ATTACHMENT V

INPO Training Guidelines for Recognizing and Mitigating the Consequences of Severe Core Damage

Attachment V

PRELIMINARY

NUCLEAR POWER PLANT
SHIFT OPERATING CREW
AND
STAFF TRAINING

TRAINING GUIDELINES FOR RECOGNIZING AND MITIGATING THE CONSEQUENCES OF SEVERE CORE DAMAGE

THE
INSTITUTE OF NUCLEAR
POWER OPERATIONS

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FOREWORD

Traditionally we have trained operators and plant staffs to function in their various capacities to ensure there would never be an accident in the industry that would result in severe core damage. This assurance should continue to be our goal.

We must recognize, however, that even though this goal is admirable and achievable we cannot assure ourselves and the public that such an accident will never occur. Thus the need exists to improve the knowledge and skill levels of personnel operating our nuclear plants to better enable them to cope with such an incident.

In response to requests and suggestions from industry trainers we have assembled this training guideline. You will note that in addition to addