
15.	Operating Experience Feedback Training
16.	Security Training
17.	Fire Team Training
18.	Emergency Team Training
19.	Simulator Training
20.	Diagnostic and Team Skills Training
21.	Training Records
22.	Testing and Evaluation
23.	Lesson Plans
24.	Contractor Training
25.	Training Administration
26.	Training Development System
27.	Instructor Training and Qualification

re-surface in another area. The results of actions taken are tracked, thoroughly documented, and retained in order to expedite the verification of activities and products by auditing bodies.

Some of the constraints affecting efficient incorporation of improvements include: the excessive time required, budget cycle limitations, inaccessibility to facilities or equipment needed, schedule conflicts, higher priority projects and activities, lack of historical data, organization or archives, support for word processing and records maintenance, and the micro-management of verification. As constraints are overcome, improvements are made to the training system.

The benefits gained as a result of this first assessment are numerous. It has forced the Training Department to systematically evaluate and use the appropriate system to make improvements (i.e., implement policy deployment). It has helped to identify variables and set parameters for measuring work processes through QIDW which will lead to standardization. It has helped to create valid data bases and records, and document issues and concerns which need to be shared with plant management, all nuclear training personnel, other utilities, INPO and the NRC. It has helped to assess training needs for the training staff and student groups. It has helped to educate training personnel which, in turn, positively affects the plant through the provision of better training products and services. It has set the stage for good practices and has improved the image of the Turkey Point training team.

Future Plans

As with any quality process at FPL, plans include the formation of a team to systematically CHECK the results and the process used in our first training assessment and ACT to improve it. Did it meet customers needs (valid requirements)? Did it achieve its purpose? Were all of the criteria used valid? What aspects were beneficial? What problems did it cause? How can they be eliminated or minimized during the next assessment? QIDW is the process to be used to enhance and verify future training assessment efforts.

The goal of training assessments at FPL are to provide an in-house mechanism to informally but systematically identify opportunities for improvement and thus achieve training excellence. We expect to conduct an assessment at each of our nuclear plants biannually, rotating between plants. Each assessment team would be comprised of training personnel from both FPL's two nuclear plants and corporate staff. Other interested FPL personnel representing, for example, our corporate Organization Development and Training Department or the fossil plants, may become involved in this important, beneficial activity. This plan will provide for a continuous improvement process and continuous input for our Training

Review Group (TAP Phase II).

Our efforts have been recognized by INPO staff and Region II NRC inspectors. One inspector recognized our first training assessment effort as the most professional, thorough assessment he had ever reviewed. However, there is a risk in conducting such thorough internal reviews of your training system and publishing the results. The risk concerns the exposure of every potential deficiency, no matter how minute, to scrutiny by the public and the regulators. These external groups, not recognizing the goal of excellence, tend to want to help us manage the results of the assessment and the action taken to make improvements. Because of this exposure, a team has been formed to evaluate the feasibility of continuing to conduct internal assessments. Until the team formulates a recommendation and provides direction for the future conduct of assessments, no additional training assessments will be initiated. Meanwhile, we continue to use the results of our first Training Assessment and to experience the benefits.

TAP Phase II: Training Review Group

The Purpose

"The purpose of the Nuclear Training Review Group (TRG) is to establish a committee structure to systematically review, approve and evaluate the effectiveness of nuclear training programs" (Reference 8). The impetus for formulating the TRG was fourfold:

- o to maintain accredited training programs
- o to provide a mechanism for management and subject matter expertise to be involved throughout the development and the maintenance of programs and materials
- o to meet the QIP goal of customer satisfaction
- o to justify the large investment of public resources

Group Structure

The following boards and committees make up the TRG:

- o Training Oversight Committee
- o Joint Training Assurance Board (JTAB)
- o Plant Training Advisory Boards (PTAB)
- o Training Review Committees

The communication flow within the group structure is depicted in Figure 4.

The Training Oversight Committee reviews current activities for cost-effectiveness and conformance to corporate policy and

procedures. Members include nuclear training management, corporate officers outside the Nuclear Energy Department, and other company training management.

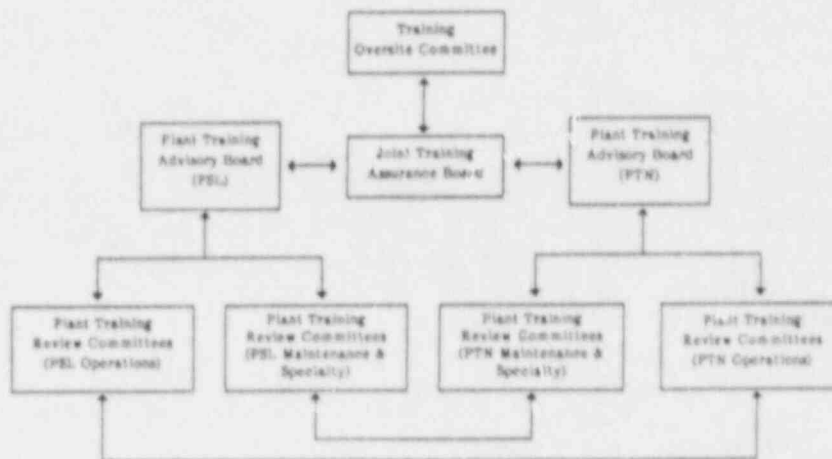


Figure 4. Nuclear Training Review Group Communication

JTAB is a multidisciplinary group whose membership includes the four senior training management personnel at each nuclear plant, and the corporate nuclear training manager and curriculum specialist. This team provides overall direction to the plant Training Review Committees and guidance to the PTAB's regarding technical training programs. JTAB is tasked by senior management to:

- o lead the effort to standardize programs, policies and procedures
- o assure adherence to FPL's Systems Approach to Training (SAT) process
- o promote communication between plant and staff groups
- o monitor quality performance indicators, corrective action plans, and commitments

A PTAB is established at both FPL nuclear plants. The PTAB's function is to provide overall direction for training efforts at the plant sites. In addition to PTAB, each plant has an established advisory board for each of the three components of the Quality Improvement Program. All four boards report to the Plant QIP Lead Team. Thus, PTAB provides an important link between training and the QIP Lead Team assuring that:

- o training objectives are consistent with plant QI objectives
- o training plans are integrated into plant plans and schedules
- o training issues are managed through the QI Program

Training Review Committees are established for each discipline area involving supervisors from both the training and plant functional department. Their function is to provide program specific oversight for activities, ensure consistent application of SAT for each program, and ensure that appropriate regulatory requirements are adequately addressed. These committees are the principal customer input to the training team.

Critical to Success

The Training Review Group is critical to the success of our performance-based training efforts and has provided numerous opportunities for enhancing training in our quest for quality. Communication between customers and trainers has increased. Issues and concerns are more efficiently resolved. Feedback is more systematically documented. Through teamwork, we are able to provide training services that meet our customers valid requirements.

TAP Phase III: Evaluating Training Effectiveness

The Need

Training represents a major corporate investment by nuclear utilities. Training personnel need practical, simplified approaches to conduct evaluations with a minimum of time and a maximum of success. A principal measure of training effectiveness is whether the successful trainee has the knowledge, skills and attitudes to successfully perform assigned tasks. However, is this the only measure of training effectiveness?

A classic evaluation system includes evaluating training effectiveness at four levels (Reference 9):

- o Reaction - the learner's opinion of the program
- o Learning - a measure of the learner's achievement of instructional objectives
- o Performance - evaluates employee's behavior on-the-job following the training program
- o System - measures bottom line results upon the organization and/or significant impacts in other ways.

However, this system does not yet seem to fully yield the information needed to satisfy all those who have a vested interest in determining training effectiveness.

Defining Evaluation

How an organization defines the purpose of evaluation is critical to the design of an evaluation system. Evaluation has been defined in three different ways:

- o a process of determining if objectives have been achieved
- o a process of providing information for decision-making
- o a process of ascertaining the merit, value or quality of something (Reference 10).

For example, if the purpose of evaluation is for decision-making, then decision makers at various levels in the organization must be identified and their valid requirements for the evaluation must be anticipated. One major decision-making group in the nuclear utility system comprises those personnel in the learners chain of command who have the most to gain or lose from a training program's success or failure. "These are the people who have both the legitimate authority and interest to see that barriers to the transfer of learning from the training environment to the work place are removed" (Reference 11). However, in addition to supervisors, many groups are concerned with effectiveness of nuclear training including: students, instructors, training support personnel, training management, senior nuclear management, other corporate management, other training groups in the company who are assessing nuclear training activities, the NRC, INPO, the state PSC, utilities who monitor each other, and other industry groups, the concerned public. Do we know the requirements for evaluation, and expectations of nuclear training, held by all of these interested groups? Are the existing nuclear plant performance indicators monitored by our industry appropriate for assessing the outcomes of training performance?

Indicators of Effectiveness

Whatever purpose an organization selects, it is recognized that a comprehensive evaluation system involves the monitoring of many indicators of performance to assure that training meets customer needs and reasonable expectations. Many indicators of effective training performance have been identified in the evaluation literature. One reference cites several indices of training performance including: productivity, timeliness, project efficiency, curriculum efficiency, cost, value, development, and professional contribution (Reference 12). Of course, each of these indicators must be operationalized depending on the particular organization and the defined purpose of evaluation.

A Systematic Study

At FPL, we recognize that the nuclear utility industry is unique, and warrants a systematic study to determine the who, what, why, when, where and how to evaluate the effectiveness of training performance. Phase III of TAP is embarking on this systematic study. Three simultaneous activities have been initiated. First, a trial implementation is being conducted using a new Nuclear Training

Procedure on the Evaluation Phase of FPL's Systems Approach to Training (SAT) process. Input into the development of the draft procedure included a comparative analysis of NRC and INPO training evaluation requirements, and the requirements in FPL's corporate Nuclear Training Manual and both plant training procedures. This comparison resulted in the draft of a standard procedure that incorporates the QIDW process and is being used in the trial implementation.

Second, a comprehensive review of the literature on training performance effectiveness is being conducted to identify processes and techniques applicable to nuclear training. Third, a qualitative research methodology is being used to identify the meaning of training effectiveness to specific suppliers, customers and observers of training performance in the nuclear utility industry. The results of these three activities will culminate in a database for use by a QI team who will review the findings, identify and seek further analysis, and work to improve and standardize a system for evaluating training performance that monitors a set of valid quality indicators.

TAP Phase IV: Communication - Interaction Model

Communication: A Challenge

The dynamic training environment today causes many communication problems both internally and externally. The challenge facing the training organization is to consistently communicate management's policies and procedures, as well as to inform training department personnel of developments internally and externally that affect training. The QIP provides the motivation and the methodology for reliable communications; therefore, QIP will be the basis for Phase IV of TAP.

A QIP team will conceptualize a model using the results of the prior phases of TAP. The conceptual model should encompass a methodology for communicating concerns regarding training and human performance among entities both internal and external to the company. Presently, internal entities include senior nuclear management (plant and corporate) and other company personnel; and, external entities include influential organizations (i.e., NRC, INPO, PSC, etc.), other utilities and industries and the general public. However, we recognize that any developmental effort, such as TAP, may change focus and scope as a result of development activities (e.g., the results of the Phase III study).

Facilitating Interaction

The intention of developing a model and testing its methodology is:

- o to promote discussion of current events and issues in our industry to determine their impact on training
- o to facilitate interaction between the various entities of the model to promote mutually beneficial decisions.

We anticipate that the first three phases of TAP will identify the normal communication channels that are functioning at FPL. The QIP team will focus on improving the reliability of these communication channels. QIDW will be applied to ensure that the structure and process for communication is developed. Indicators will be selected to measure communication effectiveness and monitor needs.

The PDCA principle must be applied in order to facilitate this high-level interaction process. A systematic assessment of communication needs must be made and the results analyzed for use in developing the model (PLAN). Following the model-building process, various techniques need to be selected to match the identified needs. Once the methodology is formulated, its implementation (DO) must be monitored using the indicators and the process evaluated to CHECK the effectiveness of results. The last step is to ACT to improve the model.

Summary

The mission of the Training Assurance Program is to assure quality training at FPL. Assurance is achieved when we can demonstrate four characteristics: Security, guaranty, confidence and certainty. Quality training occurs when we have conformed to the valid requirements of our customers based on their needs and reasonable expectations. Therefore, to assure quality training, we must link the four characteristics to our customers. We believe TAP is meeting this objective as analyzed below.

- o Security. The training system will achieve security when it stabilizes and is relatively immune to external change. Our regulatory customers expect a secure program. Their needs will be met when FPL's training system meets all valid external requirements. TAP Phase I is designed to accomplish security.
- o Guaranty. The training system guaranty is the consistent achievement of stated training objectives. Plant personnel are the customers who establish the training objectives. TAP Phase II integrates this customer into the training system.
- o Confidence. The training system must instill confidence that cost-effective products are reliably delivered to the students. Senior management wants to

have confidence that training is effective. TAP Phase III strives to find an evaluation methodology that will give management confidence in the training system.

- o Certainty. The training system must improve human performance so that the rate paying customer can be certain that nuclear generation is safe. Certainty can be attained with an open, reliable communication system. TAP Phase IV will develop the communication system for FPL to attain certainty.

The attainment of excellence in a dynamic, complex environment is the challenge to nuclear training. It is intricated by a diverse customer base. Integrating FPL's Quality Improvement Program processes with systematic training processes is resulting in personnel functioning in a proactive mode to assure customer satisfaction with quality training performance.

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Discussion

MR. TANGY: I was impressed with the pilot team working on your TAP project. In France, about 800 people are teaching in the various facilities of EDF Training System. Apart from them, 150 engineers are working on nuclear training. One of our major difficulties now is to take those people from their day-to-day work and to think a little more on the future and quality assurance and effectiveness of training. How do you deal with the question of making those people who teach day after day to work on something else than day-to-day teaching?

MS. PALCHINSKY: One way is to have them involved in the quality improvement teams, because people are working on the problems that either they have identified, as a functional team member, or maybe they were assigned a task. For example, for some of the improvement opportunities identified in the Training Assessment, we got people together, like instructors and program coordinators, sometimes from both plant sites, who are working together on these kinds of problems. This is getting them involved in improving training in a different way besides teaching or developing materials.

Another interesting way is the quality in daily work process. Right now we are going through two exciting evolutions. We are taking the entire Systems Approach to Training process and flow charting it and identifying indicators where we can check that the process is working, setting targets and limits and criteria for determining that, and identifying who is accountable -- then we will standardize the process. That, I think, is a very stimulating activity. Also we are standardizing our programs, for example, the non-licensed operator program. Those instructors are getting together and looking at where they could combine their efforts and come up with where they are common or can be common, in order to standardize the programs between the plant sites.

So those are just some of the activities that we have for instructors and lead instructors and support personnel, to get them developing and growing and thinking about the future.

USE OF CASE STUDIES IN TRAINING
NUCLEAR PLANT PERSONNEL

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Presented by Joseph P. Flynn, Jr.
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Abstract

One of the lessons learned from the Three Mile Island (TMI) accident was that the nuclear industry was ineffective in learning from previous events at other plants. As training programs and methods have improved since TMI, the nuclear industry has searched for effective methods to teach the lessons learned from industry events.

The case study method has great potential as a solution. By reviewing actual plant events in detail, trainees can be challenged with solving actual problems. When used in a seminar or discussion format, these case studies also help trainees compare their decision-making processes with other trainees, the instructor, and the personnel involved in the actual case study event.

The Use of Case Studies in
Training Nuclear Plant Personnel

Studies on how people learn point to the rather obvious facts that as humans we remember only a small percentage of what we read, a slightly larger percentage of what we hear, a little more of what we see, and a great deal more of what we do.

If our objective is to truly learn from our past and avoid repeating errors and mistakes, then we should be using a training technique that relies heavily on learning by doing, i.e., an active process.

The use of case studies is such an active learning process, and as such it has many advantages over more traditional training methods for understanding the lessons learned from industry events.

But what exactly is a case study? Let's start with the following definition: A case study is an instructional strategy designed to promote better understanding of a specific event by presenting information germane to the event in a way that the audience identifies closely with it, the key words being, "...in a way that the audience identifies closely with it."

If I tell you that something could happen to someone, you might dismiss it as a "what if." If I tell you that something did happen to someone, I may awaken your interest, but you may still

convince yourself that it couldn't happen to you. Now if I tell you that something specific did happen to someone you know or with whom you can identify, then you are interested. You will probably get the message, internalize the lessons learned, and possibly even modify your behavior so that it will not happen to you.

That is what case studies are all about -- getting the students actively involved. The method is nothing new. It has been a proven teaching technique used in medical, law, and business schools. The "new" item is the application of this method by the nuclear industry.

Case studies can be used by the nuclear industry for training managers, control room teams, and in most disciplines. Cases can be developed for managerial issues, technical problems, plant events or a combination of these. The case study method is being used extensively in the Senior Nuclear Plant Management Course conducted by the National Academy for Nuclear Training. INPO is also developing example cases for use by the industry.

So how do we do this? Ideally, case studies involve the review and examination of an actual event or events, thereby connecting the classroom environment with the real world. Obviously, the more realistic the case, the better.

The students are challenged with solving an actual problem. They are given background materials and presented with the description of an event or situation. The students must advance through the classical problem-solving steps, from identifying the problem to proposing a best solution and checking on its outcome.

Key factors to the success of this method are the case study leader and the participation of the students. This is an active learning process. One cannot sit back and "absorb" the lecture. The leader continually probes, questions, and challenges statements and assumptions made by the group.

Students are presented with the case study materials. This usually consists of a brief history, necessary technical and administrative background materials, and a problem situation. Students are assigned to work either independently or in small study groups but, in either case, they are challenged to "solve the problem." Often a series of leading questions may aid in focusing the students on the "correct" problem.

The individuals or study groups present their solutions in class, subject to the probing, questioning, and challenging by the leader and the other students. When possible, a "best" solution is identified. For historical events, the actual solutions are reviewed for comparison. When this is done it is important that the leader

understand why specific actions were taken in the original event.

The use of case studies helps promote analytical skills and the ability to think and reason clearly. Problems of varying types can be presented in a realistic setting. Tough issues can be addressed in a relatively "safe" environment. This allows the testing of decisions without an abnormal fear of failure. The continuing exchange among the group members helps the individuals learn to ask the right questions when faced with the actual situations in the future.

Discussion

DR. SALAS: Do you think that trainees should be tested? What is important to be remembered from a case study? For example, do students need to know the who and when, or just what happens so that it does not happen again?

MR. FLYNN: The bottom line is that you are trying to keep the event from happening again, so that is what they need to know. The who and the why and the where are only there to help them get that message and keep that message. Also, a case study is going to be different depending on who you are trying to teach and what it is that you are trying to teach them. The first step in developing a case study is to decide why you want to tell the student about it. If you are going to talk TMI to operators, you are going to deliver a different message than if you are talking to maintenance, or design, or plant engineering personnel. So you have to decide basically what you are going to ask them first and then design the case study to reinforce that material.

MR. BOHANON: I have always been a strong advocate of case studies. I have found that it has an equal strength that goes over into the part of literally determining whether or not that is a procedural, a design, or a training fault. In the case of driving through the concrete wall, I won't try to answer, but I think we have hold of something here that we really have failed to grasp in the past, and that is a closed loop in evaluating some of the malfunctions of the plant, as to whether they were laid to design, procedure or training. We have a tendency to throw training at every problem and that may be detrimental rather than constructive.

MR. FLYNN: I agree.

MR. FEDAKO: Do you know of any educational institutions or any other sources of training for trainers on case study methods?

MR. FLYNN: I don't know who provides training for trainers specifically on case study methods. I know that Harvard Business School uses case studies extensively. Whether or not they have a trainer training course, I don't know.

MS. FREERS: You said that one of the key factors is the role of the leader. Have you identified any skills and knowledge that person should have to be effective as a group leader?

MR. FLYNN: Not to the level that I suspect you intend by your question. We have not gone through and done a job or task analysis.

TRAINING OF OJT INSTRUCTORS

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Abstract

OJT (on-the-job) instructor training needs to include several important elements. We need to provide OJT instructors with the policies and procedures for conducting and documenting the training; we need to acquaint them with performance objectives and train them to measure performance against these objectives; but most of all we need to teach them how to demonstrate a manipulative skill at the level of the objective, for this is the most likely single teaching method that the OJT instructor will use. This teaching skill consists of several discrete elements, all of which can be taught and learned. Finally, the OJT instructor needs to know how to create a job performance measure to assess the achievement of the learners. This paper describes such a training program.

The first requirement for any instructor is to know the subject matter. Assuming that the instructor already has the subject matter knowledge, let's look at a program for equipping the instructor to teach others to perform tasks.

Somebody in the organization has to be able to develop objectives from tasks. This is not necessarily the OJT instructor. However, if someone else develops the written objectives, the OJT instructor should be the subject matter expert. In this way, the OJT instructor will be an active participant in the development of the training activities.

Once the objectives are written, we write the job performance measure (performance checklist). It is easier to do this immediately, because the objectives contain the criteria for evaluation. Our OJT instructor may enter the training cycle at this point or earlier. Now that the objectives have been developed, and the means of measuring them is available, the OJT instructor will need to develop the training activities. This is the activity where the instructor training program needs to concentrate. Our program contains the following elements:

- o OJT procedures
- o Developing learning activities from objectives
- o Demonstrating a manipulative skill
- o Providing a practice
- o Performance testing

We will not discuss procedures in this paper, as these will vary from site to site. Some procedures for scheduling, conducting and documenting OJT will be necessary. Whatever these are, the instructor will need to know them. The identification of items on the task lists to be taught by OJT should have already taken place. Generally we will want to train in the plant only those tasks which cannot be trained in the classroom or laboratory.

Choosing the Training Activity

Following a brief introductory session in which we explain what constitutes OJT and which procedures govern the process, we teach the OJT instructor how to determine the level of the objective he will be working with. In general, we are talking about manipulative skills, i.e., psychomotor skills. Thus we teach the five levels of Bloom's taxonomy of psychomotor skills. The obvious purpose is that the teaching activity will be different, depending upon how the objective is written.

For example, if the trainee is learning any manipulative skill, the objective might read like one of the following:

- o IMITATION. While observing the instructor, the trainee will be able to repeat the skill.
- o MANIPULATION. Following written or oral instructions, the trainee will be able to perform the task.
- o PRECISION. Without written or oral instruction, the trainee will be able to perform the skill.
- o ARTICULATION. The trainee will be able to perform consistently a succession of skills to complete a task.
- o NATURALIZATION. The trainee will be able to complete one or more skills automatically, with limited physical or mental exertion.

These are generic objectives. They are written to show the difference in the expected level of performance. At imitation level, we expect only that the trainee will be able to watch someone else and do the same things that the demonstrator is doing. This requires no understanding at all, only the ability to imitate. The next level, manipulation, requires the learner to be able to perform the skill according to instruction, rather than observation. Keep in mind that this means that the learner executes certain manipulative skills when told how to do so, or when reading instructions on how to do so. This is not to be confused with following the written procedure. The difference is that procedures list the steps to be performed and the sequence; a learner who is performing at manipulation level will still need someone to explain how to execute

a particular step, even though he reads it himself. For example, the procedure may say, "Verify that the motor circuit is de-energized." The learner in this case might not be able to execute that step without instruction on how to de-energize the motor circuit. When the learner is able to perform at the precision level, he will be able to de-energize the circuit correctly without any additional help from the original source.

At the articulation level, the learner will be able to combine several skills consistently and smoothly to complete a task. Naturalization refers to the ability to do a task requiring one or more skills, without having to think much about it. Swimming, or riding a bicycle are examples of some skills which many of us do at this level. At our first attempts, however, we had difficulty even imitating another person.

Developing objectives from the task requires the help of someone trained in writing objectives. As mentioned earlier, the OJT instructor does not really need to know how to do that. Here are two of the tasks involved in the job of wiring a house:

- o TASK: Mount the electrical outlet box on the stud.
- o TASK: Install the electrical outlet in the box.

For the purpose of this OJT session, we will be teaching how to install the outlet in the box. The objectives, as the OJT instructor receives them, might be like these:

The trainee will be able to:

- o State in his own words the requirements of the National Electrical Code in reference to the installation of the outlet in the box.
- o Select the appropriate tool for each phase of the task.
- o Strip the cable to remove the outer covering and insulation.
- o Strip the wire to bare the correct length.
- o Wrap each wire securely around the correct terminal.
- o Tighten the terminal screw sufficiently to prevent any movement of the wire on the terminal.
- o Ground the outlet to the box as per the National Electrical Code.

- o Insert the wired outlet into the box without undue strain of the terminal connections.
- o Secure the outlet to the box.

The first two objectives are knowledge objectives, written at the comprehension level. They are intended to be exactly the level that the trainee will have to perform the job. We do not want the trainees to recite the code from memory; they could memorize the words without any understanding whatever. We want understanding, so we want to be able to ask, "What are the code requirements on this step?" In fact, that is exactly how we will measure this objective: we will ask the trainees what the code says.

The third objective is not written in language that will tell what level it is. We need to look at the taxonomy to get our performance level. Do we want the trainees to simply imitate us as we strip the cable to remove the outer covering and insulation? That might be a reasonable first step, but ultimately we want the trainees to be able to do this entirely independent of us or any written instruction, i.e., at the precision level. In fact, that is the same level we want from all the remaining objectives. Each of these objectives is one manipulative skill. Before we qualify our trainees, we may require them to be able to do the last seven with harmony and consistency, i.e., at the articulation level. What the OJT instructor must do first is to determine what level of performance is acceptable as a result of training he is going to conduct. That decision will determine what the training activities are going to be.

Following is a lesson plan in which I teach the instructor how to demonstrate a manipulative skill. Figure 1 is a lesson presentation checklist, adapted from materials published by the American Association of Vocational Instructional Materials. * In this lesson, I would vary the activities to accommodate the level of the objective. I have inserted explanations of that in the plan.

LESSON PLAN

Job: Wiring an electrical outlet.

Terminal Objective: Students will be able to insert, prepare ends, and correctly attach wires to a grounded outlet, meeting all standards of the National Electrical Code.

* Hamilton, J., et al., "Demonstrate a Manipulative Skill", American Association for Vocational Instructional Materials, Athens, Georgia, 1977.

Tools and Equipment: Screwdriver, cable stripper, wire stripper, needle nose pliers, diagonal cutters, 6 foot measuring tape, 10 feet of Romex cable, one piece of #14 wire one foot long. An electrical outlet mockup.

Note to the instructor: Carry the tools in the leather tool carrier supplied to all plant electricians. Check to see that all the tools are in good working condition.

I. Introduce the demonstration by explaining what is going to be demonstrated, how it relates to what the trainees already know, and how it relates to future activities in the workplace or classroom.

II. Demonstrate the set of skills:

Operation

Key Points

- | | |
|--|--|
| 1. Strip the cable | 1. With the cable entering from the top of the box, the length to be stripped will be at least six inches below the box. |
| 2. Insert wire. (Have trainees imitate these steps if conditions permit) | 2. Leave no paper inside the box. Explain the reason for the code. |
| 3. Tighten screw for snug fit. | 3. Ask why this is important. |
| 4. Strip wire. | 4. Be careful not to nick the wire when removing the insulation. |
| 5. Attach wire around the screw. | 5. Bend wire clockwise. Black on brass, white on white, green on ground. |
| 6. Fit receptacle in place. | 6. Demonstrate the S-bend. |
| 7. Install screws. | 7. Remove the fiber washer from each screw. Ask students why this is done. |

III. Now that you have completed the first demonstration, students need the opportunity to review and practice. Depending on the number of students in the session, use one of the following activities:

- o Have one student go through the entire process, while you tell the other trainees what he is doing. If he needs help, ask another trainee to tell him what to do.
- o If there is opportunity for all the trainees to practice, let them all do it, but only so many as you can observe and critique at a time.
- o Have one trainee perform the steps while another watches and describes each step. Then reverse the roles.

In the event that there is only one of these jobs to do in the plant, it may not be possible to provide practice. In that case, you need to record that the trainee has only observed the operation or that he has had only one practice, and is not ready to perform the task unsupervised. The next time that this opportunity becomes available, you can give the trainee more practice.

This lesson plan contains the essential elements of a demonstration. The instructor should have met the criteria in Figure 1. (q.v.)

Evaluation

The final step in the training of the OJT instructor is the creation of job performance measures. This does not have to be a complicated task, but it needs to be done, so that there is consistency in the evaluation process, no matter who does the evaluating. Failure to do this will result in some OJT instructor being preferred over others because they "qualify" a trainee who does not perform as well as he should. The goal is well-trained and qualified employees; we cannot afford to compromise that effort.

A job performance measure needs to list the steps that the trainee is expected to perform during the evaluation phase, with any standards of performance that are required, e.g., "correct to within one millimeter", or "completed within 15 minutes", or "within .5%." The standard may also be "as prescribed by the manufacturer's qualification" etc. For the task just described in the lesson plan, here are some statements from the job performance measure.

The trainee performed as indicated on each of the following items:

	Yes	No	Needs More Improvement
1. Stripped the cable at least nine inches	_____	_____	_____
2. Stripped wire bare 3/4" to 1:	_____	_____	_____
3. Wrapped wires clockwise around correct terminals.	_____	_____	_____
4. Tightened screws sufficiently to prevent wire from being twisted loose.	_____	_____	_____
5. Made S-bend in wires before pushing receptacle into the box.	_____	_____	_____
6. Removed fiber washer from box.	_____	_____	_____
7. Securely mounted receptacle in box.	_____	_____	_____

This is not all that should be included, but it is enough to serve as a model. The OJT instructor may have to include an item concerning use of the approved procedure, or observance of some codes or standards.

Summary

OJT instructors need first of all to know their own subject matter; we do not include that in their training as an instructor. Next they need to know the procedures in effect for conducting and documenting on-the-job training. The real task of these instructors is to conduct an effective training session. We all know people who know their subject well but cannot communicate it to others. The ability to demonstrate a manipulative skill is a basic skill for an OJT instructor. We teach it by demonstrating it and observing the criteria listed in Figure 1. Our instructors also need to be able to recognize and state in their own words the level of performance expected of the trainees as a result of the session. Then they need to know what it takes to bring the trainees up to that level. Finally, they need to know how to use a job performance measure to evaluate the learners' progress. If we have people on our staff to write these, the OJT instructors may not have to do so. They will, however, be valuable resource persons to help the instructional technologists write objectives and criteria for measurements.

LESSON PRESENTATION CHECKLIST

DIRECTIONS: Place an "X" in the NO, PARTIAL, or FULL box to indicate that each of the following performance components was not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, a performance component was not applicable, or impossible to execute, place an "X" in the N/A box.

Name

Date

		Level of Performance			
		N/A	No	Partial	Full
1.	All necessary tools, materials, and visuals were organized and at hand when the teacher needed them.	—	—	—	—
2.	All tools, materials, supplies and visuals were in good condition.	—	—	—	—
3.	The instructor introduced the demonstration with explanations of:				
	a. What was going to be demonstrated	—	—	—	—
	b. How it fit in with what the trainees already knew or had experienced.	—	—	—	—
	c. How it fit in with future activities	—	—	—	—
4.	Each step necessary to the operation was demonstrated.	—	—	—	—
5.	Each step was explained as it was demonstrated.	—	—	—	—
6.	The steps were presented in a logical order.	—	—	—	—

FIGURE 1
Page 2 of 2

		LEVEL OF PERFORMANCE			
		N/A	NO	PARTIAL	FULL
8.	Safety practices specific to the operation were covered.	—	—	—	—
9.	The procedure used for the operation was the one currently approved for use in the field.	—	—	—	—
10.	The steps were presented slowly enough that students did not miss key points.	—	—	—	—
11.	Every movement in the demonstration was clearly visible.	—	—	—	—
12.	If direction of movement was of special importance, students were positioned accordingly.	—	—	—	—
13.	The instructor could be clearly heard.	—	—	—	—
14.	The instructor performed the operation with ease.	—	—	—	—
15.	The instructor set up standards of workmanship by doing a good thorough job.	—	—	—	—
16.	The instructor encouraged questions.	—	—	—	—
17.	The instructor asked key questions throughout to ensure that the students understood the demonstration.	—	—	—	—
18.	The instructor included some activity to summarize the steps and key points.	—	—	—	—
19.	The scope of the demonstration was sufficiently limited that students could absorb it all.	—	—	—	—

CHAIRMAN'S REMARKS

Mr. B. S. Magnusson
Sweden

The first presentation was by Mr. P. A. Tompsett from Central Electricity Generating Board. The paper he presented was about "An Integrated Initial Training Program for a CEGB Operations Engineer." The paper considers an overall training program for a newly-appointed Operations Engineer. The training program is designed to equip the engineer with the skills and knowledge necessary to do his duties safely and effectively. The theoretical presentation is reinforced by using either simulation and/or practical experience on site. In later stages, plant-specific simulators are incorporated into the training program. The trainee's performance is assessed throughout the program to provide feedback to the trainee, the trainers and station management.

The second paper was presented by Mr. M. C. Pate, Jr., from Carolina Power and Light Company, USA. The paper presented was entitled, "A Centrally Coordinated Maintenance Training and Qualification Program for a Multi-Unit Utility." The program is based on a five-year, five-level training and qualification process. It is given to nuclear plant mechanics, instrumentation and control technicians and electricians. The program consists of five levels of generic training conducted at a central training facility, five levels of site-specific training and five levels of employee qualification based on a qualification card system. This centrally coordinated program has obtained an INPO accreditation.

The third paper was presented by Mr. B. Cordier from Electricité de France, France. The paper was given on the subject "Computer-Assisted Training for Diagnostics and Incident Situations." The presentation shows where, in a training program, one can use computer-assisted training. The presentation demonstrated the computer-assisted training resources used, the objectives, direction now taken and its growth prospects.

The fourth paper was presented by Mr. G. G. Seigler and Mr. R. H. Adams, both from Virginia Power, Richmond, Virginia, USA. The speech was entitled, "Virginia Power's Computer-Based Interactive Videodisc Training: A Prototype for the Future." Mr. Seigler started the presentation by giving a theoretical background; then Mr. Adams gave a practical presentation of the equipment they use. VP has developed a system for computer-based interactive videodisc training. So far, they have developed two programs: "A Fire Team Retraining" and a "General Employee Training". The company has also developed a related program for conducting a videodisc tour of the company's NPS. This system was demonstrated and it was very interesting to see how it functioned.

The fifth paper was presented by Ms. Joe Palchinsky. The paper was written together with Mr. W. J. Waylett, Jr. Mr. Waylett was not present at the meeting. Both authors are from Florida Power and Light Company. The title of the paper was "Development of a Training Assurance Program." The FPL is developing a training assurance program to track indicators of training performance and future trends. The company has been integrating the quality improvement program processes with systematic training processes and the result has been an increased customer satisfaction with training performance.

The sixth presented paper was presented by Mr. Joseph P. Flynn, Jr., from the Institute of Nuclear Power Operations, Atlanta, Georgia. The paper was entitled, "Use of Case Studies in Training Nuclear Plant Personnel." There has been some ineffectiveness, from the nuclear industry side, to learn from previous events at other plants. The industry has searched for effective methods to teach the lessons learned from industry events.

The case study method can be a potential solution. By reviewing actual plant events in detail, trainees can be challenged with solving actual problems. To use the case studies in seminar or discussion format can help the trainees to compare their decision making processes and the results, with other trainees, the instructor and the personnel involved in the actual case study event.

The seventh and last paper was presented by Mr. N. A. Wiggin from New Hampshire Yankee Seabrook. The title of his presentation was "Training of OJT Instructors." OJT instructor training needs to include several important elements. The industry needs to provide them with the policies and procedures for conducting and documenting the training. The industry needs to acquaint them with performance objectives and train them to measure performance against these objectives. Most of all the industry needs to teach them how to demonstrate a manipulative skill at the level of objective. This is the most likely single teaching method the OJT instructor will use. The presentation showed in a very practical way how this could be done. The most important point was the answer to three questions: What, why and how -- in that order.

The presentations and the papers during this session were very excellently presented and most interesting. The audience put many questions to the speaker. It was a pleasure to chair this excellent session, with expert help and support from my assistant, Mrs. Roe.

SESSION 5:

EVALUATION OF PERSONNEL, PERFORMANCE,
AND TRAINING

CHAIRMAN: Mr. M. Gomolinski

THE ROLE OF CHECK OPERATORS IN ACHIEVING
OPERATIONAL EXCELLENCE AT VIRGINIA POWER'S NUCLEAR STATIONS

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Abstract

Virginia Power has implemented a Check Operator Program as a part of its commitment to excellence in the operation of the North Anna and Surry nuclear power stations. The Check Operator Program utilizes highly qualified licensed personnel to independently evaluate the performance of licensed operators and senior operators during normal, abnormal and simulated emergency conditions. Emphasis is placed upon individual and team performance as well as the procedures and training which support the operators. The check operators report to line management to ensure that their recommendations are implemented into the overall operations philosophy of the power station.

Introduction

Recognizing that its employees are the key to achieving operational excellence, Virginia Power has implemented several initiatives to involve its employees in improving the safety, efficiency, and professionalism in the operation of its power stations. One of these initiatives is the implementation of a check operator program at the North Anna and Surry Power Stations.

The Virginia Power check operator program utilizes highly qualified licensed operators to independently evaluate the performance of licensed operators and senior operators during normal, abnormal and simulated emergency conditions. Emphasis is placed upon individual and team performance as well as the procedures and training which support the operators. The check operators report to line management to ensure that their recommendations are implemented into the overall operations philosophy of the power station.

The check operator program is formally incorporated into Virginia Power's Nuclear Operations Department by Policy Statement NODPS-0-07 and Nuclear Operations Department Standard NODS-0-10 which are approved by the Vice President - Nuclear Operations.

Selection and Training of Check Operators

One full time check operator has been appointed at each of the two nuclear stations. These individuals were selected based on their technical abilities, interpersonal skills and their demonstrated commitment to excellence in all phases of station operation. The check operators were selected from station personnel who:

- o Hold an active Senior Reactor Operator License at the power station which they will serve.
- o Have served as an Assistant Shift Supervisor, or a Shift Supervisor, at the power station for at least 24 months.
- o Have successfully completed all Licensed Operator Regualification Program (LORP) requirements with excellent performance for the previous year.
- o Have consistently received above average ratings on the company performance appraisals.

Check operators are selected by the Assistant Station Managers (Operations and Maintenance) with concurrence of their Station Manager and the Vice President - Nuclear Operations. The check operators report to the Assistant Station Manager who also supervises the Superintendent - Operations.

Following appointment, the check operators receive the following training which is coordinated by Virginia Power's Power Training Services Department.

- o Simulator Instructor Training covering simulator training objectives, the use of simulator exercise guides, and the use of performance evaluation instruments.
- o Plant Evaluator Training emphasizing techniques for in-plant observations, interviewing techniques, and methods for presenting conclusions from in-plant observations to those being evaluated and to management. This training was provided by the Institute for Nuclear Power Operations for the first check operators.
- o An overview of the NRC operator licensing process, including review of the NRC examiners standard.

The check operators maintain active NRC licenses. This requires completion of all Licensed Operator Regualification Program

requirements. In addition, the check operators serve as a shift supervisor approximately one week per month to maintain a high degree of operational proficiency.

Responsibilities of Check Operators

The overall responsibility of check operators is to improve the performance of licensed personnel by identifying areas where improvement is warranted and then working with the individuals and management to implement corrective actions.

Specific activities directed toward the identification of areas for improvement include:

- o Administer annual operational evaluations of Reactor Operators and Senior Reactor Operators. This evaluation of the operator's performance during simulated abnormal and emergency conditions utilizes the control room simulators. This evaluation is coordinated with that conducted by the training department as a part of the Licensed Operator Requalification Program.
- o Conduct systematic in-plant observations and evaluations of licensed personnel performance during normal plant operation.
- o Conduct in-plant observations and evaluations of licensed personnel's performance during infrequent plant evolutions, e.g., reactor and plant startup.
- o Conduct independent operational evaluations of license candidates prior to their completion of the NRC license examination.

The check operators have developed worksheets for guidance and documentation of their simulator and in-plant observations. For example, the in-plant checklist includes the following eight general areas of evaluation:

- o Conduct of the shift turnover.
- o Knowledge and use of operating procedures, including abnormal and emergency procedures.
- o Knowledge and use of administrative procedures and Nuclear Operations Policy Statements and Standards.
- o Knowledge and use of technical specifications.
- o Taking and use of plant logs.

- o Professionalism and efficiency in shift conduct.
- o Communications with other shift members.
- o Knowledge of plant status.

This checklist is presently being revised to include approximately forty specific items to be evaluated in the eight general areas.

While direct observation of the operator's performance is the predominate method of evaluation, the check operators also ask questions to determine the operators' understanding and ability to make judgments in cases where procedures do not provide specific guidance.

Once an observation has been completed, the check operator discusses it with the individual. They jointly evaluate the root causes and possible solutions to any identified performance deficiencies. In many cases, the deficiency is limited to the performance of a specific individual. In other cases the root cause has been found to be a result of inadequate procedures or incomplete implementation of company policies.

The evaluations are documented in written reports which are reviewed with management. Particular emphasis has been placed on reviewing the results with the Superintendent - Operations and Superintendent - Nuclear Training.

Benefits

The check operator program has been well received by both the licensed individuals and management. Licensed individuals respect the knowledge and insight of the check operators and generally agree with their conclusions and recommendations. Specific benefits of the program cited by licensed operators and shift supervisors include:

- o The objective, operational nature of the evaluations.
- o The use of the observations to provide specific, positive recommendations for improving their performance.
- o The ability of the check operator to effect changes in procedures or policy where they will improve operations.

Management is in general agreement with these conclusions. Many recommendations made by the check operators have been implemented. Examples of recommendations which have been implemented include:

- o A revision to the shift turnover logs to increase their utilization in ensuring a complete professional turnover.
- o A revision to the abnormal procedure for restoration of electrical supply system to clarify the recovery process.
- o Increased emphasis on the training of operators as a shift team during simulator training sessions.

In summary, Virginia Power has implemented an effective check operator program. The concept of having the check operator emphasize peer evaluations has encouraged both the operators and management to utilize it as a method of improving overall power station operations. In addition to the evaluation of specific operators, the check operators have made recommendations which have improved the quality of team training during simulator sessions and improvements in the procedures used to operate the power station.

Discussion

MR. LATONE: It is apparently a self-audit function that you are comparing against a standard. Is that correct?

MR. SHRIVER: Yes, it is.

MR. LATONE: How about the person you are driving to work with. Are you going to self-audit him? How do you handle that situation?

MR. HENRY: It has been very well received by the operating shifts and it was something we recognized when we set the program up. In order to make this program work, we are going to have to be able to divorce ourselves from past friendships and associations. The way we started the program was that we came down and talked to Bill Doonan, who was the head of the 727 check pilot program at Delta Airlines, to find out how they were received by their peers when they transitioned into that rating or check role. We found, in his case, there was a fairly large animosity picked up when they came from the position as a peer pilot to check pilot program. Page and I, in setting up our program, could not afford to have that animosity develop. So the things that we recommend are fed back directly to the individual at the time of appraisal or evaluation. The first

person who sees the evaluation is the individual who was evaluated. When that is done, if he has questions about what the comments were, they are cleared up with the individual before the report goes to management. It has worked really well so far.

MR. BUDNICK: Has Virginia Power implemented the Human Performance Evaluation System (HPES)? If you have, what is your role in relationship to the particular system?

MR. KEMP: Yes, we have and we have a separate person at each station who is in charge of that program. We have day-to-day communications with him, but we do not directly become involved with that program.

MR. GRANDAME: Could you give me an example of some of the points of performance that you are checking these operators on?

MR. HENRY: When we set up the program, Page and I developed, for the in-plant evaluations, an overall observation check sheet that would be submitted to our bosses, the assistant station managers. Each of us, independently, because of the difference in station procedures, had developed several pages of individual areas or expounded on those categories. For example, in the procedures category, during an in-plant evaluation, we have a check sheet that shows operator performance through routine annunciators, use of procedures through non-routine annunciators. The same thing with operating procedures, routine and non-routine, and abnormal procedures. In other words, a detailed report broke down categories of how each operator was performing those functions that, though routine, become old hat and, through habit, use of required background documents may stop. That forces the operator to remember that procedure usage is something that is required for every annunciator or condition that exists. We act as a QA constantly for that individual and it has been very well received.

MR. KEMP: One thing we look for in procedures is to verify that the operator completes all his precautions and limitations, his initial conditions, that type of thing, for each procedure, and verify when he receives an annunciator, especially annunciators he does not get on a routine basis. He uses annunciator response to ensure the correct action is taken, so he can respond, correct the problem and return to normal operations.

MR. LONG: What fraction of your time do you spend in actual administration of examinations, as compared to the other observations. The observations sound to me very similar to what our quality assurance department operations monitors do. Can you compare the two activities?

MR. HENRY: The program was set up and the major job function for each check operator was in plant evaluations. To keep ourselves current and to maintain peer acceptance, Page and I stand at least five days per month of in-plant time as shift supervisors, divorced from the observation process, again, as one of the group being forced to make the decisions. With the LORP requirements, it ends up that we are right now spending about 15-17 days a month either on shift as a supervisor or evaluating people on shift as check operators. So we have a significant commitment at times. When we are in plant evaluations, we are there from nine to ten hours a day to observe both pre-watch and post-watch turnovers. I know Virginia Power's QA department takes pictures of all those processes, but they are not there continuously throughout the whole shift cycle, watching everything that the individual does during the whole day, to get a better background.

MR. FEDAKO: I am not familiar with the pilot check program. It sounds like they are doing something very similar. Who provides, or how do you factor in a key way to check on the checkers? In other words, what recourse does a person have if he does not agree with you?

MR. HENRY: As I said, each report is reviewed by the individual before we turn it in. He knows that that report goes to the assistant station manager and I have not yet had one where there was vehement disagreement with what I reported. But as in all processes, the doors are open to each manager. I would be more than happy, at that time, to meet with the individual and management to talk about the observation. It has not yet happened to me, but that door is always open.

MR. LANGE: Has the program been in place long enough for you to measure the effectiveness of what you are doing?

MR. KEMP: The program started in May of last year, so it has been about a year since we initiated the program. There are no real factors that you can put on paper in most cases to verify that the program has been a total success. But we have had quite a few areas where we have made improvements. For instance, during one of the yearly evaluations, we noticed that the operators were having problems with electrical procedures when they had a fault in electrical power, in trying to go through a procedure and restore their power to return to normal operation. We made recommendations to station management to improve these procedures quickly since electrical power failures are more likely to happen than any other type of accident. Through our recommendations this procedure was corrected and improved greatly. So in those areas, we have seen improvement, but it is hard to put on paper.

MR. HANLEY: Do you evaluate people who are in a position above the position that you hold? How does that work out in terms of

evaluating people who are shift superintendents, if you do that, or shift foremen, versus reactor operators?

MR. HENRY: We have had two license classes at Surry go up since the check operator position was created. Each of those classes has had at least one manager candidate who, by your definition, is in a position higher than the one I hold. Both of those candidates were failed by the check operator on evaluations and management backed up that evaluation.

MR. HANLEY: Not being directly involved in operations all of the time, that obviously takes some of the staffing away from the plant. Does that cause staffing difficulties in the operations department? Have you staffed specifically for the check operator program?

MR. HENRY: License numbers at Surry were more than sufficient to support it. North Anna had fewer licenses available.

MR. KEMP: When the position was created, it did put a burden on operations, with the loss of an SRO from the role of shift supervisor. Since that time, though, we have been able to re-staff with licensed SRO's to the point where we have three SRO's per shift. So it is not a problem now.

MR. SHRIVER: I want to close by noting that we have, in fact, seen improvements in both operator performance, in recommendations for team performance, in support documents, such as AP-10, the Electrical Abnormal Procedure that Page mentioned. I think it was interesting, considering the dinner discussion last night about the shuttle disaster, to note some of the root causes that were mentioned. The speaker listed seven. There are four of them that relate to what our check operators are doing. First, there was a lack of attention to engineering detail. In our case the relationship may be the operations detail. That is one of the things we are doing with check operators, to get back and look at the detail of how we operate our plants. Second, he talked about the formality of communications being a problem. One specific area that our check operators evaluate routinely is the formality and effectiveness of communications in the operations group. The speaker mentioned the lack of compliance with procedures, and both check operators mentioned that was one of the specific criteria they look at, to be sure that the procedures are used as they are intended to be used. Lastly, there was a lack of effective communications with senior management. The check operators do report to high level management in the station, to provide that bridge between the operators and the higher levels of management.

So we believe that this program is effective, and we believe we will be able to demonstrate that more in the future.

INFLUENCE OF OPERATION INCIDENTS ON THE FRENCH TRAINING PROGRAM

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Abstract

The French electricity producer, Electricité de France (EDF), and the Safety Authorities have developed, each of his own, a procedure for analyzing the operating incidents. One of the major lessons of their analysis was the importance of incidents due to human error and, among them, to deficiencies in the training of the operators. It is, in consequence, particularly important to improve the quality of these programs and one of the major concerns is how to take into account the lessons of operation experience. Our purpose is aimed at describing how this is now done.

Introduction

Operation incidents on PWR plants are mainly taken into account for operator training purposes through the organization of feedback of experience lessons implemented at the nuclear and fossil generation service of EDF on one hand, and the safety authorities on the other hand. The goal of such an organization consists in detecting, analyzing and learning lessons of incidents on PWR plants, in France and abroad; all that aimed at taking all the adequate measures for preventing other similar incidents, improving the safety knowledge of the operators.

For this purpose, it is quite important to pay special attention to events where, directly or indirectly, the operator is involved and, in consequence, to the training of these operators. After presenting some elements which can give an idea, in general, of the relationship between operation events and operator training, we are going to study more in detail the implemented organization for the feedback of experience lessons on operator training.

Training and Operation Events

Statistical analysis. In fact, it may be quite difficult to determine precisely how an incident due to one (or several) human errors may be linked to lacks in operator training. If it is sometimes easy to reach this conclusion, one may understand that, in

the general case, an error cannot be explained only by the fact that the instructors have not insisted enough on some crucial point during the training sessions.

The analysis of the annual balances of plant operation realized by the specialists of the DAF (Divison Analyse du Fonctionnement, of the Nuclear and Fossile Generation Service) show that percentages may be quite different according to the type of events taken into account. After a first "rough" classification which attributed almost half of the human errors to training problems, a more refined classification led to the following results, concerning scrams due to human errors. (One may note that the sum of percentages may be greater than 100 because one error can have more than one cause.)

Table 1. Repartition of error causes for the PWR 1984 and 1985 incidents.

Cause	1983	1984
Task complexity	31%	40%
Workstation design	22%	25%
Working time	4%	12%
Work organization	4%	25%
Procedure (presentation)	22%	3%
Procedure (technical contents)	4%	12%
Training	8%	13%
Competence	11%	7%
Procedure violation	20%	20%

These statistics concern:

- o 108 events (112 human failures) in 1983, it means a bit more than 50% of the scrams
- o 142 events (145 human failures) in 1984, it means a bit less than 60% of the scrams

In both cases, the number of the scrams due to training problems is approximately 7% or 8% of the total. These numbers can be considered as "minimal," taking into account the probable link of "training" problems (in the table) with "competence" or "task complexity."

We may also pay attention to some data belonging to an information collection program realized in 1982 and 1983 by the DAF and INPO. We should, in any case, use this information very cautiously, according to the fact that just a few events occurred on a French plant (Dampierre 3-4) and that also all these events did not lead to a so-called "significant incident." The following table shows the histogram of "experience in the nuclear field" and "experience in the position" of the agents who performed the error.

Table 2. Experience of the agents performing errors

Years	Experience in the nuclear field	Experience in the position
1 year	2%	26%
1 to 5 years	42%	66%
5 to 10 years	34%	8%
10 years	22%	

We noticed in addition that 53% of the analyzed events have had similar "antecedents"; this shows the importance of the diffusion of experience lessons.

Example of incidents. We are going to present here two incidents for which taking into account the experience lessons seems to be especially important.

Incident at Tricastin 1 on 3/2/83

During the raising of the upper internal structures, at the plant shutdown, the operators noticed that, at about 11 p.m. on 3/2/83, as the lower face of the upper plate of the upper internal structures was about 170 cm over the pool floor, the N7 and N9 assemblies remained attached to their control rods.

The raising was immediately stopped and the operators got confirmation, by videocamera, that the assemblies remained connected. A corrective intervention was then planned for the next day in the evening.

This incident, whose potential consequence on the fuel could have been significant, is mainly due to two errors during the raising:

- o bad transcription of the operations on the intervention documents

- o bad utilization of the checking procedure by endoscope; the checking was executed after each individual task and not at the end, when no assembly should remain still attached. The lack of this final check did not allow detection of the omission.

But, it seems, for our purposes, especially worthy to note that similar incidents had occurred already at the Bugey (July, 1981) and Fessenheim (March, 1979) plants. In fact, the incident report mentions that, when the operators at Tricastin realized the situation, they contacted these two plants. But this information about the past incidents should clearly have been made before this operation, in order to make them attentive to the risk of such interventions and to the necessity of following strictly the procedure.

We may also notice that a similar incident occurred at the Paluel 2 (1300 MW) plant on 8/6/85. This fact shows that experience lessons should be correctly learned in all the different types of PWR plants and also in the company in charge of this type of intervention (Framatome).

Incident at Dampierre 3 on 10/10/84

At hot standby, the alarm "low injection rate at the RCP (primary circuit) 3PO seal" appeared. The operators realized immediately that this alarm was due to the low voltage on the LDA (analog control 30V power system) circuit, and in consequence one of the two rectifiers of this circuit was immediately actuated.

In fact, the voltage decrease on the LDA was due to a wrong connection of the rectifiers during the plant shutdown and, in consequence, to the unloading of the battery. It actuated the LDA alarm but, during more than three hours, the operators did not perform any action because they thought that this alarm was activated for a less serious situation. In fact, this alarm can be activated in seven different cases. The situation was rapidly recovered after the rectifier was activated.

This incident shows:

- o a lack of rigor in carrying out connections during plant shutdowns.
- o an insufficiency of the knowledge of the agents of the risk linked to the "regrouped alarms." We may notice that this incident occurred six months after the Bugey 5 incident (5/14/84) where a similar situation took place.

Feedback of Experience Lessons

In the case of an incident involving human errors, the depth to which the incident is analyzed obviously depends on its actual or potential seriousness.

Electricité de France:

- o All incidents give way to a brief analysis conducted by Electricite de France. A fairly short official report is then drawn up, listing the main features of the incident in a standardized form. Such documents are mainly used for statistical purposes, providing material for an annual report.
- o If the incident is sufficiently serious, this analysis may be supplemented by a site visit. The licensee and the representative of Electricite de France central services then carry out a detailed study of the incident. They complete a much more precise questionnaire giving a very detailed picture of the incident from all angles (personnel concerned, circumstances and causes of the incident). The questionnaire is then used for far more extensive statistical work than mentioned in the above paragraph. It is also sent to the INPO in order to enter the data in the "international" nuclear incident data base maintained by this body.
- o In the case of major incident, the central services of Electricite de France conducts a thorough formal analysis describing the entire sequence of events relating to the incident, then establishing the tree of human failure and the tree of causes to gain a more comprehensive picture of all the deficiencies revealed by the incident. In the analysis report, if possible, a link should be drawn between the causes and the different "human factor" measures taken or planned and the opportunity taken to submit new proposals for action.

IPSN (Protection and Nuclear Safety Institute)

- o Furthermore, in France a list of ten standard criteria defining the significance of an incident has been drawn up. If the incident meets one of the criteria, the licensee must inform the Safety Authorities, although it may do so for any other incidents.

As soon as the telex from the licensee is received, a file on the incident is opened. An analysis is then carried out on the basis of the data in the telex, the significant incident report drafted at the power plant and, where applicable, the analysis report prepared by the central services of Electricite de France (see immediately preceding item). This information may be supplemented by site visits to gain a better idea of the features of the incident.

- o Significant incidents involving human errors are entered in the IPSN data bank with a view to identifying links with similar incidents for any generic studies. On the basis of the conclusions of these studies and analyses of major incidents recommendations are made to the licensee. These recommendations may be aimed at the training of the agents.

The Influence of Experience Lessons on Operator Training

In the training centers. The training centers use the analysis documents for the constitution of an incident library on a simulator. The instructor may use this library for illustrating their purposes. In particular, one of the two one-week simulator recycling stages consists of a collection of such incidents proposed to the operators. Furthermore, analysts of the operation analysis division (DAF) act as instructors in the "improving safety during operation" stage. They may present in detail some recent significant incidents.

In the computer-aided teaching program (CAT) Some incidents, which seem to have a particular pedagogic interest, have been incorporated in the CAT library (See Appendix A).

We may notice that, due to the fact that the utilization of this CAT system is facultative, we have to pay special attention to:

- o the ease of utilization, according to the variety of psychological situations of the agents who may wish to use it (night working, workload, etc.).
- o the correspondence of the CAT library with the present concern on the operation teams in general; the modernization of this library seems highly important for this purpose.

On-site training. The experience feedback is taken into account by two different ways in the on-site training programs:

- o On one hand, it is possible to determine a number of subjects to which attention of the agents must be regularly drawn; electric circuits, confinement, control-rod operation. These points are covered during special presentations (one-half day or more).
- o In addition, some incidents, which present special pedagogic interest, may also be treated in a specific session. We may just notice that the preparation of such presentations requires a pedagogical effort from the ISR (Safety Radioprotection Engineer) or shift supervisors in charge of such training activities.

We may add two important comments:

- o In general, this kind of training was much better carried out for the operation staff than for the maintenance staff. Even taking into account the diversity of competence, and consequently of training concerns, linked to the maintenance activity, this situation should be substantially improved through the effort carried out by the Nuclear and Fossil Generation Service for the training of maintenance staff.
- o In addition, even for the operation agents, the number of incidents presented in such training programs remains quite low (less than five per year) and, in consequence, an effort has to be made. This effort is one of the main means to avoid the occurrence of similar incidents (regrouped alarm treatment and connection errors which led to the safety injection tank dump, etc.).
- o Beyond these training activities, we have to mention here a lot of actions carried out in order to improve the receptivity of the staff to the experience lessons. For example, we may notice:
 - o The existence of a periodic bulletin "it happened on the plants" (7000 exemplaires),
 - o The transmission to the plants of the incident reports, statistical analysis and generic studies realized by the control services of EDF,
 - o The existence of a data processing "event file" where all operation events are registered. By consulting this file, one can quite quickly obtain a good idea of the qualitative or quantitative importance of a given type of operation problem.

Conclusion

The effort realized for the transmission to the agents of the experience lessons is, in general, quite comprehensive. It includes the transmission of detailed reports on incidents, a very large diffusion of an information bulletin, the maintenance of incident files on simulators and in the CAT program.

This effort has nevertheless to be intensified for the maintenance staff and it is also very important to increase the number of incidents presented on-site to the agents, in order to improve their preparation to the various operation situations they may encounter.

Even if the specificity of every working situation has to be taken into account, the main goal of this effort consist in giving to the agents the motivation for respecting a few "good operational practices" in any case. The respect of these basic principles should allow prevention of a substantial percentage of the actual operation incidents.

Appendix A: INCIDENTS OF THE CAT LIBRARY

Module Bugey	Safety Injection on high steam rate + P12
Module Condenser	presence of raw water in the condenser
Module Ginna	rupture of steam generator tube
Module Incidri	switch between intermediate cooling circuit ways
Module Niveau GV	scram by steam generator level protection
Module PPE	seals of primary pumps
Module Robinson	non-isolating of the pressurizer let down systems
Module Ste Lucie	closure of the principal steam circuit
Module TEG	release of gaseous effluents
Module ZION	loose part in the steam generators
Module consignation	padlocking of charging pumps
Module Incid gct	use of turbine bypass
Module Vidangev	steam generator dump situations
Module Incelec	loss of electric power systems.

Discussion

MR. BOHANON: This relates back to yesterday's discussion about case studies and things of that nature. I noted in your first table (Table 1) that there seems to be in "procedures and competence" a drop in the basic causes, yet all the rest of them are much higher than the year before. Not to be critical, what actions are there in 1986 and 1987 to rectify some of these increases?

MR. CERNES: In general, we have at EDF a human factors division which is in charge of defining actions, for instance, the method of identification. All important facts can be carried out from the analysis of the accidents and for corrections, in order to decrease the rate of such substantive errors.

MR. BOHANON: The reason I pursued the subject was the fact that, so many times, we try to address training as the basic cause. When your particular group does its analysis, I wondered how strong their recommendations could be and how much action transpired and how rapidly, when it came to be a design factor or human factor type of situation, versus training. It is a little like designing around a problem, when you try to do training to correct a problem that is really an engineering problem.

MR. CERNES: Yes, it is known that training cannot be the universal solution. Even intensifying training and taking some action, the problem almost always remains linked with the motivation and awareness of the agents to the several risks, and that is not easy to accomplish.

CLOSING THE LOOP: USING THE EMERGENCY PREPAREDNESS
EXERCISE FOR SELF-EVALUATION AND PERFORMANCE ENHANCEMENT

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Abstract

Large scale reactor emergency drills and exercises provide an unequalled opportunity to identify weaknesses in personnel performance and in emergency preparedness programs. Experience indicates that certain factors are associated with consistently exceptional response capabilities, while other factors are linked to continuing mediocre performance. This paper discusses the emergency preparedness exercise as an element of the training process and examines some of the factors that contribute to success.

Introduction

The U.S. Code of Federal Regulations (CFR), Title 10, Part 50.47 (10 CFR 50.47) and Part 50, Appendix E, require that each nuclear power reactor licensee "...exercise at least annually the emergency plan for each site at which it has one or more power reactors licensed for operation." These exercises may vary in scale and complexity from one year to the next depending on the level of participation by off-site (state and local government) agencies. Appendix E also states that, "All training, including exercises, shall provide for formal critiques in order to identify weak areas that need corrections. Any weaknesses that are identified shall be corrected." (Reference 1)

U.S. Nuclear Regulatory Commission (NRC) inspectors observe each licensee exercise and evaluate the performance, including the ability of the licensee organization to critique its own performance, identify weaknesses, and follow through with corrective action. In addition, inspectors periodically visit licensee sites to assess the condition of the licensee's Emergency Preparedness (EP) Program by auditing records, interviewing staff, and reviewing the status of corrective actions. Since 1980, Pacific Northwest Laboratory (PNL) staff members have assisted the NRC in evaluating licensee exercises and conducting inspections of EP programs.

The purpose of this paper is to discuss the various parts of the emergency preparedness exercise cycle and examine the factors that contribute to success in the area of self-evaluation and performance enhancement.

The contents of this paper reflect only the opinions of the authors and do not represent any official NRC position or judgment.

The Purposes of Emergency Preparedness Exercises

The purposes of the periodic emergency preparedness exercises, summarized from 10 CFR 50 Appendix E, Section IV.F., can be stated as follows:

- o To test the adequacy of emergency response plans, procedures, equipment, communications, facilities, and the interactions with off-site (state and local government) agencies
- o To provide staff with training and experience in emergency response procedures and operations.

Licensees often perceive these purposes differently and instead approach the exercise as if the central purpose were to provide the opportunity for federal agencies to evaluate the emergency response capability of the licensee and the off-site agencies, i.e., to demonstrate the capability for the benefit of outside observers.

This perspective and the resulting approach to exercises can have a negative impact on the licensee's ability to achieve the purposes set forth in 10 CFR 50 Appendix E. If the exercise cycle is instead viewed as an element of the overall emergency preparedness training process, it can be conducted in such a way as to make the process better serve its intended purpose, i.e., to test the various parts of the response process and to train the staff to perform their duties, thereby improving the level of preparedness.

The Exercise Cycle

A sequence of activities occurs throughout the year leading up to the annual emergency preparedness exercise at a licensed reactor site. Somewhat simplified, this sequence consists of seven steps:

- o develop objectives for the exercise based on regulations, on-site needs, and off-site agency needs.
- o prepare an exercise scenario to fulfill the objectives.
- o select exercise controllers and evaluators, provide them with appropriate training and exercise evaluation guidance.
- o conduct the exercise and evaluate performance.

- o analyze exercise performance, identify trends and deficiencies, determine the root causes and appropriate corrective actions.
- o plan and implement solutions.
- o develop exercise objectives to test the effectiveness of program changes.

This sequence repeats itself in a cycle with a nominal period of one year. However certain types of deficiencies may lend themselves to correction and demonstration only once every two years, when state and local governments participate fully in the exercise.

Each step in the sequence will be examined to discuss some of the factors that determine how effectively a licensee uses the exercise cycle to improve the level of emergency preparedness.

Develop Objectives. The objectives are the framework for the scenario events. They should:

- o be specific
- o include measurable quantities or specific observables that facilitate evaluation and review
- o include a description of an adequate or acceptable level of response
- o recognize and incorporate the objectives of participating off-site organizations
- o address the requirements of 10 CFR 50, Appendix E, Section IV.F.
- o test elements of the emergency response plan and organization according to the time schedule presented in 10 CFR 50, Appendix E, Section IV.F
- o address the pertinent guidance and criteria of NUREG-0654 (Reference 2)
- o stress elements of the emergency response plan and organization that have been identified as needing improvement
- o stress elements of the emergency response plan that have been changed significantly since the last exercise.

- o include a list of player response actions that will be demonstrated and not simulated
- o include a list of player response actions that may be simulated.

From the standpoint of performance improvement, several of the above features are prominent.

The inclusion of performance criteria in the statement of an exercise objective can be a powerful tool for forcing the feedback loop to close. Developing objectives for an exercise is the first step toward ensuring that a real, measurable performance improvement has been achieved. If, for example, during the previous exercise the staff were unable to fully activate their Technical Support Center (TSC) within a reasonable time, a good statement of the objective might include the time requirements for reaching various stages of activation.

Objectives should focus the exercise action on general areas of weakness noted during the last exercise. One general area (such as field monitoring or in-plant radiation surveys) might have been the origin of one or more specific deficiency items identified for follow-up action, or it may simply not have been exercised or evaluated adequately.

Probably the most fundamental self-improvement step in developing objectives is to include the successful demonstration of aspects of the plan, procedures, organization, equipment, or facilities that were noted as deficient in past exercises and that have since been modified. If, for example, the inability of technical support staff to correctly estimate core damage had resulted in implementation of a new core damage assessment procedure, then an objective for the next exercise should be to assess the effectiveness of the new procedure and the ability of the staff to use it correctly. Any emergency response procedure that has undergone substantial revision since the last exercise should probably be the subject of a specific objective.

Finally, in developing exercise objectives, planners should take advantage of the unique training value that can be derived from the exercise. During a major exercise, staff members may be given the opportunity to perform operations that are infrequent, for which their classroom training may not have fully prepared them. Some activities, such as taking post-accident coolant samples, are nearly always simulated rather than performed. Likewise, actual use of respiratory protection devices or full protective clothing is often simulated, making the operations requiring their use unrealistically easy. Simulation is often done in exercises to save time or to minimize cost and radiation exposures. Almost invariably, when a

licensee chooses to perform fully rather than to simulate certain infrequent actions, valuable lessons are learned and a great deal of valuable training is realized. Planners should ensure that infrequent operations simulated in previous exercises are carefully considered for actual performance to maximize the training value and all the most accurate evaluation of capability.

Prepare Scenario. The scenario is the script for the exercise. It consists of a hypothetical sequence of events described with data tables, computer printouts, and messages that are given to the players to simulate the information that they would receive from sources such as plant instruments, alarms, and first-hand observation of events. The scenario should cause the players to respond in such a way that the objective, i.e., demonstration of specific capabilities, are met (Reference 3).

The manner in which the scenario is constructed to fulfill the objectives can determine the degree to which the exercise serves to improve performance of the emergency-response personnel. Scenarios frequently follow predictable patterns year after year because the planners focus on demonstration. Planners can easily improve both the demonstration and learning aspects of the exercise by constructing the scenario so that it forces the staff to be creative and innovative in their approach to problem solving. One such approach is to rapidly escalate the accident severity rather than allow the players to get one set of plant conditions firmly in mind before presenting them with indications of a worsening situation. Forcing an evacuation or relocation of one of the on-site emergency response facilities, or failing a key communication link or computer are other means of prompting creative problem solving by the players.

Scenarios can also be constructed so that more than one player participates at each position in the response organization. Having only one major annual exercise of limited duration (typically six to ten hours) means that usually only one team of players is involved. Planners can increase participation by structuring the scenario to include a partial or complete shift turnover or rotation to give alternates some time in their assigned positions. Key players can also be taken out of action before the exercise, giving an alternate an opportunity to play. Finally, multiple opportunities can be provided in a single scenario for different staff members to perform infrequent operations, such as taking post-accident coolant samples. This gives evaluators a broader look at that particular capability and provides the learning experience to more players.

Select and Train Controllers and Evaluators. The role of the controller is to control the scenario flow by injecting messages and providing data to players as requested or at specified times. Controllers also guard against player actions that would adversely

affect the plant or the flow of the exercise. Controllers must be technically competent in the areas to which they are assigned. At times they are required to interpret data, respond to player requests, make up additional data, or provide reasonable explanations for why corrective actions simulated by the players did not work.

The evaluator's role is to observe and evaluate the players' response to the scenario. These individuals must also be technically competent in the area of observation. Frequently, a single person carries out both the controller and evaluator roles in a given location. Licensees often choose personnel who do not have positions in the emergency response organization to be evaluators. Individuals from corporate health physics, quality assurance and training, as well as contractor personnel are frequently used as controllers and/or evaluators. Several potential problems arise from this practice that may degrade the quality of the resulting exercise evaluation and critique. These include evaluator competence and evaluator instruction problems.

Evaluators who do not have a regular position in the emergency response organization may not have an adequate understanding of the duties and responsibilities that they are assigned to evaluate. Consequently, these individuals may lack the insight and first-hand knowledge required to evaluate the appropriateness of player actions and decisions or to identify the root cause of poor performance rather than merely noting the symptoms. These individuals may rely heavily on evaluation checklists provided by the planners. By their nature, these checklists emphasize observable symptoms rather than root causes.

In contrast, the ideal evaluator is an experienced person selected from within the emergency response organization. Experience and knowledge of the activities being evaluated provide insights that might otherwise be missed, especially when those activities are technical. An example of this would be assigning the primary, more experienced, Radiological Assessment Coordinator as the lead controller/evaluator for the Radiological Assessment function while one of his alternates fills the position during the exercise. The reverse can also work well; however, there may be an inherent problem in this practice. In many plant organizations, the primary designee for a given position may have as alternate a person who is his subordinate in the normal line organization. Expecting the subordinate to objectively evaluate and criticize his manager's performance may not be realistic. The practice of using personnel with recent experience in an emergency response role who may now be functioning entirely outside the site emergency response organization (e.g. on corporate staff, as trainers or line managers) can be effective.

Licensees frequently fail to provide controller/evaluators with adequate instructions and training on how to perform either of

their assigned functions. A one- to two-hour controller meeting to review the scenario before the exercise is generally devoted to the exercise control issues. These discussions often fail to provide specific criteria for evaluators to use in verifying that past deficiencies or weaknesses have been corrected. To ensure that maximum training value and performance improvement are derived from each exercise cycle, evaluators must be conditioned to provide a totally objective and critical evaluation of the performance of their co-workers. The self-congratulatory, "everything-went-really-well" evaluation sometimes seen in licensee self-critiques is not productive.

Conduct and Evaluate Exercise. Most licensees conduct brief critiques with the players in each facility immediately following the exercise. The purpose of these superficial critiques is to acknowledge superior performance, boost morale, and give the players a sense of how they performed.

It is important that licensee controllers and evaluators then meet privately to discuss their observations and to compile comments. This step of the performance evaluation process is sometimes omitted or not effectively completed because of time pressures. This omission is a serious mistake. Evaluators need time to discuss and reflect on what they saw and heard and to listen to the other evaluators state their observations before they can all fully appreciate the overall quality of the exercise performance. This verbal exchange, not only of the discrete deficiency items but to general observations of what occurred in each facility and when it occurred, is essential to the evaluator's understanding of how the actions individually observed fit within the overall picture of the exercise. Frequently, items that were overlooked entirely by an evaluator in one location will be called to mind by the discussion of events that occurred in another location. This can lead the evaluator team as a group to recognize improper performance, poor communications, misleading procedures, and other deficiencies that they might have missed individually. Similarly, a minor but inappropriate decision or action by one player may, with input from other evaluators, be recognized as a symptom of a more significant generic problem, such as a faulty procedure or the failure (or inability) to communicate adequately with others in the response organization.

After the evaluators have held a discussion and reached a consensus on the specific findings and the areas of exceptional performance (good and bad), they should present the evaluation to the players and management in an atmosphere that encourages player input. The players' perspective on performance may be quite different from (and more correct than) that of the evaluators. An open, objective exchange between players and evaluators and the use of former players in evaluator positions can prevent the development

of antagonism, particularly if the positive as well as negative features of the exercise performance are discussed in front of licensee management.

Analyze Deficiencies and Weaknesses. This step in the sequence is frequently overlooked by licensee EP staff. After an exercise and its critique are completed, the staff compiles a list of exercise weaknesses and deficiencies that includes items identified by both licensee and NRC evaluators. Depending on the skill of the evaluators and the quality of post-exercise critiques, these items will be of varying degrees of usefulness in planning corrective actions. The EP Coordinator, who will normally be responsible for resolving the items, must rely on other functional components within the licensee organization to accomplish much of the corrective action. The objective of the analysis process is to determine which items on the list are basic problems and which are merely symptoms of basic problems. This distinction must be made to determine the appropriate corrective action and to assign responsibility to the proper functional component of the licensee organization. For example, a typical exercise weakness might be stated as follows: "Notification of state and local authorities was not accomplished within 15 minutes of declaration of an Alert." This item will normally be tracked as an exercise weakness until the licensee demonstrates in his next exercise that notifications can be made within 15 minutes. However, the corrective action required to resolve the weakness may be one of several, depending on the root cause of the observed deficiency. Several possibilities are illustrated in Table I.

Table I. Possible Root causes of a Specific Deficiency and Corresponding Corrective Action

<u>Root Cause</u>	<u>Possible Corrective Action</u>	<u>Functional Groups with Primary Responsibility</u>
Personnel error	<ul style="list-style-type: none"> - Remedial training for the individual involved - Change personnel assignments 	<p>Training</p> <p>EP, Operations</p>
Inadequate organization or staffing level	<ul style="list-style-type: none"> - Assign additional person as communicator - Redefine responsibilities of existing staff positions 	<p>Operations, EP</p> <p>EP, Operations</p>
Inadequate training of the staff responsible for notifications	<ul style="list-style-type: none"> - Develop and conduct additional training for staff on notification procedures 	<p>Training</p>
Procedural deficiency	<ul style="list-style-type: none"> - Revise procedures to speed up notification process 	<p>EP</p>
Equipment deficiency	<ul style="list-style-type: none"> - Repair, procure or upgrade communications equipment 	<p>Plant Engineering, Maintenance</p>
Error by offsite agencies	<ul style="list-style-type: none"> - Hold coordination meeting or training session for offsite agency staff 	<p>Public Relations, Training</p>

Each possible corrective action listed in Table I entails some training activity, whether it be remedial training for a poorly-performing individual, initial training for staff with newly-assigned duties, familiarization of plant staff with revised procedures or modified communications equipment, or indoctrination for off-site agency personnel so they can better understand the notification procedures and messages.

Plan and Implement Solutions. The analysis discussed in the previous section indicates the expertise and resources necessary to develop solutions to the identified deficiencies. The nature of the solutions will determine the type of implementation required. To successfully accomplish this part of the cycle, the EP Coordinator (EPC) must often rely on the expertise and resources of other functional elements within the licensee organization. This is often the weakest link in the chain and the most likely to prevent improvement from occurring.

The responsibility for emergency preparedness is found at a variety of different levels in licensee organizations. The functional level of EP within the organization often reflects management's commitment to EP. In addition, this level determines the working relationship between the EPC and the functional elements upon which he must often depend. This means that the EPC can be in the position of searching for support as either a superior, a peer, or a subordinate, with the predictable results.

Another organizational feature that affects the success of this phase in the sequence is the relationship of a licensee's corporate EP and plant EP elements. Many utilities have separate corporate and plant emergency planners. Because the emergency response process involves resources and expertise from both plant and corporate organizations, formulating and implementing solutions to deficiencies that cross this boundary can prove difficult.

Once solutions to the deficiencies have been developed, they must be implemented to fulfill the next step in closing the loop. Implementation is a two-step process. The first step is to bring about the indicated change. This could be a change in the plan, a procedure, equipment, the organization, or any other element of the emergency preparedness program. The second step is the training required as a result of the change. Some changes require little or no training while others require extensive training or retraining. Although one of the last and most important steps in closing the loop, it is often inadequately done because changes are not completed until late in the cycle and little time is left to develop and conduct the necessary training before the next annual exercise or major inspection.

Two key plant functional groups that can consistently enhance the effectiveness of the EP Coordinator in the implementation phase of the cycle are Quality Assurance (QA) and Training. A strong, independent QA organization can be an extremely valuable ally to the EPC by tracking the status of deficiencies and corrective actions. With QA to focus attention on license-related issues, the EPC can sometimes obtain management support for needs that might otherwise be viewed as minor.

Likewise, a responsive centralized training organization that prepares, schedules, and conducts all plant training, maintains records, and accomplishes the interface for training of corporate staff can help maintain a more consistent training effort throughout the cycle and relieve the EPC of a major administrative burden.

Develop Objectives for Next Exercise. The cycle is complete. If properly completed, the objectives for the next exercise will include the demonstration and proof testing of any significant change implemented in the EP program since the previous exercise. The successful demonstration of the modified procedure, equipment, facility, or organization should be the final requirement for clearing a significant weakness or deficiency item from the tracking system.

Summary and Conclusions

Clearly, the intent of current federal regulations is that exercises play an integral part in the overall training process for maintaining emergency preparedness. The intent is not simply a yearly demonstration of the response capability. This subtle difference in emphasis and perspective can have a major effect on the process of self-evaluation and performance enhancement at each step in the exercise cycle. Structuring the cycle to yield maximum training value and constructive feedback to improve the response process produces a qualitative improvement in the state of emergency preparedness that results in a superior demonstration of capability.

References

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3. Martin, G. F., et al. "Report to the NRC on Guidance for Preparing Scenarios for Emergency Preparedness Exercises at Nuclear Generating Stations." NUREG/CR-3365, PNL-4758. U.S. Nuclear Regulatory Commission, Washington, D.C., 1986.

Discussion

QUESTION: I would like to take one exception to your presentation. You inferred that you have to do a drill annually. In our experience, we have found that to maintain the performance of people, particularly since we have a number of teams, at Con Edison we conduct at least a quarterly drill similar in content, using the concepts that you described here. We plan a year in advance and schedule our teams. It becomes a sacred thing and we hold to the dates. The people are not allowed to go on vacation or some of the other things, just so we can exercise those teams. We use cross-training of the teams, where one team evaluates another team. That way we maximize the feedback loops in some of the mechanisms. While I generally agree with what you said, I don't believe anyone can maintain proficiency on a yearly basis. I believe it is necessary on a quarterly or even more frequent basis.

MR. JAMISON: I agree. I do not propose that an annual exercise is sufficient. I only said it was the minimum requirement that there be an exercise annually. In fact, certain parts of the process, as you noted, must be exercised more often to maintain proficiency.

MR. BOHANON: With the advent of so many replica or plant-reference simulators, what is your view of going to a real-time, live type of exercise, using simulators in conjunction with the EOF and TSC's and all, even to the point where you couple to the off site?

MR. JAMISON: I have seen a number of those. They can be very effective. They can be very well done. The only malfunction I have seen was where the simulator crashed and there was no backup set of data. Scenarios for simulator-driven exercises often include a skeleton set of data such that if there is a simulator malfunction, the exercise play can be continued. In fact, I have seen that done once or twice when the simulator malfunctioned. The malfunction was transparent to everyone outside the control room, because the controllers carried on with the hard copy data.

The only drawback I see is that the communications links in the simulator room are often not the same, e.g., telephone numbers are not the same. Therefore, communications back and forth into the plant and outside the plant have to be simulated, or they have to designate alternative phone numbers just for the exercise. They probably do not have an ENS line in the simulator. Almost invariably, they will not have the same degree of physical proximity to the technical support center and to the rest of the plant. When movement of the people from in-plant locations to the control room is required in the course of the exercise, the timing is off, because the person has to go either to the real control room and communicate with the simulator crew by telephone, or he may have to walk across

the road outside the fence to the training building where the simulator is located. This difference in timing should be considered in creating the exercise scenario.

MR. BRUNO: The aspects of training in the conduct of this annual drill or exercise -- how do you conduct an evaluation of training objectives at the same time you are conducting an evaluation of drill objectives, and put them all together in critiques? We have had a difficult time doing that kind of thing.

MR. JAMISON: I can only say that, from my position, I do not evaluate the learning objectives. As members of the NRC observation team, we often don't see those. We only see the exercise performance objectives that the licensee has put up for himself to meet.

MR. BRUNO: That is my question. How can we do training if we don't have the objectives stated that we are going to evaluate against in the scenario -- the learning objectives?

MR. JAMISON: I am not sure that I have a good answer for that question. You evaluate the performance. The performance should speak for the adequacy of the training, and you have to design the scenario such that it elicits the desired performance.

IMPROVING OPERATOR TRAINING AND PERFORMANCE THROUGH SIMULATOR OBSERVATIONS

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Abstract

This paper describes the methods and results of INPO observations of simulator training for licensed operators. It discusses the history of the observation program to the present. Effective methods for conducting and documenting simulator observations are discussed. The methods used to analyze the observations is also discussed.

The major conclusion of the analysis is that opportunities exist for improvement in the use of emergency operating procedures. Teamwork, communication, and simulator instructor skills are also areas where improvement could be made.

Improving Operator Training and Performance Through Simulator Observations

INPO has been doing simulator training observations since 1983. These observations are an integral part of our plant evaluation process. I would like to share with you some of the history of this process; the methods of conducting, documenting, and analyzing the observations; and some of the conclusions we have drawn.

History

Since 1983, we have conducted about 140 observations. We decided early on that we wanted to observe licensed operator requalification if possible so my comments apply to just that -- observation of licensed operators as they perform on the simulator during requalification. We look at licensed shift teams because they are a sample of the operators currently on shift and we assume their performance is representative.

We also realized very early that the best way to improve operator performance was to improve the quality of training. The quality of training is, therefore, our focal point during these observations.

Methodology

A typical observation team consists of the following:

- o The training evaluator. The training evaluator is the lead person. He is an experienced "trainer" with simulator training and evaluation experience.

- c The operations evaluator. The operations evaluator is an experienced operator himself.
- o The peer evaluator. The peer evaluator is a currently licensed senior reactor operator (SRO) working in an on-shift capacity, such as shift supervisor, at a plant similar to the one being observed.

With over 100 operating plants, and all of them at least slightly different, we knew that people at INPO could not possibly stay technically current on every plant. The peer evaluator is, therefore, the one who brings current technical knowledge of the specific plant to the observation team.

So, now that we have a team, what do we do next? Prior to the observation (while we are still at INPO), members of our Plan Analysis Department review emergency operating procedures from the plant to be observed. The results of this review are documented and used by the observation team in preparation for the trip.

Prior to the trip, the observation team also reviews applicable operating experience information from the plant, the exercise guides used for training on emergency operating procedures, the plant operating procedures, and the plant EOP's.

Once at the simulator, the actual observation begins. The observation is normally conducted over a two-day period and includes observations of at least two simulator training sessions, observation of related classroom training, interviews with simulator staff personnel, and review of simulator training administration. We also select some of the scenarios to be run so that we get an opportunity to really see how well the operators can use the emergency operating procedures during complex scenarios.

While the training evaluator is mostly concerned with the training process as coordinated by the simulator instructor, the operations evaluator and the SRO peer evaluator will concentrate on operator performance. The entire team looks at how closely the simulator models the plant.

It is important to note that the actual observation of training on the simulator is done by the entire team. All team members take notes and compare notes later.

Documentation

The results of the observations are then documented by the team in a written set of field notes called an observation. The observation contains relevant facts that reflect what was actually

seen and heard. In order to promote improvement in simulator training, the observations usually highlight only the problem areas.

The written observation includes the following information:

- o number of hours of simulator training observed
- o number of hours of associated classroom training observed
- o type of training, e.g., requal, upgrade, initial
- o number of control room teams observed
- o number and type of personnel on each team observed, e.g., SRO, RO, staff
- o number of instructors
- o key points observed

The written observation is mainly a listing of the problems that were observed by the observation team. At the end of the written observation, conclusions are drawn that reference the different items in the observation that led us to these conclusions.

Analysis

After the observation is written, the items in it are categorized to allow analysis. Major categories include the following:

- o technical knowledge of instructors
- o instructional skills
- o exercise guides
- o conduct of training
- o associated classroom
- o simulator fidelity
- o simulator configuration control
- o operator knowledge and skills
- o procedures
- o teamwork
- o diagnostic abilities of operators

This categorization is independently checked, differences resolved, and the results are entered into a PC data base.

Conclusions

This data base is then periodically analyzed. The major conclusions that we have drawn based on analysis of data through 1986 are as follows:

In general, simulator training is improving, but this important tool can still be used more effectively at many utilities.

Needed improvements fall into the following four categories: operator performance, instructor skills, exercise guides, and simulator fidelity. The following is a summary of activities that you need to do to make these improvements:

Operator Performance

- o Work with the operators to identify areas where they have difficulty using the emergency operating procedures (EOP). Use this information to upgrade EOP's or improve operator training as necessary.
- o Improve teamwork and diagnostic training for the control room teams.
- o Assist the operators in becoming more familiar with the emergency plan.
- o Improve communication among members of the operating crew.
- o Emphasize the need for using procedures, especially annunciator response and emergency procedures.

Instructor Skills

- o Train simulator instructors to detect and correct operator problems in the areas of teamwork and diagnostics.
- o Improve the operator critiques performed by simulator instructors.
- o Ensure that a realistic control room atmosphere is maintained in the simulator.
- o Improve instructor abilities to use simulator training features such as freeze, backtrack, and snapshot.
- o Ensure that simulator instructors fully understand plant systems and processes, procedures, policies, and administrative requirements.
- o Teach simulator instructors the proper method for conducting pre-exercise brief. They need to "set the stage" for the exercise, but should not tell the students what malfunctions to expect.

Exercise Guides

- o Upgrade exercise guides to include adequate details to assist simulator instructors, especially instructors who have relatively little previous operating or instructing experience.

Simulator Fidelity

- o Ensure that your simulators model critical functions such as two-phase flow.
- o Review your simulator configuration control process to ensure that modifications to the plant are installed in the simulator in a timely manner.

If you were to accept and implement these recommendations, your simulator training would certainly be improved. And, as a result, the bottom line -- operator performance -- would also be improved.

Discussion

MR. DEWAR: I believe our simulators are fairly well advanced in terms of evaluating individual performance, but what we are struggling with is evaluating team performance. Could you give me some indications or some of the factors you look at that are related to team performance in the simulator as opposed to individual performance?

MR. FLYNN: We try to performance base our observations. We look for problems that result in something happening that should not happen. When we see something happen that should not happen, we look back and try to determine if it resulted because of a lack of communication between the team members, or a lack of understanding of the roles team members are supposed to play. We have a good practice that deals with teamwork and diagnostics, and we are in the process of revising it. This is not an easy question, which I am sure that you realize. It is extremely difficult to set standards in these areas so that your instructors have something to focus on. Our guideline on simulator training also addresses the area of team performance.

MR. TADYCH: I got the impression from what you said that the focus is on the EOP's. Should we be looking at evaluating operating teams during more routine types of plant activities? The EOP's are a rather degraded kind of condition. Should we intend to do any evaluations during routine operations or more minor types of casualties?

MR. FLYNN: Our focus, at least for the short term, will continue to be on the use of the emergency operating procedures. The reason we are looking at those specifically is that, in our observations, we have seen a number of problems with people being able to use them. We have seen enough problems that we feel we should focus on EOP's right now. I don't know the answer to the other question -- should we be training on the other things, the non-emergency things? To train on the routine stuff in a simulator would take an awful lot of simulator time. That is something we will have to address once we have the problems with the EOP's and the useability resolved.

MR. GRANDAME: You made reference to the fact that usually you will observe two simulator sessions. What type of sessions are you observing? Are they training sessions? Testing sessions? Are you looking at the instructor's abilities?

MR. FLYNN: Right now we usually look at whatever is scheduled. We would like to look at both training and evaluation sessions. We like to get a look at a training exercise, where the instructor interfaces with the students and interjects himself into the process and trains them. We also like to see sessions where the instructor stands back a little bit and evaluates student performance. If we can get those two, that is what we much prefer.

MR. HANLEY: The operators obviously get a lot of examinations. That is, within the facility we give at least five evaluations and re-quals a year. The NRC comes in and gives evaluations and INPO comes in and observes the evaluations, which adds additional stress on the operator. What is the effect on the operator of all these examinations? Is too much positive? What is enough? Has that been looked at at all?

MR. FLYNN: We have not done any formal analysis, if that is the type of thing you are looking for. It is certainly something that we talk about every time we make any change in the program. How is this going to affect the operator? Having come from an operating background myself, I am certainly aware of what those people go through. The bottom line is that there is no way to determine the effectiveness of training unless you look at the product, and the product is operators, mechanics, whoever you are looking at. If there is a better way, I would love to hear about it. We have not been able to figure it out. You have to look at the individual and determine if he learned what he was taught.

MR. STICKNEY: The situation we are in is that we have assessments and evaluations, training and examinations. I don't think it is clear to the operators, and sometimes the trainers, just what mode we are in. The utilities use the simulator primarily as a training device. The people who come in and look at us from the

outside want to see more assessment and evaluation, and the NRC uses the simulator as an examination device. If you look at the utilities' priorities, the simulator should be used primarily for training. I think we are starting to skew to the unusual event situation a little bit too much from what routinely these people are trying to learn and practice. We need to go back to simple basics again. You have to learn to dribble before you are ready to play scrimmage. I think we need to re-evaluate and be very careful that we separate what we are trying to accomplish with each of these.

MR. FLYNN: That is very true.

MS. PALCHINSKY: It seems that you have quite a systematic process of three people going out, observing what is happening in simulator training, and you are able to make some judgments about what the problems are, using your expertise to extract the problems and list them. I wonder if you, at INPO, have any plans to go out and observe and document what is working as well?

MR. FLYNN: As part of the observation process, for simulator observations as well as any observation that is conducted during a plant evaluation, we identify what we call "good practices." If we see something during the observation that is particularly good, we do document that as a good practice. One thing I did not say was that the results of these observations are documented in the plant evaluation report, if there is a finding and also if there is a good practice. Those good practices are transmitted on NETWORK periodically. Beyond that, if we have something that falls between good practice and normal, we have that information back at INPO. If people are interested in a particular aspect of simulator training, give me a call and we can see who does that particular aspect well and get that information to you.

MR. VANDEWALLE: During your evaluations, do you also evaluate simulator fidelity? If you do, how?

MR. FLYNN: We try to evaluate simulator fidelity. It is not a very sophisticated evaluation. During the scenarios we look for the kinds of things that are supposed to happen and see if they do happen. If we have time and availability of the machine, we have a "quick and dirty" check list that we run that can identify some common problems. We do not perform a formal check. When we leave, if we don't say anything about simulator fidelity, don't construe that to mean your machine was great on fidelity, because we just don't look that closely.

SELECTION - FACTORS AND INFLUENCES ON TRAINING

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Abstract

Personnel performance is certainly the goal of training programs and the impact of personnel performance on plant performance indicators is well known. This presentation discusses the selection of personnel prior to training and emphasizes the need for selection criteria to include aptitude intelligence, mechanical ability, work ethic, and emotional stability. Selected data is presented from Point Beach that supports a rigorous selection and screening program to ensure training successfully prepared these personnel for job assignments.

Selection of personnel is one of the most, if not the most, critical aspects of management. For if selection is properly done, training will be easier, errors will be fewer, efficiency will be higher, and management problems will be lessened. At WE, we have long been an advocate of careful selection of personnel. Currently, the selection process uses two validated examinations, as well as other screening criteria in the selection process. These examinations are validated by EEI and I am sure are familiar to some of you, the POSS and MAST.

The POSS is used to select power plant operators. It has been in use since 1981. Since that time, we also engaged in a second project for power plant Maintenance workers, resulting in a test battery called MAST. The tests used for Maintenance are almost identical to those used for Operations. As I go through an explanation of the POSS battery, I will point out the similarities and differences between the POSS and MAST tests. POSS, like MAST, can be used to select personnel for nuclear, fossil, and hydro power plants.

The operators' tests (POSS) is comprised of three components: aptitude index, experience index, and personnel index. The first component is comprised of five aptitudes: reading comprehension, spatial relations, mechanical concepts, mathematical usage, and perceptual speed and accuracy. The first test in the aptitude component is a test of reading comprehension. This test measures a person's ability to read and understand the type of material found in power plant training manuals. The reading comprehension test consists of five reading passages, each followed by several multiple choice questions about the passage.

The examinee is instructed to read the passage and answer the questions by choosing among a number of multiple alternatives. This test not only measures a person's recall of specific facts presented in the material, but also evaluates a person's ability to apply a technical or scientific concept which is explained in the material. This test is very similar to the type of task a new employee encounters in training. In fact, the reading passages are actual subject content taken from power plant training manuals, including material on instrumentation, measurement, and physical and mechanical principles. This test is included in both the Operations (POSS) and Maintenance (MAST) test batteries.

The second test, spatial relations, measures the ability of an individual to visualize the proper assembled form of an object. This test has 20 problems. At the beginning of each problem is a picture showing the component of an object. Each component part is marked to show how the object is to be assembled. This is followed by five pictures showing five different ways the parts could be assembled. The examinee must determine which form the object would take if it were properly assembled.

The spatial relations test is a crucial measure of an applicant's mechanical ability, since many mechanically related tasks require individuals to follow instructions in assembling and disassembling parts of machinery, tools, etc. Spatial relations is also important for employees who must understand the inner workings of a system - to read instruments and gauges and conceptually visualize what is happening in the system. This test is used in both the POSS and MAST batteries.

The third test, called mechanical concepts, is also a measure of mechanical comprehension. This test measures the ability of an examinee to understand mechanical principles. Each item contains a pictorial description of a mechanical situation, followed by a question and three possible answers. The test is intended to measure the ability of a person to perceive and understand the relationship of physical forces and mechanical elements in practical situations. The test was constructed based on analysis of the tasks performed on the job. The pictures deal with gears, levers, pulley systems, valves, centrifugal force, water flow, gravity, pressurized air, etc. The test has 44 problems. Tests of mechanical comprehension have a long and very successful history when used for selection for manual jobs. Previous research has shown that manual workers who have a good understanding of mechanical principles have fewer accidents and are less prone to error. The mechanical concepts test is used in both the POSS and MAST batteries.

The next test, mathematical usage, measures skill in solving and manipulating mathematical relationships. There are three

sections covering formula conversion problems, algebra problems, and story problems. The mathematical usage test was developed based on an analysis of the job duties and training material. Therefore, it measures the level of mathematical aptitude required to complete training successfully and effectively function on the job. The test contains 46 multiple choice items. The maintenance battery also includes a math test.

The last test in the aptitude series is a perceptual speed and accuracy test. It measures speed and accuracy in reading tables and graphs. The first part contains a table of numbers which is used to answer 60 multiple choice items. Part 2 contains a graph which is used to answer 24 multiple choice items. This test is not used in the maintenance battery.

This series of aptitude tests measures the important abilities that are needed to perform power plant work. They measure an individual's capability to learn the technical aspects of Operations and Maintenance work. Therefore, they can be used for applicants who have previous power plant experience, and they are particularly useful in selecting among applicants who do not have prior power plant experience.

The aptitude tests focus heavily on mechanical comprehension and spatial relations. The research validation found that these abilities are the most significant requisites of successful performance for Operating and Maintenance personnel.

The next component of the POSS is the previous experience questionnaire. It contains 92 questions related to a candidate's previous experience in school, work, and recreational situations. The questionnaire covers educational achievement and previous work and recreational activities. A candidate's answers to the experience questionnaire are scored according to a number of scales that measure past patterns of overall effectiveness in areas of vocational interest, work orientation, stability, and tendencies towards potential weaknesses in coping with stress.

The third component of the POSS is called the personnel questionnaire. It consists of 139 statements requiring true or false answers. Applicants indicate whether they agree or disagree with statements that describe an opinion or personal circumstance. The personnel questionnaire measures aspects of temperament found to be related to emotional stability.

I should note that the personnel questionnaire did not statistically validate for the nuclear jobs. This is probably due to the fact that nuclear plant personnel participating in this research study were already closely screened for emotional stability. The personnel questionnaire is still administered to nuclear applicants

for the purpose of research to determine its actual effectiveness in ongoing selection. Many utilities use an additional test which is not part of the EEI battery (such as the MMPI) to measure emotional stability. There is no time limit for the experience questionnaire or the personnel questionnaire.

The Maintenance battery (MAST) also has an additional component to the aptitude tests. It is called the background and opinion questionnaire. The background and opinion questionnaire for maintenance is similar to the experience and personnel index for Operations. It measures personal characteristics which were shown to be related to effective power plant maintenance work. It is an untimed test which takes approximately 30 to 45 minutes to administer.

For both the POSS and the MAST, composite scores are calculated for each component and for the overall test battery. Thus, the tests provide a measure of ability (or aptitude), and a separate measure of adaptability. A candidate's standing on the aptitude index is interpreted as a measure of a person's mental abilities that are important to learn power plant work and to effectively function on the job.

Candidates with high aptitude scores should be expected to understand mechanical principles, comprehend written materials, use and understand mathematical relationships, and perceive details quickly and accurately.

The experience and personnel questionnaire for the plant operator battery and the background and opinion questionnaire for the maintenance battery provide an account of a person's history and personal characteristics. The scoring of these questionnaires is based upon the relevant history and personal characteristics that were found in successful power plant workers. Whereas the aptitude tests measure the ability of a candidate to learn and perform the technical aspects of the job, the experience and background questionnaires measure the personal characteristics of the candidate to determine whether the person can effectively adapt to the job demands of power plant work.

The POSS project was initiated in mid-1978 and was completed in September of 1981. The project was sponsored by the Edison Electric Institute. The research was conducted by very prominent industrial psychologists and Personnel Decisions Research Institute. A total of 70 investor-owned electric utility companies participated in the project representing fossil, nuclear, and hydro power plants.

Research information was obtained and analyzed from thousands of company officials, supervisors, and plant Operations personnel working in hundreds of plants. A battery of experimental

tests and measures of performance were collected for 3,400 operators. Statistical analyses revealed that the POSS tests significantly correlated with performance. This validity was found for all race/gender groups. Thus the POSS tests are valid for minorities and females. We obtained similar findings for the MAST. Our experience with the POSS tests has been very favorable.

WE first started to use the POSS tests at the same time we went to a new program of selecting and training entry-level operating personnel from the local community. These individuals had no knowledge or experience in a nuclear plant facility, some were right out of high school. The POSS tests identified a group of candidates who were able to successfully complete a rigorous power plant training program. We found that these candidates had exceptionally high aptitude, primarily in the area of mechanical comprehension, and they adapted well to plant work.

The purpose of all of this is to, as best we can, ensure a high probability of success in our new employees. Recently, we filled a new class of operator trainees. The process was similar to that used in the past. In all, over 700 applicants responded to local advertisements for the positions. After surveying their applications, about 150 were given POSS.

About 50 of these were scheduled for further evaluation that includes a medical examination, alcohol/drug screening, MMPI, and an assessment interview. Only about 20 of these are recommended and sent to the plant for further interviews. At the plant, the prospective employees are typically interviewed by at least three of the following:

Plant Manager	Superintendent - Operations
General Superintendent	Superintendent - Training

From these 20, the final selections are made. Our results have been good, only one employee has been released during his probationary period. Others have transferred into other job opportunities within the plant.

Similar processes are used for non-Operations candidates. Radiation control operators are selected on the basis of intelligence tests, mathematical/logical reasoning, and mechanical comprehension.

Management positions are selected using the Wexler intelligence test, and aptitude tests for supervisory performance that includes reading speed and perception, verbal reasoning, numeric reasoning, and language skills. Additional mechanical comprehension tests are given to engineers or technicians as appropriate.

As a trainer, I like to think of training as an "operator,"

in the mathematical sense, that can (in concert with supervision, job aids, motivation, etc.) produce desirable job performance on the part of the trainee.

But training and these other factors cannot function without the trainee in possession of a matrix of factors on which to work. For example:

$$[\text{TRAINING}] + [\text{SELECTION FACTORS}] = [\text{PERFORMANCE}]$$

It is the selection process that must assure that the chosen set of desirable characteristics is present so that training can fulfill its intended function.

Discussion

MR. FEDAKO: Do you take people into your Point Beach power plant as transfers from within the remainder of your electric utility? If so, how do you handle transfers?

MR. BRUNO: Almost all entry level people who come into the plant are people from the outside. We have transfers inside the power plant, from HP to maintenance jobs, for example. There have been cases of engineering and professional/management personnel moving from our corporate nuclear engineering office to the plant and from the plant to our corporate office.

MR. LONG: Have you looked for or seen any correlation between the scores and the performance in either training or on-the-job? Do the people who get the highest scores turn out to be the best students? Do you see that kind of correlation?

MR. BRUNO: We have seen the correlation between the people who did well in the screening process, from these test batteries, and the on-the-job performance. Our personnel office has looked into supervisory evaluations from on-the-job performance to make this evaluation.

MR. LONG: What cut-off score do you use for POSS and MAST? What is the bottom score for selection?

MR. BRUNO: Aptitude Index is 11; Experience Index, 10; and Personnel Index, 9.

DETERMINATION OF THE SIMULATOR NEEDS FOR THE
BELGIAN NUCLEAR POWER PLANTS

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Abstract

Belgium has seven nuclear units in operation on two sites (Doel): twin units 1 and 2: 2 x 400 MW(e) Westinghouse 2 loop, unit 3: 900 MW(e) Framatome and unit 4: 1000 MW(e) Westinghouse, both 3 loop; Tihange: units 1 and 2: 900 MW(e) Framatome, unit 3: 1000 MW(e) Westinghouse, all 3 loop, operated by two different utilities employing operators speaking different languages. The OL's for the four latter units, dated in the '80's, and the ten-yearly revision of the 3 older units' OL, require a simulator in Belgium before a certain deadline. It was decided in common to build two full-scope simulators (Doel 4 and Tihange 2), enlarged to include training on Doel 3 and Tihange 3 bunker systems, and a partial scope simulator for Doel 1-2; an existing compact simulator for Tihange 1 continues to be used for various purposes. The rationale is explained in detail.

Introduction

The availability of a full-scope simulator in Belgium before a certain deadline was made compulsory by the operating licenses of Doel 3, Tihange 2, Doel 4 and Tihange 3. On the other hand, during the ten-yearly revision of the operating licenses of Doel 1-2 and Tihange 1, the authorities requested that the operating utilities include the use of a simulator in the scope of the operating personnel training.

Hence, the problem was as follows: should a "hybrid" simulator be built for the whole of the nuclear plants, or should the principle of representativity be applied in an absolute fashion, so as to provide a full-scope, plant-specific, simulator per unit, i.e., seven simulators?

The present paper describes the results of the studies that led to the following solution:

- o Building two full-scope simulators, representing Doel 4 and Tihange 2, respectively

- o Building a partial-scope simulator, representing the Doel 1-2 units, which are quite different from the units Doel 3 or 4.
- o The use of a compact simulator, in service for a number of years at the Tihange site.

Option chosen for the 900/1000 MW(e) units (Doel 3-4, Tihange 2-3)

The operating utilities have conducted, in collaboration with the architect-engineers, an evaluation process aimed at reaching an acceptable solution to the simulator problem. This solution was studied within the framework of a coherent training plan for the various Belgian units. The line of thinking consists of building two full-scope simulators, representing one unit of Doel and one unit of Tihange, respectively, and adding the hardware and software needed to allow them to cover the peculiarities of the other unit on the same site.

The feasibility of this solution was the object of a detailed study, during which the significant differences between Doel 3 and 4 on the one hand, and between Tihange 2 and 3 on the other hand, were analyzed. This study gave rise to the following general conclusions:

- o The choice of a reference plant of the Framatome type (Tihange 2, Doel 3) and another one of the Westinghouse type (Tihange 3, Doel 4) makes it possible to cover all the peculiar functions of the Belgian plants.
- o The control room technology of the Doel and Tihange units led to the decision to build two simulators.
- o Apart from the protection system against external accidents ("bunker"), the significant differences between the units on the same site are few in number, from a training standpoint.
- o In view of the importance attributed to a specific training in the bunker functions, each simulator will be equipped with two bunker control rooms, and the appropriate software will be different.

Hence, for Doel, a bunker control room of the Doel 3 type will be added to the Doel 4 simulator. The corresponding software will make the Doel 4 systems act according to the Doel 3 bunker philosophy. For Tihange, a bunker control room of the Tihange 3 type will be added to the Tihange 2 simulator. The corresponding software will make the Tihange 2 systems act according to the Tihange bunker philosophy.

Option chosen for the Doel 1 and 2 units

Introduction. For the Doel site, the choice of unit 4 (1000 MW(e) - 3 loops) as the reference unit for the full-scope simulator certainly allows an adequate training of the Doel 3 personnel, in view of the similarity of the units 3 and 4. However, this training function is not sufficiently specific for the operators of units 1 and 2.

As a matter of fact, the Doel 1 and 2 units have not only a different number of loops (2 at Doel 1-2, versus 3 at Doel 3-4) and safety trains (2 at Doel 1-2, versus 3 at Doel 3-4), but in addition, they contain a number of peculiarities that make them a model of their own. In particular, the twin-unit character should be pointed out: a series of auxiliary systems are common to the two units, more specifically a part of the systems that are fundamental for personnel training.

It is understood that, right from the beginning, the full-scope simulator (Doel 4) will be used as much as possible. The problem is now to determine the scope of simulation of the specific Doel 1-2 simulator, i.e., the list of training items for which the Doel 4 simulator is not entirely satisfactory. The main idea was to consider that the critical training aspects are centered around the accident procedures that allow response to accident situations described in the Safety Analysis Report for the units under consideration. So, it is definitely training the operators in the use of these procedures that has to be assured. For this reason, the analysis is based mainly on the study of the accident procedures, thus leading to the definition of the scope of simulation.

Part of the training that could be done on the Doel 4 full-scope simulator. In principle this simulator can be used adequately for all maneuvers, linked directly to the normal operation modes of the unit, from cold shutdown, all primary pumps stopped, systems not vented, up to full power operation, and conversely, from this state to cold shutdown, as well as for normal operational transients and for operation at various power levels.

Certain reactions to these incident situations can also be learned usefully on the full-scope simulator, namely:

- o Class 2 incidents, and more specifically, the incident situations on the systems used in normal operation (primary system, CVCS, balance of plant), such as, e.g.:
- o isolation of the charge/discharge line
- o charge/discharge leaks

- o malfunction of the pressurizer spray or heaters
- o opening of a pressurizer relief valve
- o incidents on the balance of plant (loss of normal feedwater, total loss of load and/or turbine trip, loss of condensor vacuum, etc.)
- o all incidents linked to the instrumentation and control systems of the control rods (since the simulation of the core physics is simplified)
- o incidents linked to the nuclear instrumentation
- o loss of external electric power supplies (in detail)
- o uncontrolled boric acid dilution
- o partial loss of reactor coolant flow.
- o Certain Class 3 accidents (low frequency accidents) such as:
 - o uncontrolled extraction of one control rod at power
 - o total loss of reactor coolant flow
 - o spurious opening of a pressurizer safety valve.

Because of the peculiarities of the Doel 1 and 2 units, certain incident situations cannot be experienced adequately on the Doel 4 simulator, however. This is specifically the case for:

- o loss of compressed air
- o loss of a power supply (power or instrumentation and control)
- o cold overpressurization incidents

This is equally so for small and medium LOCA's or small and medium steam line breaks which cause the start of the safeguard systems. In addition, it appears that certain modes of normal operation can only be learned on a specific Doel 1-2 simulator. This is the case, e.g., for the operation of conditioning the shutdown cooling system during a cold shutdown maneuver. We will see further on to what extent a reasonable scope of simulation of the Doel 1-2

simulator would allow us to cover an additional number of interesting situations.

Training on the plant-specific Doel 1-2 simulator. So, the main purpose of this simulator is to train the operators in post-accident situations leading to the safety injection signal, and during which the operator has to perform a series of maneuvers that are specific to Doel 1 and 2 and that cannot be found in the other units (because of the twin-unit character, and because quite a number of medium-term maneuvers are not automatic, such as initiation of the recirculation phase). The simulator must be capable of a simulation of the post-accident phase, including the long-term recirculation phase. All the safeguard systems will equally be simulated.

It is obvious that the simulation of the AC power supplies (external and diesel generator) appears as essential, the load pick-up after accidents in particular. The primary pump seal injection function is of a particular importance from a safety point of view, especially after the small LOCA, SLB of SGTR type accidents, during which primary pump seal cooling has to be assured in order to avoid even more degraded conditions. This is not to say that the whole seal injection system has to be simulated (which can be learned on the full-scope simulator), but an "on-off" simulation of the flow may be sufficient (for the post-accident phase).

Given the essential role played by this system, it appears preferable to simulate it completely for Doel 1-2, rather than trying to limit it to a few particular functions. The situation of the shutdown cooling system (SC) is similar to that of the chemical and volume control system (CV). For the same reason, the whole of the system's functions will be simulated for Doel 1-2. This will offer the advantage of allowing training in normal operation modes of the SC system (conditioning at temperature and pressure - residual heat removal) that are peculiar for Doel 1 and 2, and that are of prime importance for correct operation during the startup and shutdown phases of the units. In these operational modes, the CV system equally plays a far from negligible role (pressurization of the SC system - primary pressure control under solid conditions).

The simulation of the safeguard systems, complemented by that of the whole of the SC and CV systems, allows covering, in addition to the previously mentioned accidents:

- o the small break LOCA
- o the small SLB (scope of BOP simulation to be defined)
- o the loss of compressed air ("on-off" simulation of the distribution network, with simulation of the consequences on other operational systems)

- o the conditioning of the reactor coolant system (RC) during the cold shutdown maneuver.

Option chosen for the Tihange 1 unit

For a number of years, the Tihange site has had a so-called "compact" simulator; its control room is limited to a console combined with a vertical synoptic panel. The number of systems simulated is rather small, but this simulator compares favorably with the larger ones because of numerous important characteristics:

- o numerical technology, with real time response
- o use of physics formulation
- o use of an instructor's control desk (causation of breakdowns, role of the auxiliary operator)
- o initialization
- o possibility of freezing the parameter evolution
- o accelerated and slow-motion modes
- o restitution of a sequence
- o resumption of an exercise at a given point.

The "compact" simulator does not represent a fictitious plant, but definitely an existing unit (Surry 1, in the USA) for which the supplier (EAI) built a full-scope simulator that functions to the satisfaction of the operating utility. It has been subjected to a number of modifications in order to increase the similarity with the Tihange 1 unit.

Since it does not represent a complete unit, especially due to the absence of certain functions, and the non-existence of a control room, a simulator of this type mainly serves for:

- o the basic training of new operators, including staff, either as a complement to basic training courses, or as a demonstration of general operating procedures
- o the demonstration, for all personnel, of the functioning of a PWR unit; this aims at a better integration of all persons in the actual plant
- o preparing the operators for full-scope simulator sessions, by studying the essential functions in a

sufficiently thorough fashion so as to improve the benefits from the full-scope simulator courses

- o retraining the operators, in support of basic courses, in general normal and accident procedures, and by studying particular operating modes.

Because of the similarities between units 1 and 2, the choice of unit 2 as the reference unit for the full-scope

Determination of the Simulator Needs
for the Belgian Nuclear Power Plants

Characteristic Simulator Data

	DOEL 4	TIHANGE 2	DOEL 1-2
Totally simulated systems	58	53	17
Partially simulated systems	25	22	7
Represented systems	28	22	--
Non-simulated systems	24	46	2
Specific incidents simulated	331	420	162
Generic incidents (nr of categories)	10	10	10
Initial conditions	26*	26	20*
Digital inputs	5887	5700	1421
Digital outputs	16640	10800	3894
Analog inputs	0	6	38
Analog outputs	2522	2000	648
Computer	4 x GOULD 32/67	4 x GOULD 32/67	2 x GOULD 32/67
Spare capacity	20%	20%	20%

*contractual (will be extended during operation)

makes it possible to perform a major part of the unit 1 operators' training on it. A more refined analysis of the differences has identified a certain number of characteristics which require either an adaptation of the full-scope simulator, or an extension of the "compact" simulator's capabilities. The Tihange unit 1 operators' training program will include the use of the compact simulator and a preliminary training before the full-scope simulator sessions, and will be complemented by a controlled program on the full-scope simulator.

Planning

The contracts for these simulators were signed in February 1985, and the starting dates of operational use are spread over the year 1988. At present, December 1986, the control room panels of the Doel 3-04 simulator are already at the supplier's workshops; the building site was opened in August 1986. The request for a building permit for the Tihange site was filed very recently. The modelling studies are advancing satisfactorily.

Discussion

MR. BOHANNON: I noted that you stated that the simulator would have post-accident phase capabilities. Does this include uncovering the core and any slight damage to the core?

MR. CANART: Yes, indeed. We are going to have a simplified model for the core. It is only a one-point model for the neutron activity of the core.

EVALUATING PERFORMANCE MEASURES
TO DETERMINE TRAINING EFFECTIVENESS

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Abstract

This study responded to the Utility Industry's need to relate training benefits with corporate objectives -- generating megawatts safely and efficiently. Trained and non-trained employees from nuclear and fossil generating stations were rated by their supervisors on six performance skills themes. Results favored the trained group in all cases. Summary statistics and additional variables were discussed.

Background

The relationship between training and performance has long been an issue that has defied objective research (Reference 1). Commonwealth Edison Company (CECo), as well as other utilities, have a need to know "how" to relate training benefits with the overall corporate mission: generating megawatts efficiently and safely.

An article in the February 1987 issue of the "Training and Development Journal" best expressed the changing role of trainers. This article states, "... that instead of training and developing others in the time-honored way, many more of you will be involved in managing training better, accounting for it better, and finding ways to do it better. You will, in short, be doing work that supports and advances a critical business function" (Reference 2).

This research was conceived and dedicated to helping the CECo training organization become a more integral part of the corporate business. It was hoped that the process of doing this research would heighten the awareness of management and trainers to the fact that the training function does, and will continue to, improve employee performance, and contribute in a significant way to overall corporate objectives.

Methodology

The target population for this study was nuclear and fossil generating station employees who directly impacted the production of electricity. The target sample (n=150) included: instrument, mechanical, and electrical maintenance personnel; control room

operators; engineers, radiation chemists, and other technical specialists; and equipment operators and attendants. Training records from each participating station were used to identify employees who received more task-specific training than their counterparts. The quantity of training received was the criterion used to form the "trained" and "non-trained" research groups. Specifically, "non-trained" employees completed less than 50% of required courses, and "trained" employees completed 80-100% of required courses. This method excluded the "annual-type" training courses.

Data collection was conducted at each participating generating station. Two methods were used to select participants. First, convenience sampling which included all available personnel. These subjects were asked by their supervisors to complete the survey instruments. Subjects were randomly selected from the convenience sample, and then assigned to either trained or non-trained research groups based on training records. Second, specific sampling which included participants identified by the researchers through training records. These subjects were randomly selected from training records prior to data collection.

All participants were asked to complete a series of three questionnaires. The immediate supervisor of each participant was asked to rate their subordinate using the performance skills instrument. Instruments relating to each participant, those completed by the employee and their respective supervisor, were stapled together to form a packet. Each packet was coded either "trained group," or "non-trained group." All names and identifying markings were removed from these packets to maintain anonymity.

Throughout this project, only the researchers knew the group status of each participant. Selection biases (Reference 3), Hawthorne and "halo" effects (Reference 4), and other threats to internal validity (Reference 5) were minimized by the randomized, single-blind, selection process (Reference 6).

Instrumentation

A total of four instruments were utilized by this study. Three instruments were administered to the generating station personnel. These instruments will be highlighted more specifically in a follow-up study of employee learning profiles. These included a demographic form, a learning style profile, and a motivational style profile. The focal instrument, a performance skills rating form, was administered to supervisory personnel. This instrument was designed to elicit supervisory performance ratings for each participant.

The demographic questionnaire included age categories, gender, current and past job classifications, and years spent in

current and past job classifications.

The learning style profile (Reference 7) was designed as a self-analysis tool for identifying four basic styles through which the mind receives and processes cognitive information. These styles are Concrete Random (CR), Concrete Sequential (CS), Abstract Random (AR), and Abstract Sequential (AS). Each style is characterized by learning, environmental, and interactional preferences for the learner (see Table I). Learning Style preferences among generating station personnel may provide valuable insights for training departments. Internal consistency coefficients (Reference 8) ranged from 0.89 to 0.92 for each learning style. Test-retest coefficients ranged from 0.85 to 0.88 for each learning style. Construct validity coefficients ranged from 0.55 to 0.76.

TABLE I: LEARNING STYLE THEMES

<u>Style</u>	<u>Environment</u>	<u>Relationship to Instructor</u>	<u>Relationship to Student</u>
(CS)	low tolerance for distraction	traditional subordinate	ordered
(AR)	high tolerance	"guide" role	collegial
(AS)	low tolerance	expert	minimal
(CR)	stimulus-rich	instruction "guide" role	varied

The motivating traits instrument (Reference 9) was designed to identify motivational preferences. Each item represents a different motivating need-state (Reference 10). Internal consistency coefficients for each of three motivational clusters ranged from 0.61 to 0.74 (see Table II). Cluster one represented self-esteem needs coupled with affiliative and self-protective needs. Cluster two represented job security and orderliness needs. Cluster three represented ambition and creativity needs coupled with respect for authority and regulations.

TABLE II: MOTIVATIONAL THEMES RELIABILITY COEFFICIENTS

<u>Theme</u>	<u>Coefficient Alpha</u>
Factor One	0.7420
Factor Two	0.7063
Factor Three	0.6176

The performance skills questionnaire was designed to elicit performance ratings of plant personnel from their immediate supervisors. Six performance skills themes were identified by subject matter experts from the generating stations, Program Development, and literature review (Reference 11). These performance themes are:

- o concentration and awareness of hazards
- o handling stress and pressure in job tasks
- o experience and background skills
- o resourcefulness and problem-solving approaches to job-related tasks
- o responsibility for equipment and procedures
- o manual dexterity.

Five items were written for each performance theme. The items were written to provide a difficulty range for each performance theme. For example, item #1 was the simplest skill for the category; item #5 was the most difficult skill for the category. A one (low)-to-ten (high) Likert scale was chosen to rate each item. The one-to-ten scale conforms to traditional, "base ten" rating norms, and counteracts any response biases from the customary one-to-five scale used by the company.

Internal consistency coefficients ranged from 0.93 to 0.97 for each performance theme (see Table III). These high reliability estimates also support content validity issues. That is, the items appear to be interpreted alike by both subject-matter experts designing the instrument and station supervisors utilizing the instrument. The internal consistency coefficient for the total instrument was 0.74. This indicates that separate subscores representing each of the six performance themes is more appropriate than an overall, total score.

TABLE III: PERFORMANCE SKILLS RELIABILITY COEFFICIENTS

<u>Theme</u>	<u>Coefficient Alpha</u>
Concentration/Hazards	0.9353
Stress/Pressure	0.9455
Experience/Background	0.9654
Resourcefulness/Problem Solving	0.9442
Responsibility for Equipment, etc.	0.9587
Manual Dexterity	0.9688

Data Analysis

Data Analysis consisted of three major parts. Part one established internal consistency through Cronbach alpha statistics (Reference 12). Factor analysis of the Performance Skills and Motivational Traits instruments were used to establish fewer, manageable, item clusters. These item clusters were interpreted and named according to the underlying thematic content. Principal components extraction with varimax rotation was used for these analyses (Reference 13). Factors with eigen-values greater than 1.00 were retained. Part two provides summary statistics and breakdown tables for important variables. Part three provides inferential statistics responding to the research questions. Discriminant analysis (Reference 14) determined differences in predictor variables between employees classified by the criterion variable.

Factor analysis (Reference 15) was performed on the Performance Skills instrument. The results indicated a one-factor instrument: Factor 1 (eigen-value - 22.16), Factor 2 (eigen-value - 1.34). The one-factor solution was discarded for two reasons. First, factor analysis was more sensitive to global ratings from supervisors. Supervisors were suspected of applying a global image of each participant toward the instrument. The one-factor solution represents the one-factor rating system applied by the respondents. Second, the reliability analysis demonstrated that all six performance skills themes were appropriate to use as separate measures.

The Motivational Profile was subjected to data reduction using principal-components factor analysis with varimax rotation. A three-factor solution was retained for interpretation. Factor one (eigen-value - 3.63) represented self-esteem needs coupled with affiliative and self-protective needs. Factor two (eigen-value - 2.58) represented job security and orderliness needs. Factor three (eigen-value - 1.96) represented ambition and creativity needs coupled with respect for authority and regulations.

A variety of descriptive statistics were calculated for the overall sample, "trained" group, and "non-trained" group. Important variables and statistics will be highlighted.

Of the 150 participants, 76 represented the "trained" group, and 74 represented the "non-trained" group. Males comprised 98% of the participants. Job Classifications were summarized as follows: maintenance (52%), operators (8%), EO/EA (11%), health physicist (2%), all others (17%), and missing (10%). The average value for Years in Current Job was 5.1 years. The predominant learning style was Concrete Sequential (74%).

The following statistics were computed for the "trained" status group. The average age-range was 30-39 years old (35%). The

average value for Years in Current Job was 5.7 years. The average score on the Performance Skills form was 210 out of 300 possible points.

The following statistics were computed for the "non-trained" status group. The average age-range was 30-39 years-old (50%). The average value for Years in Current Job was 4.6 years. The average score on the Performance Skills form was 165 out of 300 possible points.

A stepwise discriminant analysis program (Reference 16) was computed to detect differences between the "trained" and "non-trained" groups from among the six Performance Skills variables. The Performance Skills variables must meet or exceed a significance level of 0.05 (alpha = 0.05) to qualify as discriminating variables. A test for the appropriateness of multivariate normality was demonstrated by Box's M statistic (Reference 17). The value for M was 2.3120, and not significant indicating that the discriminant analysis was appropriate given these data.

All six Performance Skills variables discriminated significantly between the "trained" and "non-trained" groups (p less than .001). In all cases, the mean value for the "trained" group exceeded the mean value for the "non-trained" group. A classification program was performed to predict one's group membership (trained versus non-trained) given the raw scores from all six Performance Skills themes. Training group status was correctly predicted in 78% of the cases. Non-training group status was correctly predicted in 72% of the cases. (Correct predictions of 50% would be expected by random guessing, or chance.)

Specific results for each Performance Skills Theme are shown in Table IV. The results are expressed in percentages for group averages and group difference scores.

TABLE IV: PERFORMANCE SKILLS PERCENTILES AND SUMMARY			
<u>Performance Skills</u>	<u>Non-trained</u>	<u>Trained</u>	<u>Percentage Increase</u>
1. Aware/Hazards	56.6	72.8	16.2%
2. Stress/Pressures	53.8	67.2	13.4%
3. Experience	57.0	72.6	15.6%
4. Problem-solving	53.6	67.6	14.0%
5. Responsibility	55.0	69.4	14.4%
6. Manual Dexterity	54.4	70.4	16.0%
Overall	55.1	70.0	14.9%
Median Age Level	35.0	35.0	
Years in Current Job	4.6	5.7	

Summary

Implications for further research indicate that training does have a quantifiable affect on job performance. The following questions -- "Were the results consistent with expectations?"; "Is there enough improvement?"; and, "How much are we saving, or are we spending too much?" -- can only be answered in the context of this study.

Expectations were optimistic, that is, we expected positive results from our training. How much? That was not an issue given the newness of our "performance-based" training efforts over the past two-and-one-half years. To better understand the questions of expectation and adequate improvement one has to know where the standard, or baseline exists. We now know where CECO's baseline exists, and subsequent improvement or effectiveness measures may be developed from this point.

The question of "bottom-line" dollars is an implication that builds upon the results of this research. The next step, or phase two of the project, is to incorporate these data and methodology into research designed to correlate human performance (as impacted by training) with plant performance. The corresponding correlations should yield bottom-line data regarding cost-effectiveness and training programs.

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Discussion

MR. LONG: You mentioned that the trained group had a greater experience than the untrained group, by an average of a year more in their current jobs. How can you be sure that the difference in test results are not attributable to that extra year's experience rather than the training?

MR. FEIZA: We looked at two job classifications -- the current job position and the past job position. It is quite possible that a trainee could have spent 15 years as a B man before having moved to an A man level, where he spent five years. So he may have a lot more experience than meets the eye at first glance.

This is one way to look at that situation. The second is that training involves time, so it is no small wonder that one would need to spend more time in the current job to gain those credits or those numbers of courses. Again, from the very beginning, we looked at quantity of training, so we expected there would be an increase in time and numbers of courses in favor of the trained group.

To answer your question more directly, you could look at the non-trained personnel a year from now, when they would have the extra year's experience, and see if they had attained the same performance level or had met the same increase as did their trained counterparts.

MR. DEWAR: What determined whether people ended up in the trained or non-trained group? Is there some performance measure that was used to put them in the trained group to begin with.

MR. FEIZA: Actually we are looking at two dimensions here.

One is the group membership, trained or non-trained. The second is that we look at the performance measures. For the first, we merely had to identify whether the person had training or not, what kind, the quantity of courses completed and the discipline. Then, after that definition step, we looked at performance measures and said, okay, if you are in this group you are trained, if you are in that group you are not trained.

MR. DE VREY: You said that the non-trained completed less than 50% of the required courses. Did they fail to complete the same courses?

MR. FEIZA: Yes, that is correct. The training matrix would list trainees in rows, and in the columns would be the required courses. We purposely excluded the annual re-qualification or re-training courses, like nuclear fundamentals or fire brigade or things like that. We focused on the core curriculum that trainees would be involved in. Yes, those are the same courses for both groups.

MS. PALCHINSKY: Did you, in your performance skills form, ask the supervisors to rate or evaluate the non-trained individuals on skills for which they had not yet been trained?

MR. FEIZA: No, the form was generic enough to merely look at the very basic, generic job descriptors -- writing ability, background skills, perfectionism, accuracy, attention to detail and so on. It was very generic and could apply to a non-trained employee -- even a general college student.

A MODEL FOR BEHAVIOR OBSERVATION TRAINING PROGRAMS

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Abstract

Continued behavior observation is mandated by ANSI/ANS 3.3. This paper presents a model for behavior observation training that is in accordance with this standard and the recommendations contained in U.S. NRC publications. The model includes seventeen major topics or activities. Ten of these are discussed: Pretesting of supervisor's knowledge of behavior observation requirements, explanation of the goals of behavior observation programs, why behavior observation training programs are needed (legal and psychological issues), early indicators of emotional instability, use of videotaped interviews to demonstrate significant psychopathology, practice recording behaviors, what to do when unusual behaviors are observed, supervisor rationalizations for noncompliance, when to be especially vigilant, and prevention of emotional instability.

Behavior (or behavioral) observation programs are mandated for all nuclear power plants in the U. S. by ANSI/ANS 3.3 (1982) (Reference 1) section 5.4.5.6.f. which states:

"Continued Observation. A continued observation program shall be established and administered by or under the direction of owner organization. Supervisory personnel instructed to recognize unusual behavior shall observe employees for performance of job-related duties, attendance, and attitude toward work and fellow employees. When unusual behavior of a person granted unescorted access is observed, it shall be reported to plant management for evaluation and appropriate action. Supervisory personnel responsible for providing of continued observation may be employed by the owner organization or by a contract or vendor organization.

For several years, Behaviordyne has conducted behavior observation training and has consulted to companies which have elected to conduct their own training. Two documents available through the U.S. Nuclear Regulatory Commission have been particularly valuable in the design of the training we provide or recommend: Nuclear Reliability Program for the Nuclear Industry (Reference 2) and Standard Format and Content Guide for Access Authorization Plans for Nuclear Power Plants (reference 3). We have found the following topics and activities important to include as part of the training:

- 1 Pretesting of supervisors' knowledge of behavior observation requirements and of signs of emotional instability
- 2 Presentation and explanation of the goals of behavior observation programs in general
- 3 Presentation and explanation of the goals of the training program
- 4 Explanation of how the training goals will be achieved
- 5 Why behavior observation training programs are needed: legal and psychological issues
- 6 What kinds of problems might be caused by an emotionally unstable person
- 7 Empirical data: problems that have been caused by emotionally unstable persons
- 8 What is meant by "emotional instability"
- 9 What are early indicators of emotional instability that a supervisor might be able to observe
- 10 What do very unstable people look like
- 11 Practice in observing and recording behaviors that reflect emotional instability
- 12 What to do when evidence of possible instability is observed
- 13 Common excuses given by supervisors for not intervening when there is evidence to suggest the presence of emotional instability
- 14 When to be especially vigilant for signs of emotional instability
- 15 What the supervisor can do to prevent adverse psychological reactions in employees
- 16 Posttesting
- 17 Evaluation of training

Some of these topics and activities merit special comment in this paper. Pretesting (Item 1) serves to demonstrate to supervisors what kinds of information they do not have that they may need. It can serve to motivate closer attention to the training and can be an indicator to the trainers of topics that may need to be emphasized. And, when compared to posttesting, it can serve as a training evaluation instrument.

Regarding the goals of behavior observation programs (Item 2), it is important to emphasize that a primary goal is to detect any emotional instability, including a change in ability to make good judgments, before there is any significant decrement in job performance. Supervisors are likely to be more familiar with the personnel department dictum that states that no disciplinary action (such as suspension or mandatory referral to an employee assistance program) can be taken until there is documented decrement in job performance. Behavior observation programs are not punitive in intent or action and, as a result, are not subject to this dictum. Behavior observation programs exist because decrements in performance in nuclear settings are potentially so costly that they must be prevented, not simply rectified.

Behavior observation programs are needed (Item 5) not simply because they are mandated but because they make good sense from a psychological point of view. A person's mental health varies over time. The initial psychological screening for emotional instability, which is conducted via testing and interviewing and which occurs at most nuclear plants prior to the granting of unescorted access, merely establishes an acceptable baseline for each employee. The screening cannot guarantee that each employee will continue to function at the level observed during this initial screening. Indeed, empirical data regarding the onset and natural history of psychopathology clearly indicates that a small, but not insignificant, number of employees will deteriorate from this observed level. Behavior observation programs provide the only practical means for detecting such deterioration so that appropriate action can be taken to prevent adverse consequences.

Supervisors need to be taught which specific behaviors are associated with emotional instability (Item 9). Given the relatively low rate of occurrence of emotional instability, many supervisors never will have had prior opportunity to observe the first signs of deteriorating functioning and will, as a consequence, have little or no knowledge of them. The problem is complicated further by the fact that substance abuse is the most likely cause of emotional instability in the workplace. Many of the substances currently being abused by younger employees have never been experienced, directly or indirectly, by their older supervisors. Even the astute supervisor who knows the signs of masked alcohol abuse is likely to be totally oblivious to those of cocaine dependence -- unless he or she receives specific training.

Showing supervisors videotapes of persons manifesting severe psychological disturbance (Item 10) may seem to be unnecessary or ill advised given the NRC's admonition that diagnosis is to be left to qualified personnel and that the behavior observation training is not intended to turn supervisors into clinicians. However, it is our belief that showing these videotapes is of considerable value, value that can be realized without misleading supervisors regarding their proper role in the behavior observation process. The tapes serve to validate the very existence of behavior observation programs. Supervisors often are unaware that formerly high functioning persons are subject to such severe pathology, severe pathology with obvious potential for substantial negative impact on job performance and the safety of a nuclear plant. Observing severe psychopathology also helps supervisors to understand why certain observable signs are important because they can observe their relationship to specific disorders. The disorders that we have chosen to illustrate via videotape are alcohol abuse, depression, mania, and dementia. These appear to be the most likely problems to occur once an employee has passed the initial psychological screening. While viewing the videotapes, the supervisors are asked to use NRC-generated checklists to see which behaviors they can identify that may have been early indicators of the onset of severe disorder (Item 11).

Supervisors have told us consistently that behavior observation training needs to be highly practical in its orientation. As a result, the training needs to be site-specific. Supervisors want to know exactly what to do when they observe behavior change that may be indicative of emotional instability (Item 12). They want to know whom to call and what that person will do. A flow chart listing names and telephone extensions of persons to contact, along with indications of what actions will occur as a function of various possible findings, seems to help considerably to satisfy this desire for practicality. Supervisors favor flow charts with a minimum of administrative layers: They prefer to speak directly with the person who will handle their employees. Supervisors also need instruction regarding how to confront the employee who is manifesting problem behaviors. We encourage them to:

- o schedule a private interview
- o begin the interview by providing clear structure (indicating that the supervisor wants to be able to state his/her observations in entirety before the employee responds and that the employee will, in turn, be given ample opportunity to speak)
- o be specific regarding what has been observed, what action will be taken by the supervisor, and what action is expected of the employee
- o avoid argument, threat, irrelevancies, moralizing, and diagnosing

Supervisors often are reluctant participants in behavior observation programs (Item 13). Their reservations need to be addressed before compliance with the program will become likely. Examples of statements of reservation that we hear most commonly are: "The employee is my friend." "I don't want to punish someone who already has enough problems." "I don't want her to lose her job." "Time will correct the problem." "They may be a little odd, but they aren't really dangerous. I've never heard of emotional instability causing any problems at nuclear plants." "I can't confront them when they know I have problems of my own." "The psychologist said he was okay when he was screened six months ago." "Nothing would help them anyway. Shrinks are quacks." "They'd never be able to afford to get help."

The trainer needs to be prepared with responses to these statements. For example, it is helpful to remind supervisors that friends help friends, they do not ignore their problems. Behavior observation programs are not punitive in orientation. The company's emphasis will be on rehabilitation, not on dismissal. Although some problems get better with the passage of time, most get worse. Furthermore, even with problems that do improve with time, much damage can be done before the improvement occurs. Nuclear plants have had problems. It is not possible to know how many of these were caused wholly or partially by emotional instability. Emotional instability can lead to unintentional errors, "honest mistakes." Sabotage is not the only concern. True, everyone has some problem or another, but some kinds of problems pose risks to a nuclear plant while others do not. It is important to make a referral to someone who can distinguish between the two kinds. Initial psychological screening only establishes an acceptable baseline. A person's psychological health can change substantially in as little as six months. Psychological treatment is not always effective, but many problems have a very favorable prognosis if appropriate treatment is received promptly. Most health insurance policies provide at least some mental health coverage. Low-fee clinics exist in most areas. Cost does not need to be a barrier to adequate treatment. Mental health services are not reserved for the wealthy.

Supervisors have many priorities other than their role in behavior observation. They cannot be optimally vigilant at all times. As a result, it is helpful for them to know when to increase their vigilance (Item 14). They should increase their vigilance when a specific employee is known to be experiencing significant stressors in his/her life. It is helpful to give supervisors lists of common significant stressors. When reviewing these lists, supervisors often are surprised to discover that pleasant events can be as stressful as unpleasant ones (Reference 4), and that the impact of many small stressors can sum to equal that of a single, large stressor (Reference 5).

The most successful behavior observation programs seek to prevent emotional instability -- not just detect it (Item 15). Supervisors can have a very positive influence upon the mental health of their employees. They can titrate demands, recognizing that understimulation can be as burdensome as overstimulation. They can encourage employees to be realistic in the goals that they set for themselves. They can focus more on successes than on failures, on good efforts more than on good outcomes. They can delegate effectively and help their employees to do to the same. And, they can set a good example by taking time for recreation and for friends.

The scope of the behavior observation program that we have described may seem overly ambitious. But, it has been our experience that everything that we have described is essential and can be covered adequately in as little as eight hours, preferably in two four-hour sessions on successive days. The pace necessarily is fast, but this helps to keep supervisors from feeling that their time has been wasted. Feeling that their time has been well spent may be the best single contributor to a positive response to the entire behavior observation program.

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Discussion

MR. SWAM: One of the things you did not address was how you felt about recurring training for supervisors in behavior observation.

DR. BERGHAUSEN: Does a training course like this have to be repeated? I think it does. The problem is so much the fact that these are very low frequency occurrences and the lower the frequency of occurrence that you want somebody to be able to deal with, the more often the program should be repeated. Ultimately there must be a compromise. I don't think that most companies would be willing to devote the time necessary to keep behavior observation skills at an optimum level. In other words, to be able to keep the supervisor capable of getting the same kind of score on post-testing of plus or minus five percentage points, to be able to get that over the course of a year, day in and day out, probably would require booster training perhaps quarterly. What I am saying is that quarterly training may be necessary to keep things at an optimal level. But I think that probably is unrealistic. At a more realistic level, annual or biennial (every other year) booster training is probably what is more reasonable.

MR. BOHANON: Do you feel that simulator evaluations could possibly be used to impose certain structured stress on the operator and, in turn, obtain observations in terms of behavior under high stress conditions?

DR. BERGHAUSEN: Yes, and I think that is an excellent idea. The closer the behavioral observation can be related to stressful work times, the better indication you have of the person's overall function. If simulator training is a high stress time, if problems are going to develop, they are more likely to show there.

MR. HYMAN: If the intent of the program is not to be punitive in nature, but it is being performed by the same supervisors who evaluate these people, how do you train the supervisors to separate their behavioral observations from their performance appraisals of the same employee?

DR. BERGHAUSEN: I don't know whether we do that adequately. That is certainly a concern. But our hope is that the dimensions that are being checked off on the checklist that we present are dimensions that are quite different from the dimensions that are being rated as far as on-the-job performance goes. The goal of a program like this is to make these observations before there is a decrement in job performance and I think that that further separates the relationship between what is observed in terms of behavioral change, and what the job performance evaluation is going to be like.

I am not sure that our attempts to foster this separation are totally adequate, but they are a step in the right direction.

I did not get a question with regard to empirical data. We don't have a lot at this point, but there is some forthcoming. I am going to be chairing a paper session at the upcoming meeting of the American Nuclear Society. The session is on the topic of "issues in emotional stability screening." There are three papers that are coming out of TVA that are all excellent. One or two of them will deal with the issue of frequencies with which behavior observation has detected problems, how many people have needed to have their unescorted access privilege revoked, and what kinds of problems provoked the revocation.

Finally, I would invite any comments about experiences with behavioral observation programs here, at future meetings, or in correspondence.

CHAIRMAN'S REMARKS

Dr. M. Gomolinski
France

The main part of this session was devoted to evaluation of training programs. It is interesting to note use of several methods.

Virginia Power has developed a check operator program that utilizes highly qualified licensed personnel to independently evaluate the performance of licensed operators and senior operators during normal, abnormal and simulated emergency conditions.

In France, the operating experience has shown some connections between human errors during incidents and lack of training. Conversely, improvements in the training programs are resulting from operating feedback.

Pacific Northwest Laboratory uses large scale reactor emergency drills and exercises to identify weaknesses in personnel performance and emergency preparedness programs. But, success in using that observation to implement training to improve performance varies greatly from one facility to another.

INPO uses observations of simulator training for licensed operators. The major conclusion of these observations is that opportunities exist for improvement in the use of emergency operating procedures. Teamwork, communication and simulator instructor skills are also areas where improvements could be made.

In the same scope, mention can be made of the Commonwealth Edison presentation of trained and non-trained employees on the same six performance skills themes. Results favored the trained group in all cases.

Selection of personnel: Wisconsin Electric Power emphasized the need of selection criteria to include aptitude intelligence, mechanical ability, work ethic and emotional stability. Selected data has been presented from Point Beach that support a vigorous selection and screening program to ensure training successfully prepares the personnel for job assignments.

Behaviordyne Psychological Company presented a model for behavior observation training program, for managers and supervisors, to learn to select and respond appropriately to changes in on-the-job performance and judgment before there is any substantial overall decrease in job performance.

In the Belgium presentation, the evaluation concerns in fact the determination of the simulator needs which are at the origin of the decision to build two full scope and one partial scope simulators.

SESSION 6:

DIAGNOSTICS AND TEAM TRAINING TECHNIQUES

CHAIRMAN: Mr. M. Hada

AN APPROACH TO TEAM SKILLS TRAINING

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Abstract

The U. S. commercial nuclear power industry has recognized the importance of team skills in control room operation. The desire to combine training of team interaction skills, like communications, with technical knowledge of reactor operations requires a unique approach to training.

An NRC-sponsored study identified a five-phase approach to team skills training designed to be consistent with the systems approach to training currently endorsed by the NRC Policy Statement on Training and Qualification.

This paper describes an approach to team skills training with emphasis on the nuclear power plant control room crew.

An Approach to Team Skills Training

The ability of team members to coordinate their actions to achieve task objectives involves team interactions such as information exchange among team members, group problem solving, and giving and receiving task assignments. Such team interactions are especially critical to effective team performance under conditions requiring a great deal of interdependence among team members and during unpredictable situations such as abnormal or emergency events in the nuclear power plant (NPP) control room. This paper describes an approach for designing, conducting, and evaluating team skills training for nuclear power plant control room crews. This approach to team skills training, identified as a result of an NRC-sponsored study, is designed to be consistent with the systems approach to training currently endorsed by the NRC. A systems approach to training, as currently implemented by the military and by U.S. utilities, involves the deliberate, orderly process of analysis, design, and development of performance-based training programs and their systematic implementation, evaluation, and revision to ensure continued effectiveness.

Background

The commercial aviation industry has successfully integrated team skills training into cockpit crew training. The aviation industry has recognized that breakdowns in cockpit crew performance have contributed to airplane accidents. Technical as well as team skills are provided in training that focuses on interpersonal communications with high fidelity flight task simulations. Although recognized by the military and aerospace industry as an important component of training, team training is still the focus of research and development to improve understanding and application of team skills.

Team Skills

Both team skills and technical skills are used by the control room team of shift supervisor (SS), senior reactor operator (SRO), reactor operator (RO), and shift technical advisor (STA) in the U.S. control room. The control room team is often supported by auxiliary operators, chemistry and instrumentation and control technicians and others.

Team skills are the interactions among team members that are required to successfully complete a team task. Trainers and researchers describe two levels of team skills: generic and operational team skills. Generic team skills may be exhibited in all types of team tasks. These are whole sets of techniques or strategies for achieving effective team interactions. Five generic team skills have been identified by team training researchers and practitioners: effective communication, feedback, effective influence, conflict resolution, and leadership.

Effective communication is critical to team task interactions since all team skills rely on communication. Effective communication involves strategies for informing, directing, asking, answering, receiving, and authorizing.

Feedback is important in helping team members determine the appropriateness and effectiveness of their actions. Feedback is especially important in rapidly changing task conditions where direct equipment or instrument response information is not available to all members of the team. Performance feedback or critique is important for verification of the actions of individual team members.

Effective influence refers to the skills of individual team members in expressing their views to other team members or persuading them that a certain action should be taken. It involves asking the questions needed to get additional information as well as assertiveness in stating or defending a position (i.e., inquiry and advocacy). In the control room, effective influence is important in

situations involving joint decision making and problem solving which are aided by team members who can effectively ask questions, obtain additional information, and state their opinions.

Conflict resolution is an important generic team skill which involves techniques for addressing and resolving conflicts. Skilled conflict resolution focuses on the problem and achieves a solution acceptable to everyone.

Leadership skills, which are especially important for control room supervisory personnel, involve achieving the proper balance between concern for team members and concern for task performance. Management styles need to be adaptable to different task conditions and team members.

Besides these generic team skills which are needed for effective team performance, operational team skills focus on the interactions that take place between team members performing specific tasks. Operational team skills are situation-specific interaction requirements involving information exchange, information evaluation, task assignment, performance direction, performance feedback, coordination, strategy development, problem solving, and decision making in the context of control room operations. Operational team skills are identifiable using task analysis information for specific team skills.

Approach for Team Training

The NRC developed and published a sample approach to team training that incorporates the already-mentioned information about generic and operational team skills with a systems approach to training which is used to train technical knowledge, skills, and abilities (KSA's). This approach provides team members with generic team skills and involves specific practice or applied training that transfers these skills to the control room application.

United Airlines has implemented a similar approach in their cockpit crew training where crews have the opportunity, following classroom training, to apply their skills in practicing realistic team tasks. This basic training is offered once to each cockpit crew member with subsequent refresher training. Research has shown that generic team skills training alone is not sufficient to ensure transfer of these skills to the task-specific operational context (Campbell and Dunnette, 1968).

To design and implement a systematic team training program, team skill objectives must be identified for training at both the generic and operational team skill levels. These objectives must then be used to design and implement basic generic team skills training in the form of familiarization and practice training. The basic team skills training program should be designed to:

- o focus on transferring generic team skills to operational team skills applications;
- o include all members of the control room team;
- o integrate self-study, classroom presentation, and role playing or practice exercises.

Next, team task training should be provided in an operational context to provide an opportunity to apply teams skills and technical skills together in the performance of control room tasks, with emphasis on team skills practice. Selection of tasks for practice of team skills should be determined by task interaction requirements including the criticality and complexity of team interactions involved. Team interactions during emergency tasks involving unpredictable or rapidly changing actions are particularly important. Tasks involving more complex team member interactions such as frequent communications are good choices for providing team training. The aviation industry as well as the nuclear power industry emphasizes realism in team training scenarios.

Several practical matters can enhance the effectiveness of team skills training. Practitioners recommend the use of instructor guides to facilitate conduct and evaluation of team skills training exercises or simulations. Periodic repetition of training will increase long-term retention of team skills (Dyer, 1984). Instructors should be knowledgeable and experienced in team skills training and should facilitate exchange of performance feedback and critique. Participation of the entire control room crew, not just the supervisors, in team training is recommended.

Team training, like other performance-based training programs, should be evaluated at two levels. Trainees' team skills acquisition should be evaluated in much the same manner as technical skills, with evaluation criteria based on team skills training objectives. The use of critique checklists or exercise guides facilitate this type of objective performance evaluation of trainees' team skills.

The effectiveness of the team training program should also be regularly evaluated. On-the-job performance evaluations addressing adequacy of team skills should be used to identify observed weaknesses in control room team performance with implications for team training program improvements.

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Discussion

MR. LONG: It seems to me that there is one fundamental concern that you have not addressed. In fact, each shift team is different, at least in our utility. That is one thing we are trying to address right now, to try to understand what the appropriate team relationship should be, and try to get those standardized because each shift supervisor decides for himself how his team is going to function.

MS. ROE: In a way that depends on the leader of the team to adapt to different styles. I think if everyone has been given the training on the generic and operational team skills, they should be able to effectively communicate, which to me is the basic requirement. I think it is up to the leader to be able to integrate all of this, which is a big responsibility. Did that answer the question?

MR. LONG: I guess in a way it was more of a comment than a question. We all have to be aware that there really are great differences in the way each shift functions. We have examples, as I suspect every utility here does, of problems occurring as a result of a substitute crew member being with a normal shift complement. That substitute's behavior is quite different in a particular transient. If the shift supervisor is not alert to that, a lot of trouble can occur because they are working at cross purposes.

MS. ROE: I agree with you.

TRAINING OF CONTROL ROOM CREWS IN PLANT DISTURBANCE DIAGNOSIS
A METHODOLOGICAL FRAMEWORK

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The purpose of this paper is to outline and describe the background considerations when developing training in diagnostic search for nuclear power station control room crews. The four main factors in these considerations are discussed: human information processing, diagnostic search, crew coordination during the diagnostic search, and finally training and teaching methods. Together, they constitute the cornerstones for the theoretical foundation of the diagnostic search training.

The methodological framework in this paper was tested in practical circumstances during October and November 1986, involving control room crews at a Swedish PWR nuclear power station. A report of the findings during this test will be issued later this year.

Purpose of this Paper

This paper is mainly about what happens after the initial phases of a certain training administration are carried out, i.e., after the different need analyses are completed and the design and development work is on its way to the point where the practical training methods are considered (Reference 6):

ANALYSIS	DESIGN	DEVELOPMENT	IMPLEMENTATION	EVALUATION
*Knowledge	*Objectives	*Instructor's	*Practical	*Result evalu-
*Skill	*Training	Guide	application	ation
*Performance	programme	*Training		*Revision
	structure	material		
	*Methods	*Audio-visual		
		aids		

During these phases the intended training program is outlined, constructed and adjusted to fit its purposes. This consists mainly of determining the following factors (Reference 2):

<u>Factor</u>	<u>Content</u>
Objectives	Description of goals which should have been achieved after the training is completed. These goals are stated in operational terms defining the terminal goal behaviour of the operators.
Target group	Definition of participants in the training and description of the participant background knowledge, attitudes to training and individual differences which will have influence on the training.
Training conditions	Definition of practical and economical conditions of the training such as cost, locality, equipment and other aspects.
Instructor/instructors	Description of instructor requirements and their corresponding performance criteria in order to get a base for selection of suitable instructors.
Training content	Description of training content derived from the objectives and goals described above.
Training methods (incl. AV aids)	Description of training methods to be used during the training. The selection of these methods is made by analysing the taxonomical level of the content and choosing training methods accordingly.

It is the latter factor which is of special interest in this paper. It includes a number of important questions, such as the following?

- o How to teach the operators to utilize the principles of diagnostic search, i.e., content and diagnostic search procedures.
- o How to teach the operators to cooperate and coordinate their actions during disturbed system states while carrying out diagnostic search.
- o How should audio-visual aids in general and a full scope simulator in particular be used in order to optimize the training outcome as far as crew coordination and diagnostic search are concerned?

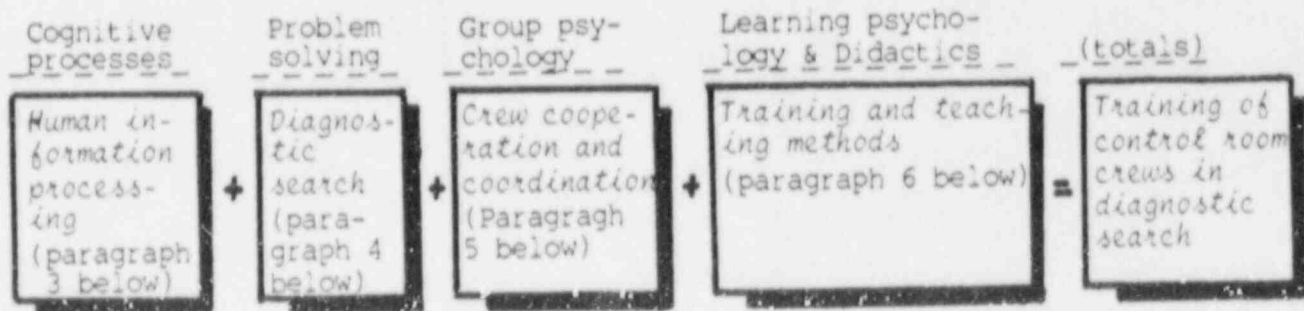
For the instructors involved in the diagnostic search training, it is a matter of how to "transfer" their knowledge and skill about crew coordination during diagnostic search in such a way that the operators will understand and in the future use them in real life situations. Based on this and the questions above the purpose of this paper can be summed up as follows:

To outline and describe the main background factors of a method of training nuclear power station control room crews in plant disturbance diagnosis.

This paper will focus on the factors which have influence on the choice of training and teaching methods in practical terms, i.e., at a "classroom level."

Main Factors Involved in Training of Diagnostic Search

A great number of contributing factors can be isolated, the most important of which are the ones directly influencing the crew members' practical application of diagnostic search principles. The figure below contains the main factors discussed in this paper as well as the main areas in which the factors are studied:



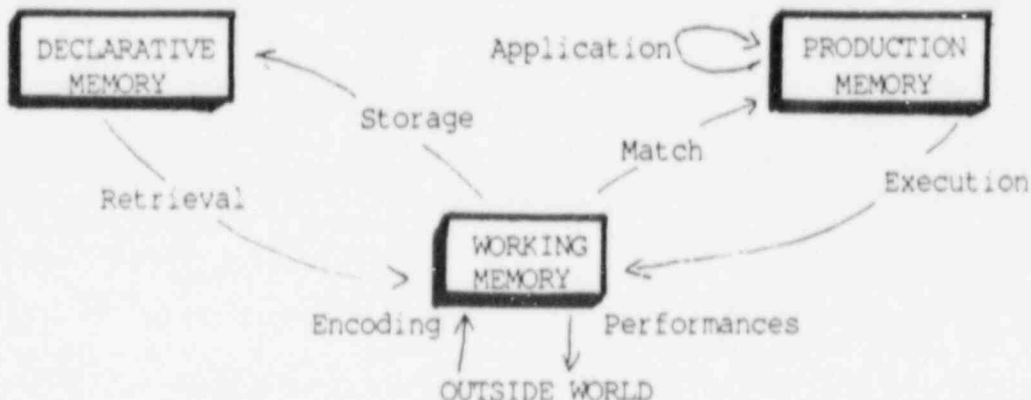
The basic principle behind the figure is that facts, skills and attitudes from all four main areas have to be considered when arranging diagnostic search training for control room crews ... and not only considered but also used in the training. Below, each factor will be briefly discussed in order to form a methodological framework for diagnostic search training involving control room crews.

Human Information Processing

The reason behind the necessity of a human information processing model when constructing diagnostic search training is at least twofold. First, the model is indispensable as a guiding tool when the diagnostic search sequence and the diagnostic rules to be used in the training are produced. Secondly, it is a very useful instrument when considering the different parts involved in the training as far as content and sequence are concerned. The model will then indicate what is necessary to include in the various

lectures, etc. and in which order these lectures and their respective content should be presented to the participating crews.

The model chosen and used here is based on the notion of condition-action pairs called productions (Reference 1). The condition part of the production specifies a certain set of data whereas the action part described what to do in the situation. The basic idea is that human beings have acquired "rules" (=productions) from learning and experience and when a practical situation is to be handled the information in that situation is compared to the condition part of the production. If there is a correspondence between the situation information and the condition stated in the production, the action part will give direction as to how to act in that particular situation. The model is illustrated as follows:



The working memory is the central unit of the model. It handles active information from the outside world as well as retrieved data from the declarative memory and converts productions from the production memory into performance commands. The declarative memory contains long-term stored information which is retrieved and used by the working memory when needed in a practical situation. The production memory holds productions, the condition part of which is compared to active information about the outside world in the working memory. A practical situation is treated by the use of different processes as shown in the figure above.

- o The encoding process converts the perceived information about the outside world into cognitive units. The information is represented in three ways:
 - o Temporal strings which preserves from a sequential point of view, e.g., position of words in a sentence, etc.

- o Spatial image which specified configural information, e.g., shape and size.
 - o Abstract proposition which relates to the semantic and conceptual relations of the information.
- The coded information is deposited into the working memory as cognitive units in an active state but of fairly short duration.
- o The storage process consists of remodelling the active but transient cognitive units into long-term memory traces in the declarative memory. This is for instance done when the same information occurs many times which increases the probability that it will become a permanent trace. The information is stored in its represented form, i.e., cognitive units. These units could be thought of as nodes with interconnecting links which could be parts of more complex hierarchical structures, such as sentences etc.
 - o The retrieval process transfers stored information in the declarative memory to the working memory.
 - o During the matching process the content of productions is compared to coded information from the environment. While during the retrieval process the representation of data is of no importance, the matching of retrieved information is highly dependent on representation type. This is natural because of the different nature of the treatment during the various processes.
 - o The execution process deposits the action part of the match production into the working memory. The production could be expressed as "IF-THEN" relations:
 - IF when approaching a railway crossing, the red light signal is flashing and the level-crossing gate is closed
 - THEN slow down and stop the car x yards from the gate.
 - o The performance process converts the action part of the production into commands in the working memory which results in reaction or behavior.

As the production selection is based on matching, criteria for how a certain production is chosen play a vital role in the model. Production selection is made according to five so-called "Conflict Resolution Principles", i.e., solving the conflict of competing productions.

- o First, the degree of match states that the production, the condition part of which resembles the compared information in the working memory the most, will be chosen.
- o Second, production strength by which the strongest production is chosen.
- o Third, data refractoriness is based on the notion that the same data cannot serve in two patterns at the same time. Once picked a production cannot apply again which prevents a certain production being used over and over again, thus avoiding getting into fruitless loops without a stop.
- o Fourth, the principle of specificity will be applied when two productions match the same data but the condition part of one of the productions is more specific than the other.
- o Fifth, goal dominance which states that when a specific goal is determined, productions that refer to this goal are preferred to other productions not linked to the goal.

When an operator is experiencing or learning partially or completely new things without having access to for instance, instructions, the operator has to interpret a lot of information and use a great number of matched productions. This is done in small steps in a mentally controlled process which could in more complicated situations contain productions involving variables. Hence, only one production at the time can be processed. This serial processing is time consuming and puts a lot of strain on the working memory as much data and many productions have to be kept activated there simultaneously. The demand on the working memory is especially eminent when abstract propositions are processed as their hierarchical structures are more complicated. When the operator is getting better acquainted with the situation, the information processing will become more and more automated due to two knowledge compilation processes called composition and proceduralization. The former process means that a sequence of productions could be transformed to one single production when the sequence is used a number of times. The latter process builds versions of the productions that no longer require information to be retrieved from the declarative memory into the working memory. When the processing is automated the production matching can become parallel and therefore speeded up with less strain put on the working memory.

Activation of information could be initiated in three ways:

- o First, stimuli from the outside world could be a source of activation.
- o Second, executed productions builds structures that could constitute reasons for activation
- o Third, activation could occur as a result of productions focusing on goal structures present in the working memory.

Additional relevant information is retrieved by means of activation spreading from the original sources to affiliated nodes in the network. The main spreading mechanism is association and a piece of information will become active to the degree it is related to the original activation source.

Diagnostic search

When an unplanned change or a disturbance has occurred the operator's task is to find its origin, rectify it and avert its possible consequences. The operator will therefore perform a search within the affected system in order to locate and identify the disturbance. As the search is done by considering signs and symptoms of faulty components or disturbed functions, this is called the "diagnostic search." The search is carried out according to a personal mental plan for how to perform it. Studies of these plans show that there are patterns which could be grouped together in more general "search strategies" depending on the qualitative criteria of the search (Reference 17). Search strategies are tactical plans guiding the operator during his fault finding activity.. The active parts in a search strategy are the diagnostic rules, i.e., personal "internal mental directives" how to proceed during the search. the nature of these diagnostic rules vary according to two aspects:

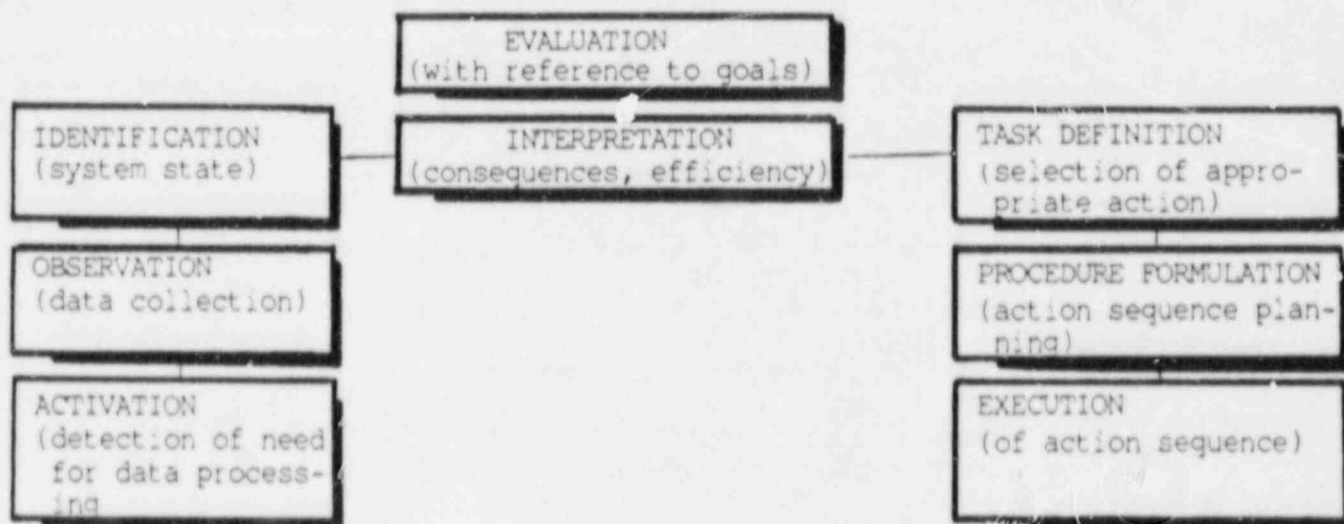
- o General or specific diagnostic rules
The rule could either give very specific directives how to solve a problem which means in practice that the rule has to be perfectly adjusted to the type of system that rule is applied. On the other hand the rule could only state how to proceed in general terms which makes the rule applicable to many different types of systems.
- o Algorithmic or heuristic diagnostic rules
Algorithms could be defined as "rules which either produce a solution to the disturbance problem or terminate the search at a defined failure point" (Reference 9). This means that when a set of algorithms is applied during a diagnostic search, the cause of the disturbance is always found or

the search is finished at a predetermined point. But there are of course numerous occasions when an applied tactic will not result in solving the problem at every attempt. The applied tactic is here more a "rule of thumb" and acts like a guideline how to solve the problem without guaranteeing that its application will automatically lead to the solution of the disturbance. This kind of guideline is called a heuristic rule. It has no problem-solving characteristics in itself but leads the operator to discover methods how to find the disturbance cause. In sum, this means that algorithmic rules are means of reproductive activity whereas heuristic rules refer to productive actions of the operator (Reference 16).

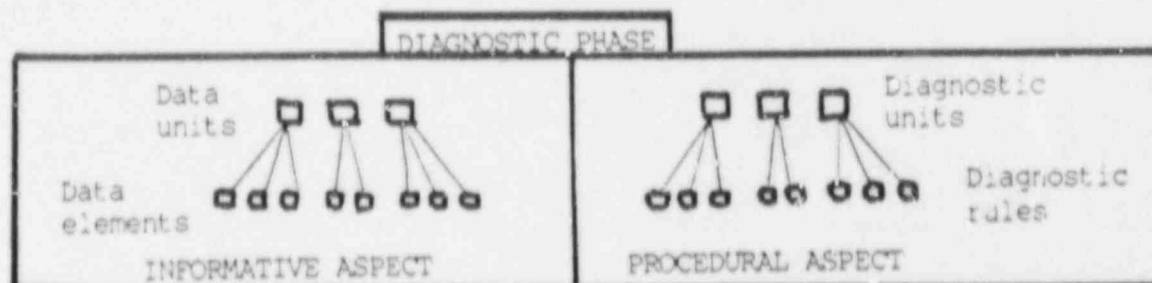
When combining the two aspects, four different types of diagnostic rules and their corresponding applications could be discerned:

	SPECIFIC	GENERAL
ALGORITHMIC	Operational instructions	Methodological guidelines, policies etc
HEURISTIC	Specific method-finding rules	General guidelines for disturbance and system state diagnosis

This paper concerns the diagnostic rules included in the general guidelines for disturbance cause and system state diagnosis. These rules should be seen as an important and useful complement to the operational instructions used by the operators. In principle, general heuristic rules apply only if the operational instructions are non-existent or do not give intended results. Or, to quote a German scientist, "heuristics is the science of finding solutions to problems whenever there are no algorithms" (Reference 10). The diagnostic rules are used during the operator's problem solving activity (Reference 18), here called diagnostic search sequence:



Each of the eight squares in the figure constitutes a diagnostic phase. In accordance with the production system theory (described in paragraph 3 above) the diagnostic rules consist of an informative aspect as well as a procedural aspect which correspond to the condition and action parts of the production respectively.



When applying diagnostic rules the operator must know how to use the rule, which is stated in the procedural aspect, and have sufficient technical and system knowledge to be able to implement the rule correctly. The latter is provided by data elements of the informative aspect.

Crew cooperation and coordination during diagnostic search

With few exceptions disturbances requiring heuristic diagnostic rules are tackled by the control room crew members as a group, i.e., the disturbance solution is a result of a joint effort by the crew. Thus, group dynamics phenomena and other related issues

have to be considered when arranging training for crews in diagnostic search.

Three factors determine the performance of the crew during, for instance, diagnostic search (Reference 19):

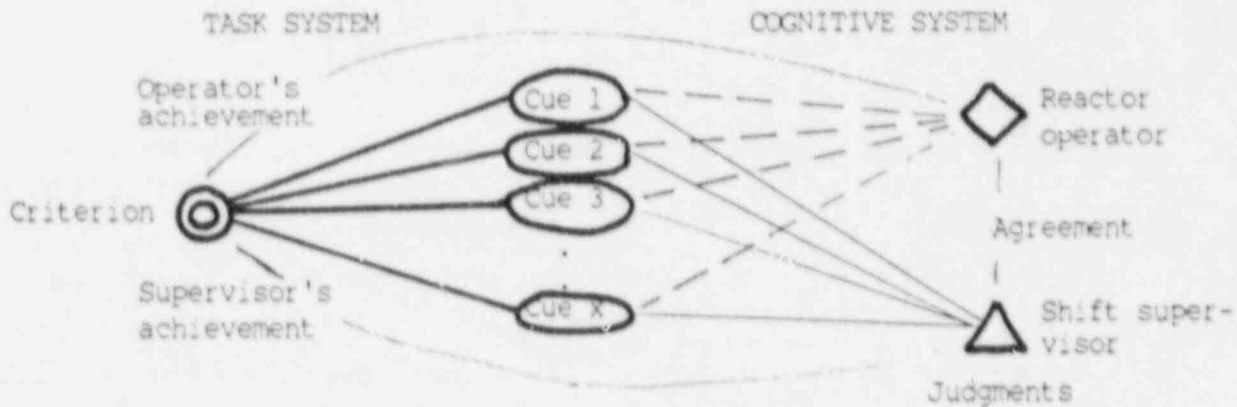
- o Task demands which include the requirements put on the crew when carrying out the system state diagnosis. the latter differs depending on:
 - o Task type, i.e., whether the crew members can carry out sub-tasks within the diagnostic search at the same time (divisible task type) or the crew members are not able to do so (unitary task type).
 - o Performance criterion, i.e., whether the diagnostic task requires maximum output during a certain period (maximizing) in order to find the only solution or the crew has to find the best solution because there are either a number of acceptable solutions or a correct solution is not known (optimizing).
 - o Use of resources, i.e., whether the crew are able to use their combined resources freely (discretionary) or the crew is not able to do so (constrained situation).
- o Group resources consist of the combined knowledge, skill, attitudes and physical aids of the crew members which are available during the diagnostic search.
- o Group processes are the means of utilizing group resources when trying to satisfy the goals of the diagnostic search, i.e., the way the crew members use their resources from an overall productivity point of view.

An important group process aspect is how the shift supervisor influences and steers the crew members during normal and disturbed system states. This could be expressed using a continuum representing the participation of the supervisor during the diagnostic search (Reference 11):

1	2	3	4	5
OWN DECISION WITHOUT EXPLANATION	OWN DECISION WITH EXPLANATION	PRIOR CONSULTATION	JOINT-DECISION MAKING	DELEGATION
The supervisor completely on his own	The supervisor explains afterwards	The supervisor decides on his own but after consultation	Joint decision which may or may not be overruled by the supervisor	The supervisor will not overrule joint decisions

In Swedish nuclear power stations the joint decision making is most frequently used when the crews are encountering previously inexperienced disturbance. The specialized task functions of the operators are brought together and coordinated by the shift supervisor on both formal and informal grounds. In essence this means that the supervisor "has the last word" in a formal background if there are any differences of opinion among the crew members. On all occasions, though, the crew members are entitled and encouraged to discuss the situation in a very informal way and this regardless of whether the supervisor later has to make a formal decision or not. The underlying idea is of course to generate as much information as possible in order to look at the problem from all its aspects. According to some researchers this informal discussion method could sometimes contradict its purpose (Reference 13). As a consequence of "Group-think" incorrect decisions are made because the formal goals of making high-quality decisions are replaced by the informal goal of consensus. This could make the crew members less open-minded and create stereotype ways of tackling problems as well as putting group pressure on individual crew members in cases of different opinions.

Different opinions will be the result of different values among the crew members but could also be the consequence of various ways of working the problem over. As this involves differences in mental processing and could substitute productive problem-solving efforts with less fruitful intra crew argumentation, it is known as cognitive conflict. An explanation of cognitive conflict is probably best done by using the "Lens model" (Reference 5) and an example:



In the model the criterion is the goal variable that the operator and supervisor are trying to assess by judging its value, etc. This is done by means of cues used by both the operator and the supervisor. The correlation between the true value of the criterion and the judgments is a measure of the operator's and the supervisor's achievements. If the method of assessing the cues is very different for the crew members, the degree of agreement will obviously be smaller compared to two crew members using roughly the same assessment method.

Applied to diagnostic search, these cognitive differences between the crew members are due to numerous factors in complicated relations to each other. One way of trying to decrease the differences in order to avoid cognitive conflicts, is to explicitly train the crew members together in diagnostic search. Even though there are a number of difficulties involved in such a training (Reference 4) proper arrangements should guarantee the crew a profitable outcome.

The issue of communication between the crew members during a diagnostic search is of vital interest when training crew cooperation and coordination. This is especially so during the observation and identification phases of the diagnostic search sequence as relevant data has to be generated and considered in order to form a base for diagnosing the present system state. In his role of being officially responsible for the coordination of the crew member actions, the shift supervisor could optimize the first phases of the diagnostic search by finding the fine balance between encouraging information generation and directing the crew members' attention. Both these aspects have their obvious assets but could also be disastrous to the outcome if not carried out correctly.

Training and Teaching Methods

Learning has been defined (Reference 7) as "... a change in human disposition or capability which can be retained ... and often is an increased capability for some type of performance." Training is the means by which these changes in dispositions or behavior are obtained. In the context of diagnostic search, the purpose of the training could be expressed as follows:

To teach and exercise individual crew members concerning the nature and application of diagnostic search as well as the role of the individual member in the crew during diagnostic search.

This paper is only concerned with general heuristic diagnostic rules, the extraction of which is made from interview and observation data involving experienced crew members who have successfully managed to diagnose and counteract disturbances. The

individual crew members' ways of tackling the disturbances are put together to form rules based on common behavior patterns. Thus, the rules are not immediate tools for solving the disturbance problem but constitute a method which will increase the probability of finding the relevant symptoms and functions which will reveal the disturbance cause. As a consequence, the crew members are taught the diagnostic rules and their application together in order to safeguard a similar interpretation of the rules within the crew. The use of the rules requires a similar (if not identical) technique for all crew members when going through the diagnostic search sequence. As this technique was not commonly used among the crew members before the training, an adjustment is necessary for some or all of the crew members. This adjustment brings us to the principles behind the methods used in diagnostic search training.

If the operator has not previously internalized the diagnostic search method, adjustments to this method are required at two occasions:

- o During the diagnostic search training in order to understand and profit from the training
- o During the operator's normal work at the power station when encountering disturbance for real.

Depending on training content and the operator's present sets of productions concerning diagnostic search, two types of changes (Reference 20) and adjustments are possible. Below, these types are shown together with their corresponding training methods (Reference 12) and similar concepts in learning psychology (Reference 15):

ADJUSTMENT

ASSIMILATION - TYPE I CHANGE

Description: Adjustment which means changes in the hierarchical production structures but not to the extent that these are reformed.

Change results: The operator has extended his range of knowledge and productions which improves the present way he is performing the diagnostic search.

Training methods: a) Facts presentation when the purpose only is to make the operator qualitatively better while using the present diagnostic method.
b) Adaptive training method when certain parts of the search behaviour are to be changed.

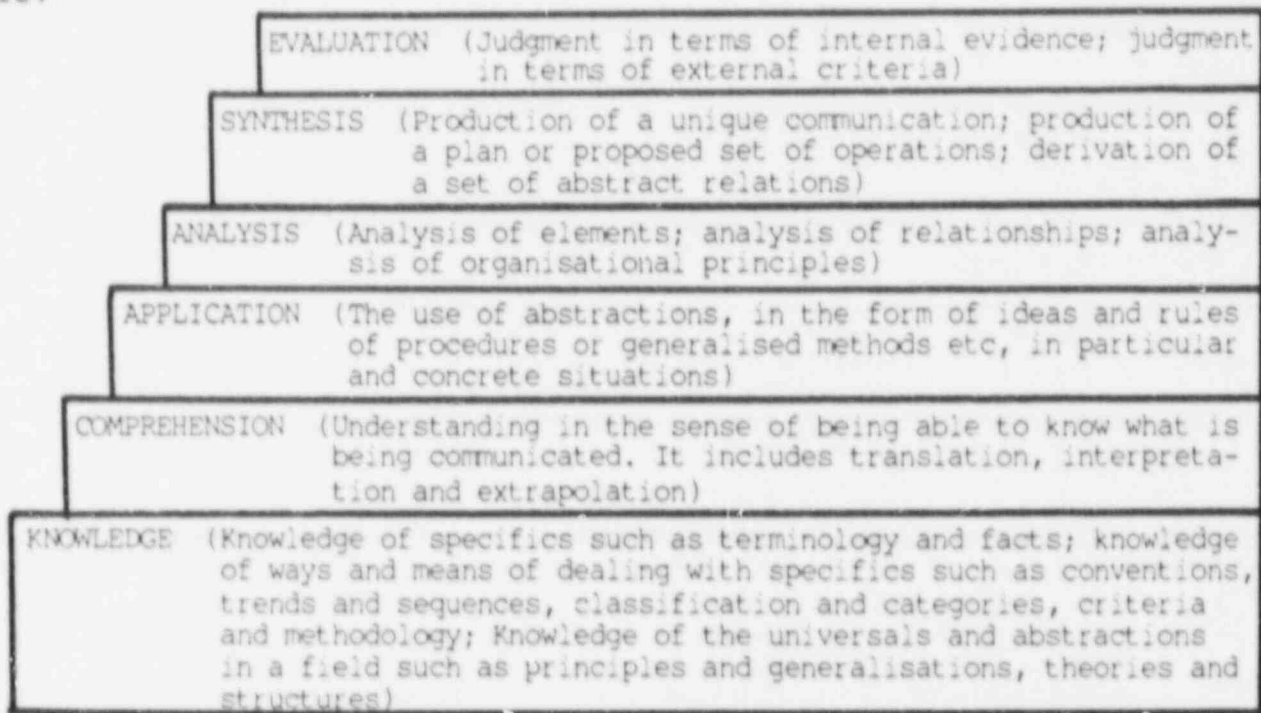
ACCOMMODATION - TYPE II CHANGE

Description: Adjustment which requires major changes of the hierarchical production structures to such an extent that these are reformed.

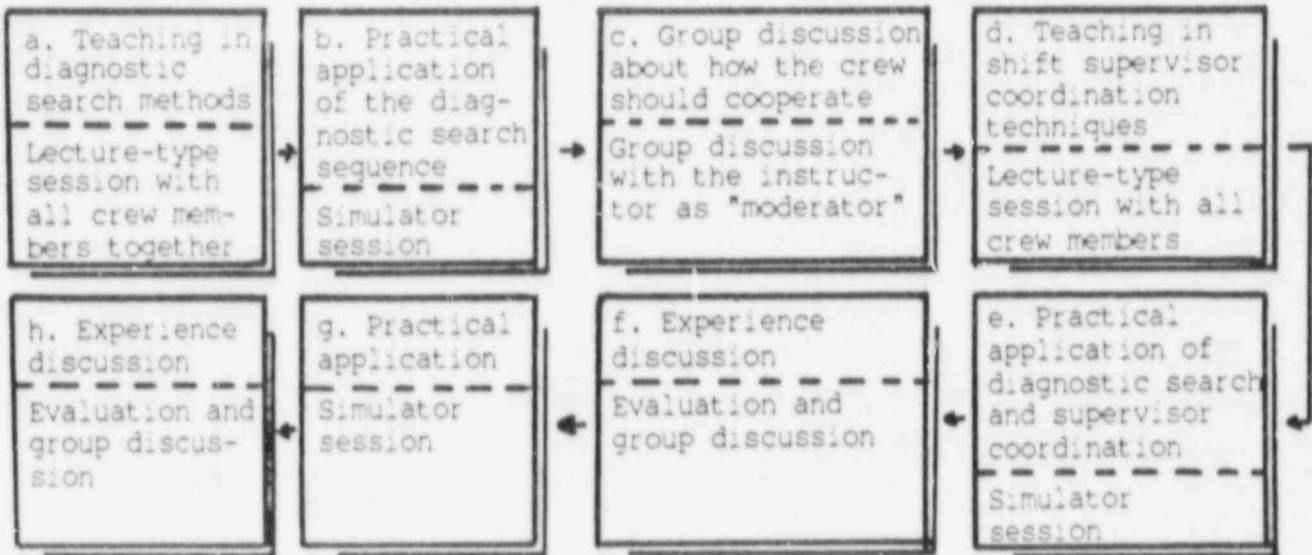
Change results: The operator has restructured and incorporated new productions, the consequences of which are changes of the present search procedure in favour of the method introduced during the training.

Training methods: Confrontative training which derives its name from the "confrontation" of new conflicting information with the existing production structures. The new information is deliberately presented to the operator in such a way that their production structure cannot assimilate the information.

It is obvious that the training content consists of parts which require different cognitive processing, partly because of the structure but partly also because the training goals specify different processing. For example, the retention of stress symptoms (which are given during the diagnostic training) activates long term memory traces in the declarative memory while an analysis of the relationships between completely new parameters will require a much more complicated production system activity. Thus, the various types of required cognitive processing must be mirrored in the training in terms of time allocation and teaching methods. The various parts of the training content can be analyzed by means of a "cognitive taxonomy" (Reference 3) which will give indications of which teaching method to use. The taxonomy is not strictly hierarchical but in many cases a higher level in the taxonomy requires a satisfied lower level.



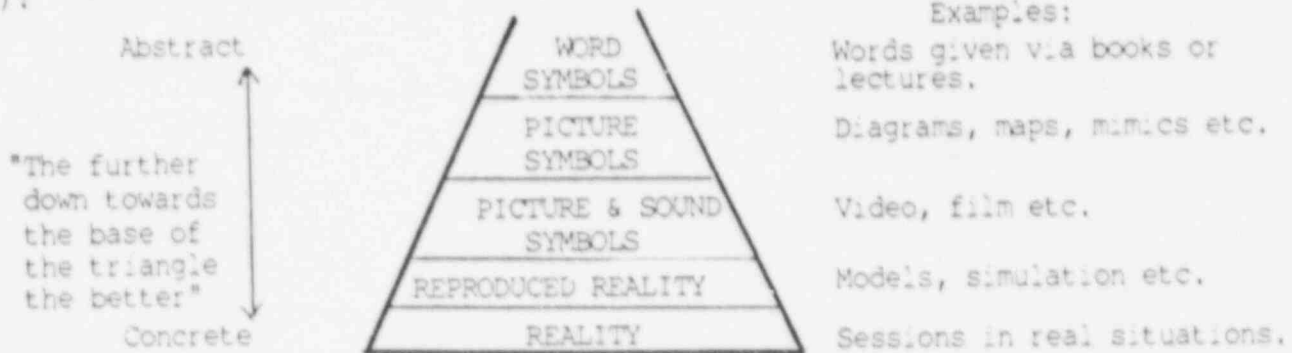
The practical use of instructions and algorithmic diagnostic rules is most often done on the three lower levels of the taxonomy. due to the fact that these rules always have the intended effect, productions will rapidly be formed and retained when needed which will equally rapidly make the production processing automated. A practical situation necessitating the use of general heuristic diagnostic rules will include the entire taxonomy and especially the three upper levels. When presenting this to crew members who have internalized the heuristic diagnostic rules, a confrontative training method is required. The principal steps of this methods are shown below:



Before the training starts the instructor will lay down a "psychological contract" together with the crew members concerning among other things integrity issues (if for instance video is used) and "rules" on how criticism should be given and received, etc. The latter issue is particularly important as it will pave the way to de-briefings as free from prestige as possible. Behavior changes will otherwise be blocked by defensive considerations and arguing.

During each simulator session the instructor is constantly pointing out the different phenomena which are vital in the diagnostic search sequence and rule application. If the crew members, and especially the shift supervisor, are uncertain in terms of crew communication the simulated transient is "frozen" and the uncertainty discussed and cleared out. After step d in figure 12 above, the crew has access to all information needed in order to act according to the diagnostic search sequence. From a learning point of view this means that the necessary productions for the sequence are already formed and it is now a matter of strengthening the productions to such an extent that they will become "dominant" over earlier productions which are not applicable any more.

In principle, the teaching methods are chosen according to the "rule of thumb" laid down more than forty years ago (Reference 8):



A Practical Application

The considerations, forming the methodological framework of diagnostic search training, have been applied in practical circumstances involving Swedish PWR control room crews in October and November 1986. The training program consisted of four days diagnostic search lecturing and practicing (see figure 12 above) at the nuclear power station crew training center (KSU) in Studsvik. In this training the facts and findings mentioned earlier in this paper were incorporated and put together to form a practical training course in diagnostic search. Thus, the desirable productions and production hierarchies were defined concerning crew member coordination and cooperation as well as shifts defined concerning crew members coordination and cooperation as well as shift supervisor behavior during the search. Twelve general heuristic diagnostic rules were used in the course and practically implemented during sessions in the full scope simulator. The reactions of the participating crews were very favorable towards the course and it was strongly recommended that all control room staff (and possibly including technicians allocated to the control room crew) should participate in diagnostic search courses on a regular basis. A full description of the diagnostic search training will be available in a report which will be issued within a couple of months.

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PRE-LICENSE TEAM TRAINING
AT SAN ONOFRE NUCLEAR GENERATING STATION

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Abstract

Team Training at San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 has been developed to enhance the performance of station operations personnel. The FACT Training Program (Formality, Attention to Detail, Consistency and Team Effort) is the common denominator for operations team training.

Compliance with good operating practices is enhanced by operators working as a team toward the same goal, using the same language, practicing the same operating and communication skills, possessing a clear understanding of individual roles and responsibilities of team members and practicing attention to detail in every task. These elements of effective teamwork are emphasized by the processes and criteria used in the Pre-License Operator Training Program at SONGS.

Introduction

Southern California Edison's (SCE) San Onofre Nuclear Generating Station (SONGS), located in San Clemente, California, is a three-unit station. Unit 1 is a Westinghouse plant which originally went on line in 1968. Units 2/3 are Combustion Engineering designed plants and achieved commercial operation in 1983 and 1984 respectively. This paper will present the origin and development of the San Onofre Operation's Team Training Program and its integration into operator pre-license training.

Background

Operator professionalism has been a concern to San Onofre Nuclear Generating Station's management, the Nuclear Regulatory Commission (NRC), and the Institute of Nuclear Power Operations (INPO) for the past four years. Retired Admiral Wilkinson, Past President of INPO, stated in an address to the NRC in 1982 the "managers and supervisors at all levels need to be more involved in the details of operation ... Managers ought to take more plant tours and conduct more inspections to better assess plant conditions and performance of plant staff ... Some supervisors appear to be reluctant to actually train, observe, coach, and correct their

personnel ... Communications among operators, craft personnel, and supervisors are sometimes too casual resulting in confusion in terminology and operational errors. Some stations are too relaxed in their use of and adherence to established procedures. Shift turnovers sometimes are too informal. Certain stations need a greater emphasis on professionalism in carrying out routine activities. (Reference 1)

These observations were later supported by then NRC Commissioner Victor Gilinsky when he stated "good performance depends on an operator's sense of professional pride and dignity ... Utility management has ... shared in discouraging professionalism." (Reference 2) SONGS's management perceived these concerns as a unique challenge which they planned to actively pursue and correct in order to enhance the NRC's perception of nuclear plant operator professionalism at SONGS.

Among the factors affecting this perception is the concept of procedural compliance. SONGS's management believes that:

- o Strict procedural compliance is a prerequisite for operating a nuclear power plant;
- o Operators must acclimate themselves to this reality continuously for the duration of their work experience;
- o Management has the responsibility of ensuring that this task is accomplished consistently and continuously;
- o Management also has the responsibility of providing the resources and stance which would be supportive of this operating standard.

To gain a perspective about the characteristics of operating a nuclear power plant with compliance as a frame of mind, in 1983 SONGS' Operations Management initiated research and observation efforts using a variety of previously established resources. These included, but were not limited to:

- o NRC's Systematic Assessment of Licensee Performance (SALP);
- o SCE's Action Plan for Improvement of the Operation of San Onofre Nuclear Generating Station, Units 2 and 3;
- o Results of Plant Operation's Personnel Review Committee's Conclusions and Recommendations;
- o INPO Site Incident Reports for 1981 and 1982;

- o Edison Electric Institute's Nuclear Plant Operator Reduced Task List;
- o Simulator and Control room observations using INPO's Good Practice - Conduct of Operations.

Hypothesis

SONGS' management now had the tools to define the concerns raised by NRC and INPO and establish how they related to San Onofre. It was assumed that since operators:

- o Were initially evaluated and tested for job aptitude and prerequisite knowledge via the Power Operations Selection System (POSS Test); and
- o Were trained for technical skills and knowledges which were supposed to translate into desirable operator behaviors; then
- o They would possess those characteristics and behaviors that would ensure good operating practices upon completion of their training.

However, the manner in which the operator's tasks were to be performed was not necessarily defined. Therefore, the need was clearly indicated to define, in behavioral terms, those characteristics and behaviors in which operators needed to be trained for the performance of their tasks to ensure the safe, efficient, and compliance-oriented operation of a nuclear power plant.

Management analyzed those behaviors which were discovered to cause non-compliance and non-professionalism and established their converse behaviors. The compliance-oriented and professional operator behaviors were identified as:

- o Vigilance
- o Attention to detail
- o Analytical thinking
- o Teamwork
- o Decision making
- o Consistency
- o Communications
- o Formality
- o Leadership.

These behaviors were translated into a program which would emphasize Formality, Attention To Detail, Consistency and Team Effort, or as it has become known at San Onofre - FACT.

Program Goal

The FACT program goal was established to achieve the desired professional and compliance-oriented behaviors. The program's objectives were established to:

- o Obtain concurrence on a standard of performance expected during various modes of control room operation;
- o Ensure a consistency of operating practices;
- o Ensure a consistency between simulator training and control room practices;
- o Establish definable performance criteria which support Formality, Attention to Detail, Consistency and Team Effort (FACT).

Program Design

The program is designed with the understanding that FACT training would provide the common denominator for influencing a change in operators' behaviors and subsequently change the attitude of Operation's personnel. This would provide clear and uniform standards of acceptable performance. There are two courses in the training program which consists of lesson plans supporting the desirable operator skills/behaviors and the implementation of these skills:

- o FACT for Supervisors
 - Performance Management
 - Decision Making
 - Action Planning
- o FACT - Operational Effectiveness
 - Control Room Communications
 - Operational Problem Solving
 - Tailboarding
 - Annunciator Response
 - Written Communications
 - Procedure Use - Normal, Abnormal, Emergency
 - Plant Monitoring
 - Plant Manipulations

The operator training instructors receive our regular instructor training, all segments of FACT and training in facilitative skills which are the instructional methodology of the entire FACT training program. The instructor training program emphasizes:

- o The rationale for the training so that the operator will have a clear picture of the importance of these skills. This increases the operator's motivation to learn and use the new skills on the job;
- o That these are not really new skills but ones that ensure all operators approach their job from the same fundamental level;
- o That these skills are developed from the attributes an experienced operator gains over considerable time by trial and error;
- o The responsibility of the instructor for ensuring that the principles and models of FACT are reinforced in all phases of training.

The Operation's Supervisors are trained in both courses of the program - FACT for Supervisors and FACT for Operational Effectiveness. Supervisors are asked to provide review and comment of the material presented in the scenarios, role plays, examples or case studies. A pocket guide is provided during their training listing the critical steps for the desirable behaviors identified to help them make the transition from the classroom to the plant/job. They use and reinforce the models from both courses in their daily work. Supervisors also provide feedback to the Nuclear Training Division on the application of the models in the workplace.

Lesson Design

Each lesson within each course was developed in a systematic and consistent manner which included:

- o Correct behavioral model, or critical steps;
- o Realistic video tape or examples of the model;
- o Practice modules based on the model;
- o Behavioral checklists;
- o Prescribed feedback strategies.

By structuring each lesson in a uniform manner, we attempted to ensure consistency of lesson implementation, feedback and reinforcement of the behaviors desired.

Program Implementation

In the initial implementation of the FACT Program, all Senior Reactor Operators (SRO's) of the three units at San Onofre were trained in two separate groups. These groups included Shift Superintendents, Control Room Supervisors, Shift Technical Advisors,

Instructors, Training Administrators, and Plant Management. An outgrowth of this heterogeneous grouping provided for consistency and cohesion in applying the FACT principles among the different units. These training sessions provided for a commitment to the program by bringing the station policy makers together to develop a common Standard for Good Operating Practices. This standard became the foundation of FACT Program behavioral checklists and would be continuously reinforced by management through individual operator and shift performance appraisals. Operation's management believed that an individual's attitudes and/or beliefs are more amenable to change if the correct behaviors are reinforced and if the individual knows that strict accountability will be expected. The on-shift management was assigned the responsibility for this reinforcement.

An important side benefit from the FACT Program's implementation was that in many instances this was the first time that many of the people from Unit 1 (Westinghouse) had the opportunity to communicate on a common ground with those from Units 2/3 (Combustion Engineering) since they were now able to share common experiences and areas of concern.

Other licensed operators, non-licensed operators and non-supervisory shift personnel were then trained in the FACT for Operational Effectiveness during their normal shift requalification period with their shift management in attendance. The program's content was presented and initially practiced in the classroom. Further practice was provided during the simulator portion of their requalification training when instructors and shift management worked as a team to reinforce the desirable FACT behaviors.

Parallel License Candidate Evaluation

The Pre-License Review Phase of operator training at San Onofre is a nine-month period of training prior to the NRC license exams. It consists of a review of all previous Systems and Fundamentals Training, an Introduction to Integrated Plant Operations, and Initial Simulator Training for license candidates in small teams.

During the initial implementation of the FACT program for the licensed operators and supervisors, it was perceived that the license candidates in the Units 2/3 Pre-License Review Phase of training being conducted at that time were also experiencing problems in communications and assertiveness. A training analyst was asked to perform an analysis of the Pre-License group's operating behaviors and team interactions and provide alternatives for solutions to these candidates' problems. This analysis included:

- o Observation of simulator training;
- o Identifying issues pertaining to communications, assertiveness, power or influence, etc.;
- o Analysis of the Simulator audit examination results;
- o Correlation of INPO's Systematic Approach to Simulator Malfunction/Scenarios to the Standards of Good Operating Practices developed by the SRO's during FACT training.

Based on this analysis, two instruments to assess candidate performance and identify operating and team interaction deficiencies were developed.

The first instrument developed was a Simulator Observation Checklist, a behavioral checklist, based on the Standards of Good Operating Practices. This Likert-type scale can be used to determine the areas of strength or weakness as they relate to the FACT critical steps. The instrument is structured such that a particular area of concentration can be observed and assessed - Communications Process, Cooperation and Team Interaction, Roles and Responsibilities, Task Process and Decision Making/Problem Solving.

The second instrument developed is a Control Room Communications Observation analysis tool by which a team's communication's patterns can be plotted during a given period of time. Analysis consists of providing the quantity, types, and people involved in all communication activities. This type of information can provide data to diagnose the status of power and influence in the group since there is a direct correlation between frequency, direction, type, and amount of talk to power and influence. When an individual knows he has influenced others, he tends to act like a person who has more power; he talks with more confidence to more people. (Reference 3) Analysis of the functional relationship between the Control Operator (CO) in charge and the Assistant Control Operators (ACO) can occur using this communications instrument. Both of these instruments were pilot tested with this Pre-License group.

Another aid to assess operational performance was the use of the video cassette recording system that was introduced during the simulator portion of this training period. Since this was the first time that this type of equipment or process was being used in operator training, it had to be presented in a non-threatening manner. The following guidelines were implemented:

- o First, the equipment was made available for the team's use and review if they chose to use it;
- o Second, it was not to be considered a tool for the evaluation of the team by others;

- o And third, it was recommended they review the recording immediately following a simulator session for prompt feedback and for the team's own self evaluation, critique and analysis.

Some groups viewed the tapes in private and discussed their actions or perceived problems.

After the NRC examinations were administered to this pilot group, FACT program feedback was obtained using these three methods:

- o The Pre-License program's participants were interviewed using a structured questionnaire;
- o Recommendations from the training analyst were synthesized and documented;
- o Instructors provided feedback and recommendations for change.

A more formalized FACT Program for Pre-License candidates resulted.

Units 2/3 Pre-License Team Training

The initial introduction of team training as a process is formally presented during the Initial Simulator Training in our Pre-License Review Phase of Training. As stated previously, this phase of training consists of coursework which reviews theory, systems training, administrative requirements, and introduces integrated plant operations in the classroom and simulator to prepare candidates for NRC licensing. Prior to the candidates' initial simulator training, a classroom briefing is held which:

- o Reviews the FACT models and skills;
- o Provides the Team Training Criteria Checklist;
- o Provides an overview of the Team Training Process;
- o Delineates roles and responsibilities.

The FACT criteria is provided to each student in the form of handouts which include:

- o Standards of Good Operating Practices as developed by shift management during the initial FACT implementation;
- o Station order - Control Room Formality which describes the fundamentals of good communications;
- o Site Directive - Formality and Attention to Detail which defines station policy regarding formality and

attention to detail in all activities and assigns responsibility for ensuring the implementation by personnel;

- o Team Training Criteria Checklist;
- o Control Room Communications Observation Analysis.

Simulator observations, observations of plant walk-throughs and observations of audit exams are the primary responsibility of the Team Training Coordinator. These include three instructional methods which are hierarchical:

- o Observation/Feedback
- o Coaching/Feedback;
- o Evaluation/Feedback.

The Simulator Instructor and Team Training Coordinator work cooperatively during the simulator training to reinforce task and team behaviors. The Simulator Instructor functions as a technical authority providing task input and the Team Training Coordinator concentrates primarily on the team's interaction and group processes. Both individuals have the responsibility for providing feedback relating to FACT skills and their implementation during simulator scenarios to the license candidates.

Initially, the Team Training Coordinator conducts observations of each team. The purpose of these initial observations are to:

- o Build a level of trust with the operators;
- o Identify individual team members' styles, values, assertiveness, influence, and communication patterns;
- o Gain an overall perspective of team norms, interaction and dynamics;
- o Identify areas of strength and/or weakness in individual and team behaviors or the implementation of FACT skills.

This type of observation is usually completed in a random manner during the early courses of the training phase.

During the later stages of the license candidates' training, the Team Training Coordinator observes and provides feedback to the candidates immediately following their practice plant walk-throughs and simulator exams. This process involves the Coordinator's acting as a silent observer during these sessions. Discretely taken notes

provide the basis for the feedback. The feedback is a narrative description of what occurred in behavioral terms. Comments on mannerisms and behaviors that could be adversely interpreted by facility and/or NRC examiners are provided. Alternative behaviors are suggested and demonstrated. For example, the emphasis of eye contact when communicating demonstrates the candidate's confidence. These types of observations enable the Coordinator to provide further coaching and training in the areas of non-verbal communication, assertiveness and command presence.

During simulator training, coaching is used as the primary instructional method. Coaching involves the instructor directing the students through a series of exercises designed to familiarize them with the equipment and topics they will learn. Coaching is often considered a less formal type of instruction and therefore less threatening than traditional instruction. This helps to establish a rapport between students and their instructor (coach) which aids the learning process and reduces student apprehension. Coaching is used primarily in teaching Abnormal Operating Instructions (AOI's), Emergency Operating Instructions (EOI's), Response to Minor Malfunctions on the simulator, and Practice Scenarios combining all operational requirements. Feedback is given primarily at the conclusion of each scenario. We have found that providing feedback during a scenario causes confusion and detracts from the technical knowledge and learning experience required.

Team Evaluation

Evaluation and feedback to team members primarily takes place following the Practice Scenarios. The Team Training Criteria is used by both the Team Training Coordinator and the Technical Instructor. Feedback is also provided to the Cognizant Training Administrator on team dynamics and individual skills and/or knowledge by both the Instructor and Coordinator.

A video cassette recording system is used in the simulator regularly with the Team Training Criteria and Communication's Observation Analysis instruments to provide viable feedback and evaluation. Informal comments or notes by the Team Training Coordinator are made in conjunction with the tape and instruments. Many of the candidates take the tapes home to view them in the quiet and privacy of their own home. A coincidental fallout of this experience is that the license candidate's families become involved in the viewing of the tape which helps them to better understand the operator's job. The families are then generally more supportive of the time and energy required by the license candidates to prepare for NRC licensing.

The Video Cassette Recorder is one of the most effective feedback mechanisms available and powerfully reinforces all the other feedback processes. It can be used at any time as needed or

desired. It can be used both openly and covertly depending on the timing of the training and the needs of the group. It has been found that open use of the recorder at the beginning of the simulator training provides a foundation of trust for team members. Early in the training or with new team members, license candidates are usually more comfortable viewing or critiquing the tape privately. As the teams evolve, the use of the VCR develops group trust and respect for individual styles, capabilities, knowledges and expertise. Non-verbal behaviors are noted and brought to the team member's attention. There is no denying the behavior when the candidate can see it for himself/herself. These non-verbal behaviors can include body stance, board position, tone and pitch of the voice, manner in which something is said, i.e., use of "weak" words, etc. This subjective type of feedback can be the most threatening for the team members and presents the greatest challenge for the Team Training Coordinator.

The organization and structure of the teams has been a concern of the training administration during the past several years. Traditionally, license candidates were trained and evaluated in fixed groups. That practice is changing in an effort to attain consistency among all the license candidates. Now, teams are trained as an entity during the initial phase of simulator training, and as the training evolves into more sophisticated operational aspects (EOI's, AOI's, NRC practice Scenarios), the license candidates are rotated among all groups. This ensures consistency of behaviors across all candidates, focuses on the task rather than personalities, and prevents the development of "group think" (Reference 4) whereby all members tend to think alike.

Problem solving strategies are encouraged so that the candidates themselves can introduce changes within their groups which would enable them to work together more effectively. As the group progresses through the training, the simulator instructor is asked to complete the checklist and provide feedback. This strategy is used to ensure consistency between the instructor and Team Training Coordinator.

A variety of other Human Resources Development Instruments and strategies are available as required. These are The Team Orientation and Behavior Inventory (TOBI), Leader Effectiveness and Adaptability Description (LEAD), The Systematic Multi-Level Observation of Groups (SYMLOG), The Keirseley Temperament Sorter, Stress Management, Progressive Relaxation Techniques, Neuro Linguistic Programming, etc. All of these strategies are geared toward the needs of the group or team members.

Program Evaluation

The FACT Program and Pre-License Simulator Training are evaluated by analyzing the number of Site Incident Reports (SIR) and Licensee Event Reports (LER), On-Shift Observations of operators, and Regualification simulator Observations. The number of SIR's and LER's have decreased since 1985 when these programs were initially implemented. The effect of the implementing FACT training during the Pre-License Review phase of training is believed to have contributed to this reduction in incident reports. Operations training instructors are performing on-shift evaluations using the Team Training Criteria and providing feedback to Site and Training Management. Using the Team Training Criteria, the Team Training Coordinator will be observing and evaluating shift teams during the 1987 Regualification Training Program on the simulator. The results of these eiforts will be used to revise the existing FACT programs to enhance Supervisory and Operational Effectiveness.

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TEAM BUILDING AND DIAGNOSTIC TRAINING

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Abstract

While developing a commercial training program to improve teamwork in control room crews, General Electric's Nuclear Training Services made an important discovery. Traditional training methods for developing teamwork and enhancing diagnostics capabilities are incomplete. Traditional methods generally help, but fail to fulfill the long-term needs of most teams. Teamwork has been treated as a short-term performance problem. Traditional diagnostic training suffers from a similar problem. Too often, it covers only the basic principles of decision-making, ignoring the development of expert diagnostic capabilities. In response to this discovery, we have developed comprehensive training in Team Building and Diagnostics.

The Problem

The nuclear power industry faces constant evaluation of the line between maximum operating efficiency and maximum practical safety. There are times during the operating cycle of a nuclear plant when it is necessary to suspend operation to resolve a potential safety matter. A growing number of studies and reports indicate that the key in minimizing this trade-off is the quality of teamwork exhibited by nuclear plant personnel.

The ability of utilities to operate nuclear power plants safely while minimizing the number of unplanned shutdowns depends, to a significant degree, on the ability of nuclear power plant personnel to perform in a team environment. (Reference 1)

About one-half of the nuclear industry's significant events in 1983 and 1984 were attributed to human performance problems of station personnel. (Reference 2)

There is ... a recognized need for focused team skills training because poor team skills have been observed to cause poor team performance even when individual team members are known to have adequate technical knowledge. (Reference 3)

Human performance problems were classified by the Institute of Nuclear Power Operations (INPO) into three broad areas: the

interface between individuals and plant equipment, the interface between individuals and procedures, and the interface between individuals. The data provided by INPO does not distinguish between the three interfaces, but makes clear that training to resolve human performance problems must improve both diagnostics abilities and teamwork.

Our Discovery

Shortly after GE began teaching teamwork and diagnostic training an important discovery was made -- the traditional approaches for improving teamwork and diagnostics were incomplete. Our trial training programs did improve team performance. The difficulty came in the transition back to the job. No matter how much improvement took place during training we could not reliably predict improvement in job performance.

After a significant amount of introspection we were able to identify the problems we were facing. Our efforts at improving teamwork were failing for the same reason so many management and supervisory programs fail to produce the desired results. Even though the trainee learned a new set of behaviors, there was nothing in the work environment to encourage or reinforce using the new behaviors. Or as we now realize, if the team culture will not support change, change does not take place. (Reference 4) So, effective teamwork requires training that focuses on both team skills and building an accepting team culture. Indeed, the development of effective organizational culture has been labeled the prime management role. (Reference 5)

In diagnostic skills training we found an even more perplexing problem. Simply developing an "accepting team culture" was not enough. Our initial approach had been to teach a proven problem solving process. Our process involved nine steps that led trainees through problem identification, determination of cause, and implementation of a solution. We reinforced the process with practice exercises and critiqued trainee performance. Even if the team culture was accepting, often the trainees were not. Frequently, trainees did not believe the process would be effective on the job.

Our first reaction was to add more examples of how the process would work. Few were impressed. We next attempted to refine the process, fluctuating from streamlining to beefing-it-up. It was during one of these cycles that we realized that the barrier was bigger than we were. Almost all of our trainees had had prior training in problem solving. In fact, most had completed the training prior to the studies that indicated that more training was needed. In short, they assumed our approach would fail because they had already seen it fail.

At that point we realized that the content of our training program had to be radically changed. At the center of that change was a fundamental distinction; diagnostics are not problem-solving processes, they are trouble-shooting tools. In addition to teaching our trainees a process for effective diagnosis, we needed to give them tailored diagnostic tools that would work reliably. Our response took us outside the realm of industrial training. We found our answer in professional training programs, specifically legal and medical, where diagnostics are recognized to as a process, but as discrete cognitive skills.

Our Response

The GE response was to train control room crews to build functional team cultures and diagnostic algorithms. We still teach team skills and ensure that each crew understands the principles of problem solving, but those topics are covered more in the form of remediation.

Team building. We start with team building because that is the foundation for the diagnostic process. Until the crew understands how to build a functional team culture and is committed to doing so, teaching new behaviors accomplishes little. (Reference 6)

We teach teambuilding in three separate lessons. First, we address team tasks. (Reference 7) This is primarily an introduction to the concept of teamwork. Our goal at this point is to establish the contextual boundaries that will surround the following lessons. Currently, we focus on four general tasks:

- o strategic development - developing and executing a comprehensive plan
- o task assignment - evolving an assignment process that is thorough and accepted by the team membership
- o decision-making - using all the team's resources to make decisions that support the strategic plan
- o Coordination - executing team activities in a smooth and effective manner.

The next lesson is the heart of the training program. Team culture is explored at the level of corporate cultures and then brought down to the level of team cultures. Research indicates that the only true cultures are team cultures, developed at the level of individual working units. (Reference 8) To illustrate the process we explore the bricks and mortar used to build a team culture. To begin the team's assessment of their working culture, we examine the mortar

that holds the team together -- the team's value system. We then explore the process that shapes the value system, sorting out dysfunctional values and promoting functional ones. Finally, we look at the bricks that the mortar binds together -- team members. We found that it is necessary to emphasize personality differences but to discourage decision making based upon personality.

The third lesson deals with team skills. These are the skills necessary to sustain a strong functional culture while accomplishing the team tasks. Throughout the individual skill development units, we found that it was necessary to incorporate exercises that both illustrated the team skills and allowed trainees to practice. Practice exercises that did not illustrate the differences between individual and team skills proved to be of little value. The problem seemed to be that few of our trainees could differentiate between the two different types of skills.

The first skill unit is team communication. Specifically, we focus on the critical differences between individual and team communication. Our research indicates that team communication is more than a lot of individuals communicating at the same time. We teach our trainees how to recognize situationally implied messages, to promote unsolicited feedback, and to monitor communication between other team members. Most importantly, we teach them that there is a subtle shifting responsibility as you move from individual to team communications. In addition to team communication, we look at the nonverbal communication of team leaders, both appointed and emerging. We have found that effective nonverbal communication is a critical leadership skill (reference 9) that all team members need to understand.

The next skill unit is team decision making. The content of this unit is another GE discovery. Early on we used an exercise from NASA that was intended to show the superior quality of group decisions over individual decisions. Unfortunately, the exercise did not always work. Rather than scrap the exercise, we looked for differences that could explain why it worked sometimes and failed other times. Our discovery was that there are two ways that groups arrive at decisions. Some groups have members arrive at individual decisions and then they negotiate the group's position. Other groups arrive at genuine collective decisions, with no negotiations involved. The key difference is that, in the negotiated decisions, each individual makes decisions based on personal information. The groups that make collective decisions share personal information, before any decisions are made, creating a team data base. The result is that team decisions are based on a collective data base, instead of being the negotiated compromise between partially-informed individual decisions.

The third skill unit is peer reinforcement. Peer reinforcement is needed for effective team building, but cannot be differentiated as an individual or team skill. While the content is no different than what we would include in a supervisory skills course, the difference is in the application. Positive reinforcement of the worth and contributions of team members is so important that all team members must participate. In fact, we have discovered cases where reinforcement from a peer was more powerful than reinforcement from a supervisor. So, we teach our trainees that reinforcement of other team members is as much of a peer's responsibility as it is a supervisor's.

The final skill unit covers conflict resolution. Again, this is not a unique "team" skill. Rather, it is a necessary skill for effective teamwork. We strongly believe that a team must be made up of a diverse mix of individuals to ensure that the skills and knowledges needed for effective diagnostics are present in the team. Diversity, however, is a breeding ground for conflict. Differences in individuals mean differences in opinion, differences in approach, and differences in attitude. Effective conflict resolution prevents the negative side of diversity from outweighing the positive qualities. We teach our trainees that the best way to resolve conflict is to take an assertive position. We help them assess their abilities to be assertive, and we help them make any needed corrections.

At the conclusion of the last skill unit, the trainees participate in a group exercise that requires that they complete all four team tasks and use all four team skills. They are evaluated using the teamwork rating scale attached to this paper. This rating scale can also be used during simulator training or on the job to assess the teamwork of an operating crew.

Diagnostics. Our approach to improving diagnostics is to teach the construction and use of diagnostic algorithms -- similar to troubleshooting charts. Our adoption of this process was based on the express feedback of trainees during our early trial programs. Early processes generally improved either accuracy or speed at the expense of the other. The development and use of diagnostic algorithms improves both the accuracy and speed of diagnosing cause.

In structuring the unit on diagnostics we had to ensure several key objectives were accomplished. First, and most important, we had to convince the trainees that this was a useful process. Second, we needed to ensure that the trainees had sufficient knowledge. Third, the trainees had to learn the process well enough to perform as a group. Finally, trainees needed to practice using the process and using the resulting products. These objectives were accomplished with a performance pretest, instruction on developing diagnostic algorithms, practice developing algorithms, and validation exercises.

The performance pretest consists of what some individuals refer to as a drill. The instructor gives the trainees a set of plant conditions, some symptoms of possible problems and then answers trainee questions. The trainees are limited to asking questions that can be answered yes or no. At any time the trainees are allowed to identify the problem and its causes. If a trainee answer is correct the test ends. If the trainee is wrong the test continues. Throughout the test a running total is kept of both time and the number of questions asked. If possible, the specific questions asked are also recorded.

Following the pretest, the trainees receive instruction in the development of diagnostic algorithms. We believe that it is critical for the trainees to develop the algorithms. Proponents of "expert systems" advocate the delivery of completed algorithms. We oppose this position. The only way to ensure that the trainee understands the algorithm well enough to use it is for him to develop it. (Reference 10) This does not preclude the instructor gently guiding the creation of the trainees' product, but it does preclude canned algorithms. To aid students we have developed a job aid that guides them through the development process. Our model is the second attachment to this paper.

Next comes practice exercises. Trainees are given an initial set of conditions and symptoms and the instructor then leads them through the development model. Initial attempts at development require a significant amount of instructor guidance. However, trainees usually require no more than two guided practice sessions before the group can function independently.

Following each development exercise are validation exercises. The validation exercises are conducted in the same manner as the pretest, except that the trainees now have a completed algorithm. The validation exercises accomplish two goals. First, they make sure that the trainee's algorithm is valid. Second, they demonstrate the effectiveness of the process to the trainees.

The Results

Preliminary results show successes in both areas. The impact of the team building module will be the most difficult to evaluate. Currently, we are limited to feedback from the few plants that provided the training to their crews early in 1986. These are the only plants that have had the time necessary to make any significant changes. In this group many plants report that they have made changes in the team cultures of the crews and believe that it has been beneficial.

With the diagnostics module, two different kinds of results are expected. In the short term, the comparison between the pretests and the validation exercises has demonstrated increased process efficiency. In the long term, improved diagnostics should result in increased plant availability for two reasons. First, as crew diagnostics improve they should recognize and diagnose problems before they require a plant shutdown. Second, improved problem diagnosis should lead to increased anticipation, so crews will recognize potential problems and correct them before they become serious.

In any event this two-pronged approach to crew training, improving team culture and using diagnostic algorithms, should substantially reduce human performance problems by improving crew performance in all three interface.

Other Applications

As an adjunct to this program we are also exploring the use of algorithms to accelerate task analysis, improve learning of systems function and interface, develop job performance aids and teach emergency operating procedures. In all four areas we believe that algorithmization will produce positive results.

We have also expanded our work in team building to include a course for managers. The crews that attended the base course had always claimed management should attend, and management asked for the course. Team Building for Managers is a more intense look at the process of fostering team and organizational cultures. Like Team Building and Diagnostics, it too is based on a discovery. The key discovery for the managers, is that management does not create culture; rather it works with the culture that already exists. Cultures require time to change. Effective managers who realize that are patient enough to wait to see the results of their actions.

As important as it was to discover that control room teams needed more than training focused only on team skills, we suspect that we have uncovered just the tip of the iceberg. Viewing working units as discrete cultures and using algorithms to capture and improve work processes may be only the first of the "new age skills" (Reference 11) that must be addressed in industrial training.

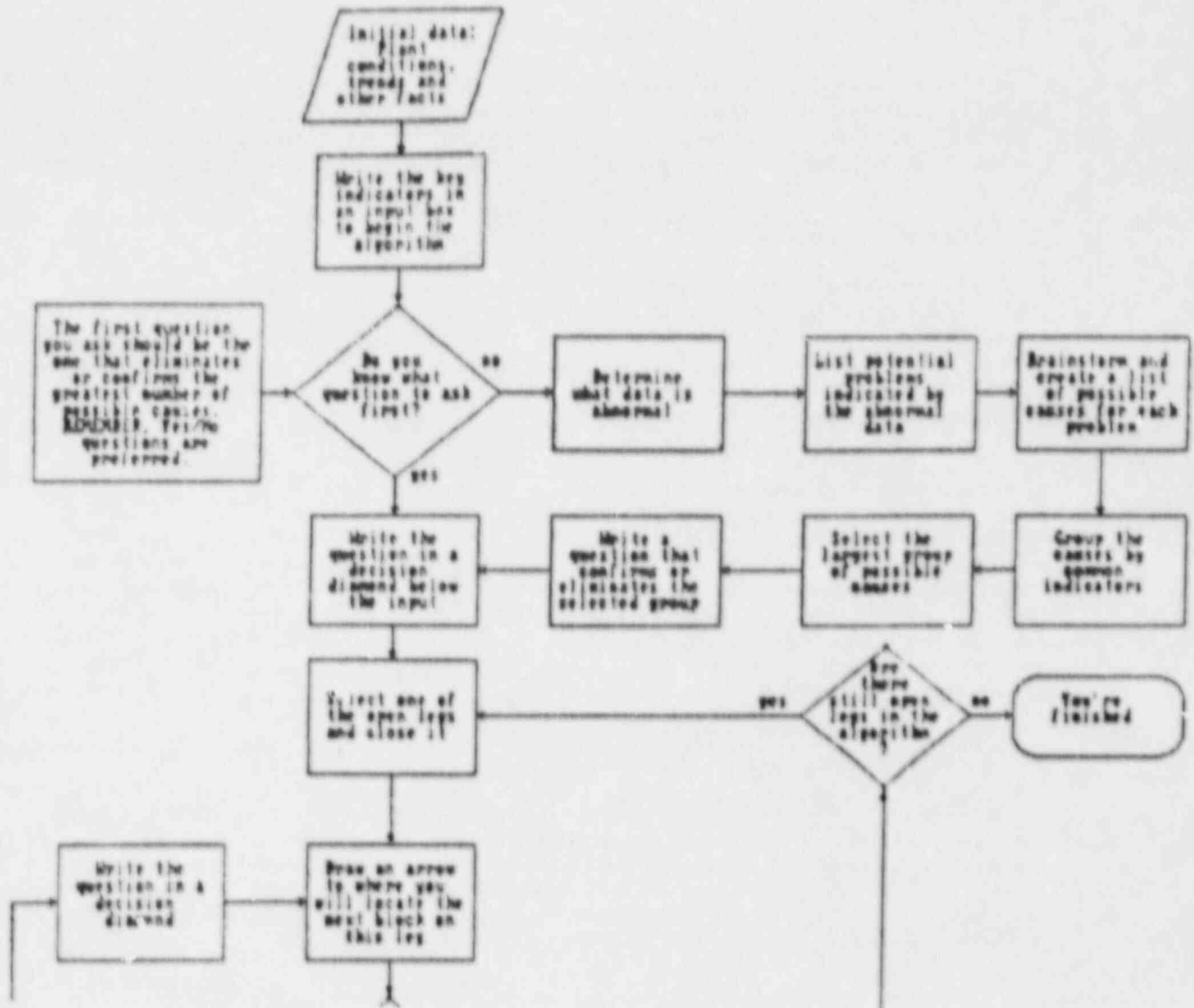
TEAM WORK RATING SCALE

1. FEEDBACK - anticipating input needs, providing unsolicited feedback.		
<p>Members wait to be asked for inputs. Inputs answer only the questions to be asked.</p>	<p>Some members volunteering information. Answers complete, even when questions are not.</p>	<p>Abundant unsolicited feedback. Few questions required. Inputs complete and useful.</p>
2. COMMUNICATION MONITORING - Monitoring team communications to assure fidelity.		
<p>Members ignore other conversations. Fidelity of team communications low.</p>	<p>Members listen to each others conversations. Major technical errors corrected.</p>	<p>Members assume responsibility for fidelity of team communications. Errors corrected quickly.</p>
3. STRATEGIC DEVELOPMENT - Leadership; overall plan; whole situation perspective		
<p>No one "in charge" Plan is insufficient. Procedures not used, or violated. Loss of overall perspective.</p>	<p>Team leader "in charge." Plan is well developed, and adequate. Overall perspective of critical conditions is maintained.</p>	<p>Team leader clearly directs team activities. Plan is detailed and comprehensive. Panoramic perspective of situation maintained.</p>
4. TASK ASSIGNMENT - Assignments to accomplish specific tasks		
<p>Unable to justify deviations from procedural assignments. Important tasks not done/ done incorrectly because of poor assignment. Team members reject assignments.</p>	<p>Task assignments appropriate for the situation. Team members accept assignment strategy.</p>	<p>Task assignments are consistent with crew strategy. Assignments promote team development. Members willingly accept all assignments.</p>
5. DECISION MAKING - employing an effective group decision-making process.		
<p>Individuals present conclusions, not reasons. Process dominated by one or two people. Conflict is suppressed.</p>	<p>Mixture of reasons and conclusions presented. Decisions made by consensus. Most team members support decision.</p>	<p>Team developed a common data base. Decisions evolved from common data. Team members clearly support and implement decision.</p>
6. COORDINATION - Team interactions leading to task execution.		
<p>Task not accomplished. Team members unable to resolve conflict. Team members sidetrack often.</p>	<p>Major aspects of task accomplished. Some discord evident.</p>	<p>Individual activities compliment each other. Task completion in most efficient manner.</p>

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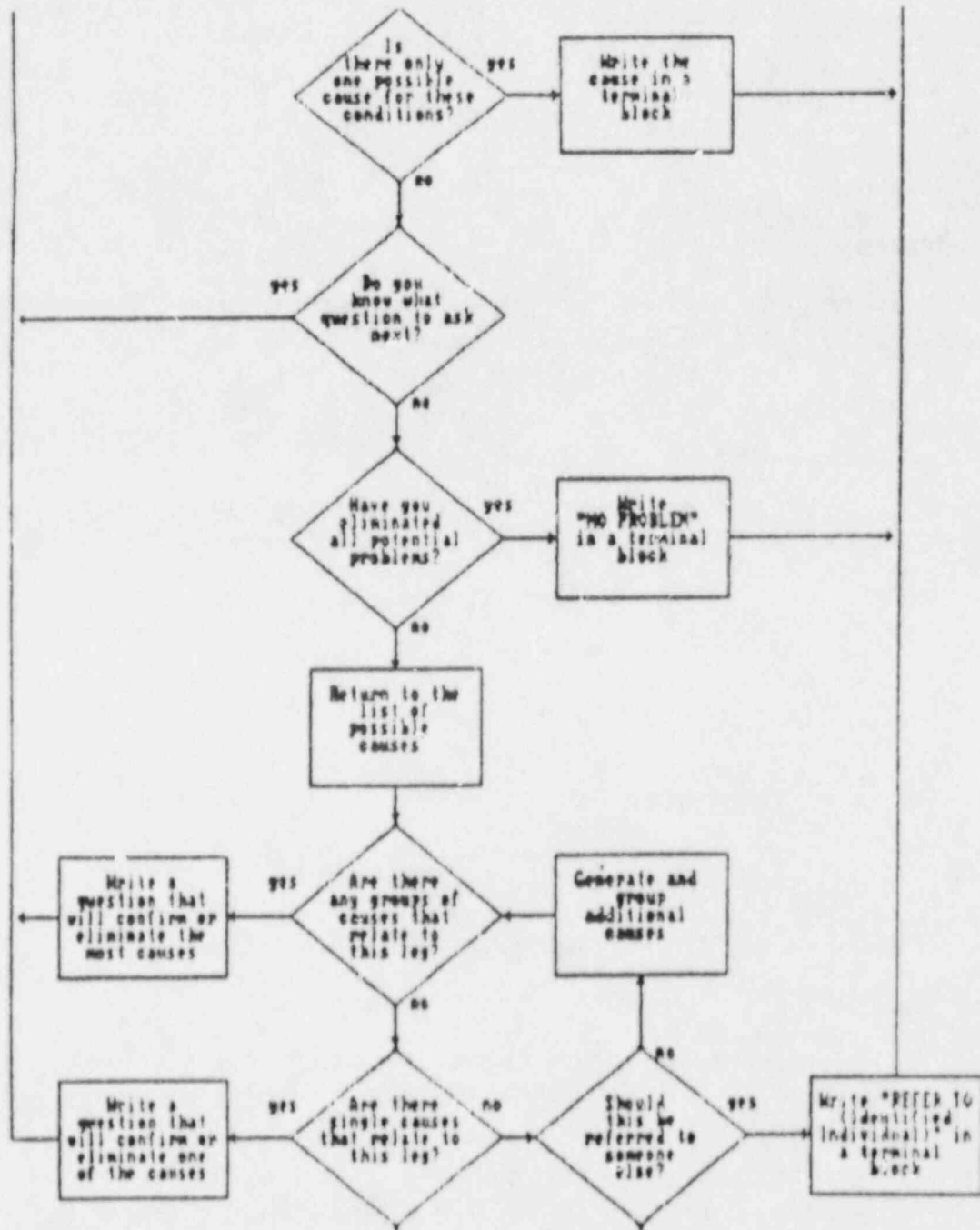
GENERAL ELECTRIC

Guide for Developing Diagnostic Algorithm



(Continued on following page.)

Guide for Developing Diagnostic Algorithm (cont.)



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Discussion

DR. PERSENSKY: How does the diagnostic training reinforce, if it does reinforce, the symptom-based EOP's, as opposed to the event-based EOP's.

MR. BULMER: It is really very similar. In both cases you are dealing with symptoms. With an EOP, you are dealing with symptoms to determine an immediate action. Once the immediate actions have been taken, you have essentially taken care of the emergency. Then you shift to look for cause on the basis of the symptoms. So the algorithms that we are developing supplement what individuals are already dealing with. We are not reverting to classifying events.

EXPERIENCES AND SOLUTIONS
WITH AN INTEGRATED MODULAR APPROACH TO NUCLEAR
EMERGENCY PREPAREDNESS AND RESPONSE TRAINING PROBLEMS

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U.S.A.

Abstract

Increasing public concern with nuclear safety after TMI and an escalated level of licensing requirements regarding nuclear emergency preparedness have presented unique challenges to the U.S. utilities in expeditiously setting up effective training programs. This paper summarizes the generic aspects of these challenges, identifies the causes, and describes solutions derived from experiences at several nuclear power stations in the application of an Integrated Modular Approach to emergency response training. Also described are features of the critical design and implementation elements in this approach, the use of Job Analysis, Test Banks, Qual-Card System, and a Graduated Instruction and Practice Scheme, and the factors that have a significant impact on the schedules and effectiveness of training.

Introduction

Experiences since the TMI accident and the recent Chernobyl accident continue to demonstrate the need for nuclear emergency response preparedness. In the United States, such need has been judicially emphasized by regulatory requirements regarding emergency planning (EP) and training to provide capabilities in, or to establish, the following [1],[2],[3]:

- Emergency Plan
- Emergency Response Organization
- Emergency Response Facilities
- Accident Classification and Emergency Action Levels
- Emergency Communications and Notifications
- Inplant Accident Mitigation and Corrective Actions
- On-site Operational and Technical Support
- On-site Personnel Protection and Accountability
- Off-site Response and Support Coordination
- Public Protective Action Recommendation and Implementation
- Radiological Assessment and Environmental Surveillance
- Emergency Recovery
- Demonstration of Overall Accident Management and Public Protection Capabilities through Drills and Exercises

The increase in the scope of regulatory requirements for emergency response preparedness and an increasingly vocal public apprehension of severe nuclear accidents have created unique problems and challenges for emergency planning and training groups. Furthermore, nuclear station, utility corporate, and non-utility (off-site) agencies must be capable of successfully responding to any level of declared emergencies and must demonstrate that capability biennially, in part or whole, through federally observed exercises. This requirement puts demands on the training program to be highly integrated and effective, and to meet tight schedules. The ability to mobilize plant and corporate resources, and non-utility off-site parties, in training and exercises often becomes the decisive factor in obtaining or maintaining an operating license.

This paper presents a portion of Stone & Webster Engineering Corporation's experience as a consultant in working with US utilities to establish effective on-site (4,5,6) EP training programs. Emphasis is placed on the design and implementation of an integrated Modular Approach to EP training of station personnel, which approach has been applied successfully in a number of operating and near-term-operating-licensee (NTOL) cases. This approach can substantially improve EP training design and implementation, especially in the NTOL case, in terms of meeting schedules and avoiding costly and unproductive paths.

Overview of Training's Role in an EP Program

An overview of the major elements involved in an EP program is presented to highlight the potential problems and challenges in establishing a working EP training program. Although there are many forms and classification schemes through which to express the contents of an EP Program, these elements can be summarized generically into the following categories:

- Planning
- Training
- Exercise
- Facilities
- Technical Support
- Document Production and Control
- QA/QC

Major tasks in each of these EP program elements are given in Table 1. EP Training takes its mission assignments and schedules from Planning, with system approaches (e.g., hardware and software choices for dose assessment) defined. Training must deliver results that will enable the Exercise to meet the final goal: passing the annual graded exercise, within the schedule. To implement their tasks, both Planning and Training must rely on the

Table 1. Emergency Planning
Program Elements and Tasks

<u>Program Element</u>	<u>Major Tasks or Support Activities</u>
1. Planning	<ul style="list-style-type: none"> a. Overall planning and coordination of EP related budget, manpower, schedules, commitments, system approaches, exercises, logistics, etc. b. Development and updating responsibilities for EP related software, including: plans, procedures, organizations, etc. c. Corporate/Plant/Off-site liaison; licensing and public affairs interfaces; management briefing.
2. Training	<ul style="list-style-type: none"> a. EP Overview and Indoctrination program. b. Prepare lesson plans, mini-scenarios, tests, and other training aids, for field and classroom use. c. Develop and qualify instructors. d. Secure training facilities and equipment. e. Develop training matrix and schedule; conduct classes, evaluate results and keep records. f. Coordinate specialty group drills. g. Maintain a library of EP training references.
3. Exercise	<ul style="list-style-type: none"> a. Full-scale exercise planning and coordination. b. Scenario development, submittal, revision, production, and distribution. c. Exercise logistics; referee, controller and observer briefing and assignments. d. Conduct of full-scale exercises; critique and summary report of findings, etc.
4. Facilities	<ul style="list-style-type: none"> a. Specification, procurement, installation, distribution, maintenance, and inventory of all EP-related equipment, systems and facilities that are not assigned to any other departments. b. Maps, status boards, plans, procedures, drawings, and other office supplies for emergency uses. c. Emergency vehicles; aerial transportation and surveillance coordination. d. Setup and maintenance of EP physical facilities. e. Miscellaneous logistics for training and exercise uses.
5. Technical Support	<ul style="list-style-type: none"> a. Plant operations; plant systems and engineering. b. Environmental and Meteorology. c. HP/Chemistry: dose assessment; post-accident sampling of plant data; radiation protection. d. Core physics and fuel related calculations. e. Licensing. f. Corporate communication and public affairs. g. Simulator training. h. Medical, fire fighting and security support.
6. Document Production and Control	<ul style="list-style-type: none"> a. Word processing and document production. b. Maintenance and updating of a central master file of current versions of all EP related plans, manuals, procedures, and forms, etc. c. Issuing, receiving, distribution and filing, of all correspondence and communications; overall program record management responsibility.
7. QA/QC	<ul style="list-style-type: none"> a. QA/QC audit; check compliance with relevant corporate policies and guidelines. b. Interface with NRC and INPO QA audits.

support of Facilities, Technical Support, and Document Production and Control, with each subject to the audit of QA/QC to assure program quality and enforcement. The effects of various feedback and interaction between program elements and participants, while not shown in Table 1, can be as complicated and as significant in determining the appropriate course as is the initial licensing program.

Generic Challenges in EP Training

EP training presents unique challenges because of its:

Scope - Multifaceted:

On site and off site, the plant and corporate management, the utility and the public, and the local, state and federal governments are all elements involved in an EP response. The orchestration of all of these parties to produce a unified response to a simulated or actual nuclear plant emergency is directed by a utility emergency response organization according to scores of plant, procedures, manuals, guidelines, agreements, and commitments (software). These in turn dictate the use by the participants of a multitude of emergency equipment and facilities (hardware) in a pre-planned fashion, each linked by a network of emergency or augmented communication systems.

The vital role that Training plays here is to set the EP mechanism into motion: to involve every participant identified by planning in the running of the emergency software on the emergency hardware in an organized way and as pre-planned, such that the end result fulfills the utility's responsibilities for preparedness. Training activates the participants by proper indoctrination through classroom and field practices, entering each one into the emergency response network and linking them coherently according to Planning Exercise tests all the "links" and "gears" until the "machinery," or the emergency response organization, fulfills the corporate commitment and applicable Federal requirements.

The scope of training necessary to achieve these goals, on site and off site, is significant.

Breadth - Multidisciplines:

A large cross-section of the utility's plant and corporate organizations is involved: preparedness must be addressed by every discipline, and emergency response preparedness cannot be considered complete if even one such element is missing.

Target - Multileveled:

Preparedness for response to credible types of accident scenarios requires the direct involvement of a majority of the plant and corporate levels of personnel. The teams of administrative assistants, technicians, operators, engineers, supervisors, plant managers, and corporate staff and executives must be trained and qualified in various response roles as identified in the emergency plan, covering all shifts and hours.

Schedule - Invariably tight:

Because of annual training exercise requirements and other commitments, training for complete on-site response preparedness usually must be accomplished in less than one year. For extremely pressing cases, as for some NTOL's, it could be demanded that everything be ready in 8 to 10 months. Tight schedule is usually the most visible and serious problem presented to the training group -- because of the extensive work to be done in almost every aspect of the EP program. In the NTOL case, training also must compete with other pre-operational activities for the available time of key personnel.

Such problems, however, may not be equally visible to management, whose limited knowledge and experience in meeting EP requirements often result in little patience for long schedules and extensive programs. Unfortunately, persuading management by way of inadequate performance in a full-scale graded exercise is not an approach that training departments can afford to take.

Method - Necessarily diverse:

To cover the objectives of EP training, it is seldom possible to limit the training methods to conventional classroom-type instruction. The vast scope of the training, the multidisciplined and multileveled composition of trainees, and the unique way by which EP is to be integrally evaluated all call for the use of a diverse combination of training techniques and formats. These techniques and formats must be prepared and delivered separately. For example, lesson plans and audiovisual aids are needed for classroom sessions, while scenarios, data sheets and emergency kits are required for field exercises and most drills. The extent of coordination and the number of instructors involved also vary from one format to another, with some best served by a team approach. Such variety and diversity in training techniques and formats pose further challenge in the area of training program design.

Evaluation - Unique and stressful:

Even before an exercise, various corporate QA, INPO, and NRC audits, inspection tours, and fact-finding interviews may be conducted as a part of the total evaluation process. The full-scale exercise receives much added attention, being observed and critiqued by major federal teams, which are well-staffed with trained observers. Within 48 hours, the public will have a chance to hear the regulatory agencies' preliminary comments and deficiency findings on the exercise, well before the utility has a chance to develop a response. The news media also can participate in the exercise. Observations and records of critical acts and performances that are important to the federal decisions are sometimes subject to verification and different interpretations, and must be quickly reviewed, clarified, or contested. All these factors contribute to making the evaluation a particularly unique and stress-laden event.

Consequence - Costly and critical:

The consequence of inadequate performance could be significant and costly. Remedial exercises may have to be scheduled and conducted to demonstrate correction of deficiencies; fines may be imposed; licensing activities or approvals may be delayed; and, in the most extreme case, a show cause order for shutdown may be issued. In any event, training will have to be at work again to assist in correcting personnel performance inadequacies.

Since the early 1980's, training at most U.S. nuclear sites has undergone considerable changes [7]. Not only has training acquired a larger and more important role in the qualification and upgrading of plant personnel, but the better-trained personnel have provided much constructive feedback (during and after training), further impacting training and even the basic design, operation, and maintenance of plants. The use of site-specific simulators, ultra-modern computer-based and videodisc presentations, and various innovative heuristic and behavioral techniques, plus the additional audit, inspection, and accreditation requirements from INPO and the NRC have all ensured it is no longer an "invisible trade" with negligible manpower and budget needs. Along with this trend, of course, is the ever increasing need to measure the cost effectiveness of a training program to justify the prudence of expenditures. Consequently, the tasks of training and the tests of the results have been analyzed, defined, and conducted in increasing detail and rigor.

The training department that has gone through this evolution caused by the collective effect of the factors given above is quite different from that of several years ago. One of the new challenges for the EP training program developer is getting

the existing training department involved to accept both its much wider current role and the need for an integrated training program.

Specific Problems from Experiences

Problem of initial assessment for program design inputs:

For cases where an EP program must be totally revamped or newly created, proper assessment of what has been done and how well, and what needs to be done and when, is essential. Accurate initial scoping that covers the status of both on-site and off-site capabilities and the associated constraints, often is difficult but necessary. It is necessary for the development of a realistic schedule and also necessary when obtaining management approval of resources needed to meet this schedule. Without a clear and thorough initial assessment, a training program could be designed with little reserve capability to deal with the certain, but unforeseen, adverse events that potentially can disrupt the implementation schedule.

Problem of off-site influences on schedules:

The exact balancing of matching resources with schedules to achieve the desired goals does not always work for EP planning and training, because of the non-technical and other off-site emotional and political factors involved. Certain off-site conditions may have an interlocking effect on the available on-site options for hardware and software choices in the areas of communications, prompt notification, and off-site surveillance. On-site training may be impeded if decision-making requires extra meetings and lengthy coordination steps. The many changes and interim positions, may result in delays or the need for retraining and re-drilling. These off-site conditions, including participation and cooperation in the total effort, are not always within the utility's control because of the factors cited above.

The potential delays in schedule that these off-site interfaces may cause are sometimes beyond the utility's control and ability to remedy. Such potential trouble areas should be identified as early as possible to guide the program design in seeking an aggressive, early initiatives to resolve the problems or to strategically bypass the problem. Only then can training be set in motion, based on a relatively firm framework. Adequate consultation and planning based on experienced design input advice at this stage is critical.

Other problems and considerations in on-site training design and implementation:

- Who in the emergency response organization must be trained? In what aspects of the emergency response must the person be trained and to what extent?
- How many persons must be trained for this position?
- When in the sequence of training must this be accomplished?
- How does the planner and trainer keep track of who has received training and the adequacy of that training?
- How will turnover and change of assignments of personnel be accommodated?
- How will the impact of changes in system approach, emergency response organization, and leadership be accommodated?
- What impact will result from changes in plans, procedures, action levels, set points, or and other required emergency response software? What software is incomplete or unavailable?
- What impact on schedule will result from delays in delivery, modification, or changeover of emergency systems, equipment, or any other emergency response hardware or facility items?
- What special provisions are necessary in scheduling of management and union personnel, and what is the availability of key station personnel for training and related support?
- Are training and test materials accurate, consistent, balanced, and updated; is the organization prepared for the processing of feedback?
- How will the need for retraining and requalification be tracked; how will personnel be notified, and what record keeping is necessary?
- Does the training program have adequate management, staff, and logistic support?
- What special provision must be made to provide for the development and qualification of training staff? Is the workload reasonable enough to preclude burnout?

What are the deficiencies in the existing training program that have been previously identified by various QA audits; what is the status or resolution for each?

An Integrated Modular Approach to EP Training

To provide a basis for tackling these problems and challenges, an Integrated Modular Approach to the design and implementation of emergency preparedness and response training has been created and refined through case experiences.

The integrated component recognizes the broad facets of an EP training program and the unique method by which it is evaluated, while the modular component deals with the dynamic environment from which program design inputs and support activities are determined. The modular approach provides the flexibility and the diversity that the program implementation requires because of its multidiscipline, multiformat, and multilevel nature while the integrated approach is necessary to accomplish EP training program initiation and to conclude the final phase while the program is delivered in modules in the middle.

The integrated design approach minimizes the potential of a chaotic program implementation by considering the maximum number of input parameters and constraints affecting the modules as can be identified at the onset of EP training development. Typical input parameters include overall schedules, plant status, off-site geopolitical inputs, corporate philosophy, and the emergency organizations, divisions of responsibilities, response protocols, system approaches, backup alternatives, manpower and resource allocations, and EP-related licensing commitments.

Within the framework established by these integrating or connecting elements, the program is developed and built in modules that can be as varied and flexible as desired to meet the individual functional or personnel group training requirements. An important realization from our experience is that the sooner this framework is set up, the faster the modules can be completed - and the firmer the framework, the fewer the revisions of the modules, and hence the quicker and smoother the program implementation. It pays to carefully cast the input parameters and constraints in the beginning to be as realistic and complete as possible to ensure individual modules are relatively invulnerable to changes that occur during the course of implementation.

On the other hand, even the most well thought out and planned program design cannot guarantee to have provisions for all contingencies. Through experience, a variety of generic contingency elements may be adapted as program implementation aids

to specific site situations. Use of these, and a careful layout of the initial framework and the modules, help create a more efficient program that is able to meet schedules with less manpower and budget requirements, and with fewer repetitive or unnecessary, unproductive efforts.

Typical steps in the design of an EP training program using this Integrated Modular Approach are identified and discussed below:

Framework Steps -

- Obtain Management Support
- Identify On-site/Off-site Status and Constraints
- Define Training Goals
- Match Overall Schedule and Resource Requirements
- Perform Job Analysis and Define Training Modules and Submodules
- Develop Training Matrix
- Identify Personnel to be Trained
- Establish Qual-Card System and Evaluation Standards

Module Development Steps -

- Develop and Qualify Instructors and Teams
- Establish a Graduated School of Instruction and Practice
- Develop Lesson Plans, Handouts, and Audio-Visual Aids
- Prepare Study Plans and Table-Top Simulation Events
- Set up Test Bank, Procedures for Evaluation and Security
- Schedule Classes and Drills
- Conduct Classes, Table-Tops, and Drills
- Process Training Homework, Feedback, and Suggestions

Integrating Steps -

- Review Exercise Deficiencies and Take Corrective Actions
- Program QA/QC, Progress Monitoring; INPO/NRC Interfaces

Set up the framework for identification of individual modules and program design:

The "Framework Steps" above are aimed at setting up the initial framework for developing the modules. Obtaining management support is a prerequisite to the fast and efficient development and implementation of a successful program, because of the broad spectrum of personnel, disciplines, and resources required. As presented earlier, it is then vital to develop an accurate assessment of the initial constraints and their status of both on-site and off-site aspects of the EP program. If certain

off-site or nontechnical elements seem to take more time than the schedule would allow for their resolution, it is often advisable to set an early cut-off date for making decisions, to include or exclude such efforts or events, and to save the demonstration of those portions of the emergency plan for the next, or a separate, exercise. Under present regulations, certain possibilities exist while other options are moot.

Similarly, if major systems or parts thereof are not likely to be ready by the anticipated exercise date because of foreseeable circumstances that are beyond the utility's control, then they should be subject to the same include-exclude decision. The purpose of an early decision is to avoid those last-minute communications and scope changes, which could seriously affect the on-site organizational performance and training progress, especially for cases where the schedule is tight and the luxury of retraining to accommodate changes is absent.

After the primary training goals are defined, drafts of schedules and required support estimate can be presented to corporate management, refined, and then approved. Changes should be expected and contingencies allowed where possible, with alternatives and their costs included.

To answer the question raised earlier about who, what, when, and how of on-site training, a Job Analysis is used in conjunction with the Site Emergency Plan and the training goals and schedules just completed. For NTOL and cases where EP programs are being extensively revised, Job Analysis serves to bridge the gap between what is written in the Emergency Plan and what the plant managers and supervisors would like to have based on their own experience. Such analysis also covers details that are not usually given in the Emergency Plan but which may be important to good performance.

Job Analysis first sorts out the major functional blocks in the Emergency Organization section of the Emergency Plan, and uses a combination of discussions, interviews, and inter-departmental exchanges among the EP planning, training staff, the plant supervisors, and the site emergency response managers, to develop a description of each of the jobs assigned to the block under that supervisor or manager. As examples, the description would include the number of HP/Rad-Chem technicians required to cover the Post-Accident Sampling System, and the qualification and responsibilities of each person in the Dose Assessment Team at the EOF.

Guidelines for sorting out the functional blocks depend on the utility's philosophy in the response approach and the station's division of responsibilities. An examination of the station's

Emergency Plan Implementation Procedures (EPIP) and the on-site Emergency Organization will confirm the functions assigned to each group. Each of the five traditional main categories of emergency response elements --

- Command and Control
- Accident Assessment
- Notification and Communications
- Protective Actions and Recommendations
- Corrective and Support Activities

-- can be subdivided into approximately ten functional areas. One such sample breakdown is given in Table 2.

Table 2. Example of Emergency Response
Breakdown into Functional Areas.

1. Emergency direction and control
2. Plant operations
3. Corrective actions and repair
4. Technical support
5. Radiological accident assessment off site
6. On site radiation protection
7. Administrative support
8. Communications
9. Public affairs
10. Security

An alphabetical function code is assigned to each position according to its functional area. Next, a unique numerical staff code is given that identifies the individual and the level of the position in that functional group. For example, the responsible manager is given a staff code "1." These codes may be accompanied by other codes for the position, such as an operation location code and an availability time code, thus making the organization chart of greater use. Examples of the codes applied to an ALERT level of emergency organization are given in Table 3 and in Figures 1 and 2.

With a simple code system like this, all positions within emergency response organization can be sorted and processed easily on a database system. The principal use of this information is to aid the development of the Training Matrix, which is described later in this section.

Job Analysis is a top-down process that provides the key personnel an opportunity to define the job descriptions in their groups, given the group's responsibilities. Each supervisory level person is confronted with similar questions regarding the kind of staff, how many persons, each to do what, that they need to

Table 3. Emergency Response Organization Code Key

FUNCTION CODE	OPERATION LOCATION	AVAILABILITY TIME
A - EMERGENCY DIRECTION AND CONTROL	CR - CONTROL ROOM	OS - ON SHIFT
B - PLANT OPERATIONS	OSC - OPERATION SUPPORT CENTER	30 - 30 MINUTE
C - CORRECTIVE ACTIONS AND REPAIR	TSC - TECHNICAL SUPPORT CENTER	60 - 60 MINUTE
D - TECHNICAL SUPPORT	CP - CONTROL POINT	NA - NON APPLICABLE
E - RADIOLOGICAL ACCIDENT ASSESSMENT OFFSITE	EOF - EMERGENCY OPERATIONS FACILITY	
F - ONSITE RADIATION PROTECTION	GH - GUARD HOUSE	
G - ADMINISTRATIVE SUPPORT	ON - OTHER ONSITE	
H - COMMUNICATIONS	HQ - HEADQUARTERS	
I - PUBLIC AFFAIRS	ENC - EMERGENCY NEWS CENTER	
J - SECURITY		

Figure 1. On-Shift Emergency Response Organization

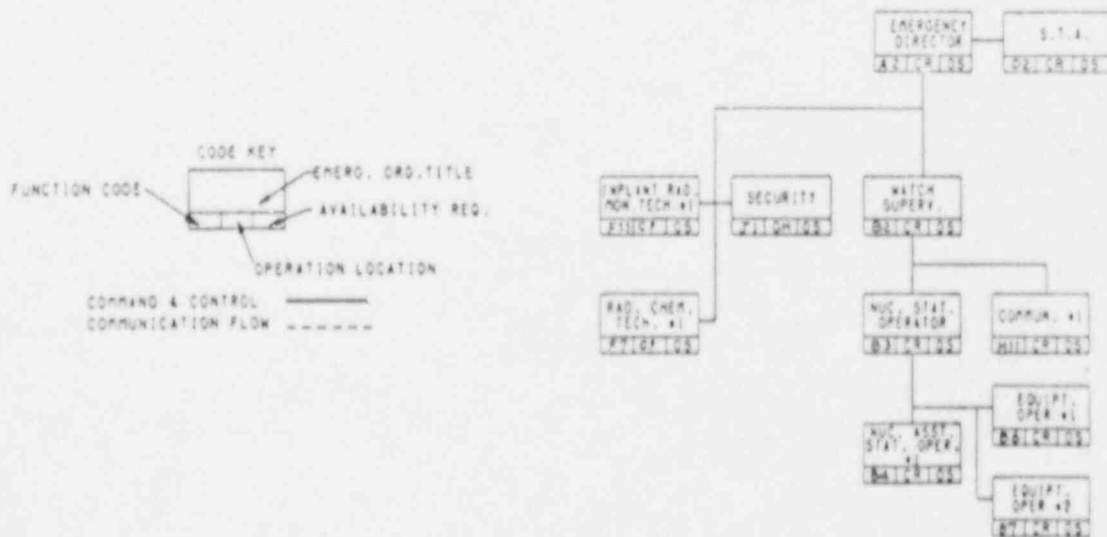
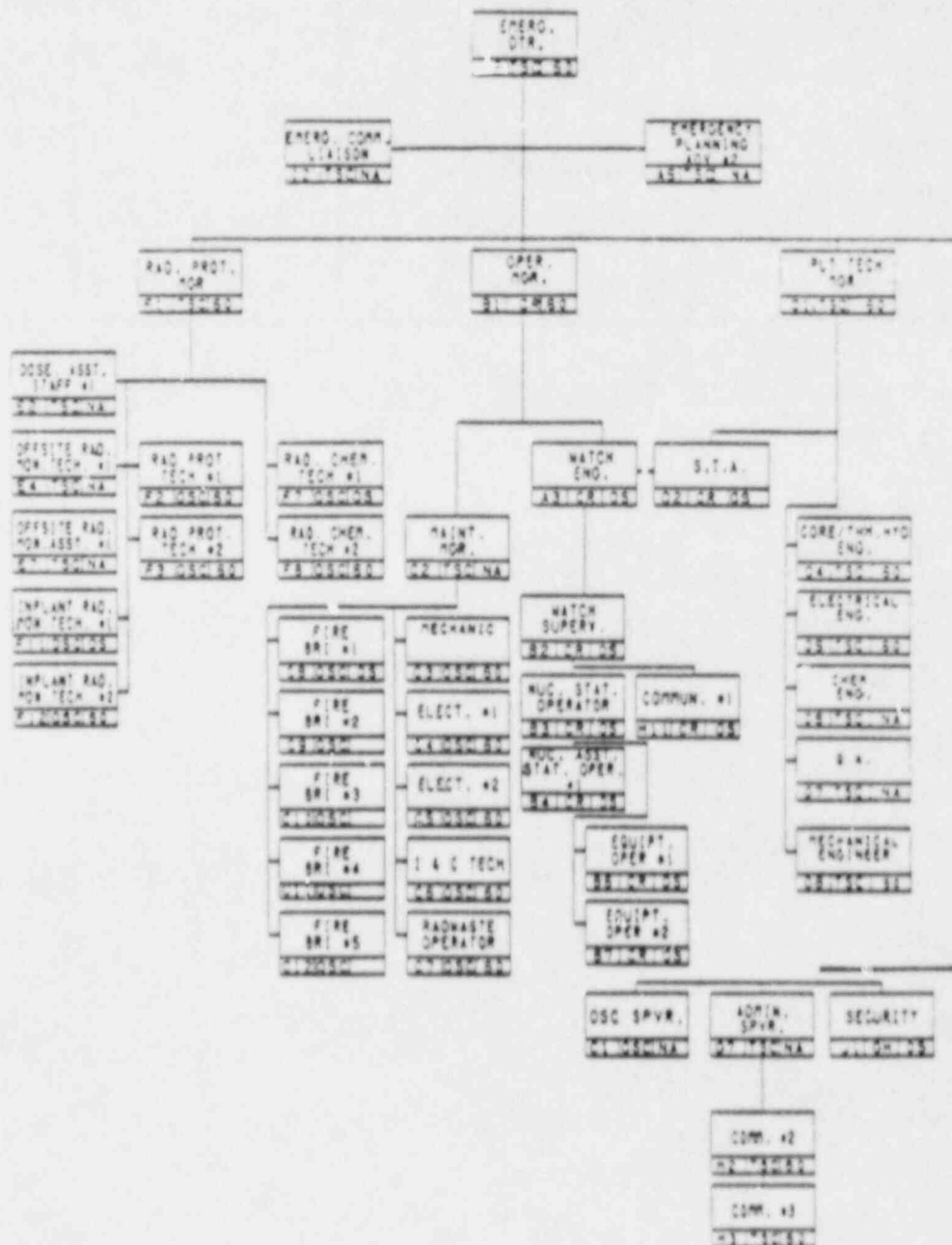


Figure 2.

ALERT EMERGENCY AUGMENT EMERGENCY RESPONSE ORGANIZATION



accomplish the assigned mission be their superiors or as required in the Emergency Plan. The staffing decision process repeats at the next level of supervisors.

Through this process, each supervisor in the organization is given the authority and responsibility (with accountability), to define the composition of his or her staff, and thus is allowed a more or less "personalized" style of leadership that has the benefits of the group leader's own knowledge and experience of how to do the job best in the plant environment. Such freedom to individualize a group's composition is, of course, subject to the limits set by the Emergency Plan, unless the potential benefit is commensurate with the difficulties in revising the Plan commitments and that occurs.

The use of Job Analysis results in a more reliable, and workable, functional definition of the emergency organization that is likely to only infrequently require change in job descriptions or in the structure of the organization. By allowing supervisors to participate in the design and confirmation process, the need to fine tune the organization has already been greatly reduced. The direct benefit goes to Training: a Training Matrix can be constructed and finalized much sooner and is less likely to be changed in the future, once completed.

The Job Analysis effort provides the job description for each position in the emergency organization and thereby forms the basis of training and qualification requirements. With qualification requirements defined, training modules within each functional area can be defined. A companion analysis of the entire spectrum of emergency response protocols and procedures is performed to facilitate a layout of the training modules. Specialty subjects within a functional area are identified, and sub-modules defined to provide the appropriate training of personnel in these subjects.

Each module contains a number of "courses" whose presentation format may be decided later by the instructor or team of instructors who are assigned to cover it. Formats can include classroom, field practice, drills, or combinations thereof, depending on the nature of the subject and the background of the trainees.

The EPIP's should be consulted to make sure that every emergency procedure to be used in particular functional area is included in the module or sub-modules, and the position responsible for the execution of a particular EPIP is indeed included in that functional area. This process checks the completeness of the EPIP's and tests the consistency of the Job Analysis descriptions. Missing procedures or positions can easily be identified through this process, and remedial actions taken promptly to avoid later impact on schedules.

When the training modules and courses are defined for each functional area, and the qualification requirements are determined, the Training Matrix can be developed. The Training Matrix provides a correlation of the positions to train and the training courses required. A computerized process is used to provide the first draft, which takes the function code and the staff level code output by the Job Analysis for each position, and matches them with those attached to the modules and courses that cover the same functional area. A joint review of the draft by the supervisors and the EP training staff will decide if modification is needed to avoid over- or under training.

The final task in this initiation phase is to fill the positions with the names of individuals to be trained. Beside fulfilling the minimal number as required by regulations, station and corporate manpower commitment, turnover rate at that level, and the availability of personnel for EP training in that particular category, also should be considered in determining the number of persons to be trained for that position.

To keep track of who has received what training and the scores or adequacy of the person's training, a Qual-Card system (i.e., Qualification Card System) is used. In this system, a qualification card, in duplicate, is maintained by the EP department and Personnel Department for each of the individuals named for the emergency response organization. The card is maintained to reflect the individual's emergency response position, qualification and training courses required versus completed, and the associated dates and scores. The EP copy is signed off by the responsible instructor after each training with the attendance record and performance scores, including the keeping of records for drills and field practices. An updated copy is periodically forwarded to the Personnel Department for the reference of the department which assigns the individual.

The Qual-Card system is one answer to the problem of tracking training results and retraining needs. The version of the course and the performance evaluation test used are retained together with the dates, so that it can easily be decided whether retraining is required when major changes or revisions in the subject occur later. Its use also provides flexibility in scheduling multiple sessions on the same subject with different dates for the trainees to select, so that each could attend a session with minimal conflicts. This has been found to be an effective scheme for managerial trainees and union personnel, who either constantly face a shortage of time or are under contract rules such that they cannot be required to attend training on dates set by management.

For QA audits, the Qual-Card System provides a basis for validating the training program; for planning and management, it serves as a monitor of training progress by offering statistics on percentage of training completed versus scheduled to be completed.

Lastly, a standard of evaluation must be established for all training formats to be used. For classroom instruction, it is usually the passing score on the written test; for field and drill formats, it can be a "Satisfactory" or "Unsatisfactory" criterion. Such evaluation standards may be reviewed and approved by the existing Training Department, with reference to existing standards

Module Development Steps. Using the Training Matrix and the defined training modules, a team training plan with divided responsibilities is formulated. The modules are further differentiated into sub-modules of manageable sizes to deal with different specialty areas or different group requirements. Each can then separately concentrate on the materials that the particular functional group needs to know. The following is an example:

Functional Block:	Protective Actions
Training Module:	Protective Action Recommendation (PAR)
Functional Areas:	- Emergency Directions and Control
	- Plant Operations
	- Radiological Accident Assessment (Off Site)

The result is the division of the training module PAR into three sub-modules: one for emergency management personnel, who have the undelegatable responsibility of officially notifying off-site agencies of the utility's PAR; one for the control room operators and shift supervisors (plant operations), who, in the highly unlikely and hypothetical case of a General Emergency situation rapidly developing before the augmented response organization can take over, must face the duty of off-site PAR determination and notification within 15 minutes of the declaration of that General Emergency; and lastly, one for the Dose Assessment group, which usually is charged with the responsibility of calculating off-site dose projections and making recommendations of PAR's to the response manager.

Each of these three functional groups has a different background and is charged with different aspects of the subject function. The instructors are also different: they will have come from the teams that cover Emergency Direction and Control, Operations, and Dose Assessment, respectively.

Instructors are the key to training quality. Initially, EP training group members, senior staff members of the plant who also are knowledgeable of EP requirements, of consultants may be used to develop a core team. The EP training manager should review

the educational background and professional experience of these core members, who in most cases also are given the task of developing the lesson plans and are responsible for the strategy of delivering the training modules. Reception of EP training by the general plant staff depends to a large extent on their reactions to the quality of the training, which comes directly from these instructor teams.

In a tight schedule situation with little or no prior EP program established on site, the number of people to be trained within the given time limit may be large. Workload on the training staff may even include non-training duties such as in Exercise or Technical Support areas. Under such circumstances, total workload control should be considered in training assignments, to avoid instructor burnout. Team training is a good solution with the added benefit of having at least some backup in case of personnel turnover.

For most NTOL cases, it is not unusual that training materials must be developed at the same time that emergency plans, response organization, equipment and procedures are undergoing rapid revisions or changes. Experience shows that overall network changes and the resultant retraining required can be minimized, if development and finalization of a set of core technical emergency procedures are prioritized, and their frozen versions made available for training at a reasonably early stage. Experience indicates that all software for the graded exercise should be available and frozen at least two to three weeks before the exercise date. Changes made after that would make it very difficult for training to be consistent unless the changes are minor and few.

Notification and Communication modules must be developed at the earliest stage possible to allow for software variances and hardware changes, which are often beyond the utility's sole control and are first identified during training. Scheduling must also consider the fact that emergency response organization and procedure developments, training (including off site), and trainee feedback often form a strong and unavoidable dynamic cycle in the presence of off-site influences. Such influences may bring about changes that are not expected by the on-site teams.

Modules can also be designed to have abbreviated and detailed versions to suit the multi-level trainee compositions. For certain groups, especially managerial, an introductory or overview type of instruction often is adequate.

The preparer of test materials for each module must address the problem of security and adequacy. Test questions must not be known to trainees before the exam even though the course has to offered more than once to different members in the same group.

Or, in the case of retraining, a fair evaluation must be obtained of achieved level of understanding after the second attendance.

A common solution is to set up a Test Bank that contains a pool of test questions, large enough to develop many test questionnaires without excessive repetition. A computerized Test Bank is designed that will draw and print a questionnaire using a simple random number generator. The generated random number is used to draw pre-numbered questions from the Bank. The pool can be partitioned so that certain fixed, key questions will always be drawn into the questionnaire, but appearing in a different order each time. To assure quality, all test material, as well as lesson plans and answer sheets, go through peer review. Depending on the size of the class, more than one test form may be used in the same class to further assure the validity of the test. Security provisions are applied during drafting of the test material, as well as on the retrieval process from the Test Bank.

For each module, guided by schedule and other hardware constraints, instruction methods are selected and a Graduated Instruction and Practice Scheme is implemented. For example, the following (except the last two) may be employed within a module:

- o Self-study plans
- o Computer-based studies
- o Classroom instruction
- o Simulator instruction
- o Table-top exercises
- o Team drills and group drills
- o Facility drills
- o Partial or full-scale dress rehearsals

Team drills involve different teams for regular shift, night shift, and backup teams to any shift. Group drills are for different functional groups, such as Health Physics (HP), Operations, Maintenance, and Communicators. Facility drills involve one or more of the emergency response, such as control room (CR), operations support center (OSC), technical support center (TSC), off-site emergency response facility (ERF), and various off-site, non-utility-operated emergency centers, etc. Specialty group drills, such as those conducted by fire, medical and security groups, are also necessary.

Procedures also are established to process the feedback and course evaluation of each session. These are solicited on standard forms collected at the end of each session. Review of these forms by the principal trainer is mandated to assure that no reasonable comments of constructive suggestions will escape the proper management attention for consideration. This also serves to complement the top-down process of organizational definition by the Job Analysis approach.

Integrating Steps. The ultimate means by which to integrate the results of all the modular training in a full-scale exercise. The primary measure of the success or failure of the training program, from a licensing point of view, lies in the outcome of the graded exercise. However, full-scale practice exercises often provide valuable information to the EP program, for its supposedly less perfect status. Deficiencies found at this stage can be used to strengthen the weak links in all aspects of the EP program, including the modules in the training program. Any findings that reflect inadequacies in personnel training, shortcomings in software and hardware readiness, or leadership in the organization, should be used positively. In addition, corporate QA, NRC or INPO pre-exercise audits also can supply useful indications directed toward improvement.

Conclusions

Nuclear emergency preparedness and response planning has met with increasing regulatory requirements and continued public attention since the TMI accident. Challenges in setting up effective on-site training programs to achieve the required level of EP performance can be met with an Integrated Modular Approach to training. This approach is designed to deal with the significant scope, tight schedule, dynamic input environment, and the multi-discipline, multi-level nature of EP training challenges.

The role of training in an EP program has been examined. Specific problems in on-site training design and implementation from case experiences are presented. Solutions to these problems with Job Analysis, Qual-Card System, and other features in the Integrated Modular Approach are described. Design and implementation steps of this approach have been presented and discussed.

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Chairman's Summary

Mr. M. Hada
Japan

The session dealt with the diagnostics relating nuclear power plant operations and team training techniques. There were five speakers in this session. The presentations given were:

- o An Approach to Team Skills Training
M. L. Roe, U.S. Nuclear Regulatory Commission
- o Training of Control Room Crews in Plant Disturbance Diagnostics -- A Methodological Framework
Jan Hedegard, Swedish Nuclear Power Inspectorate
- o Pre-License Team Training at San Onofre Nuclear Generating Stations
Mark Hyman, Southern California Edison
- o Team Building and Diagnostic Training
S. Bulmer, General Electric Company
- o Experiences and Solutions of Nuclear Emergency Preparedness and Response Training Problems with an Integrated Modular Approach
R. K. Liang, Stone and Webster Company

Mrs. Roe introduced an approach to team skills training with emphasis on the NPP control room crew. Mr. Hedegard introduced an outline of methods used for training of control room crews in the Swedish PWR plants last year. He also displayed and explained a method to select airline pilots on the same basis as the selection of NPP operators. Mr. Hyman reported team training methodology applied in the San Onofre Nuclear Generating Station. Mr. Bulmer mentioned the fact that the traditional training methods are incomplete for developing teamwork and enhancing diagnostic capabilities and a new method developed at GE was introduced. Mr. Liang introduced a methodology for emergency response and preparedness training especially developed and evaluated by Stone and Webster.

All papers were interesting and valuable. However, the chairman would like to stress the necessity of developing human relations before starting team training. Methodology, itself, is a rather theoretical and well-defined technology, but there still is ample space in which human factors could play an important role. Integrating such human factors into the methodology is one of the necessary factors which is not well discussed and surveyed.

It was also observed that professional specialists or organizations on nuclear training are actively working. They understand theories, methodologies and other basic techniques for training. In the current Japanese situation, basic training or common training, including simulators, is being conducted by the Training Centers, but still the formation of teams and team training of a shift, as a unit, is an important field where utilities should take the initiative. The expertise of professional personnel or organizations should be well utilized in the utility programs. The chairman looks forward to further reports on the results of actual utilization of methodologies on the actual nuclear power plant crew training.

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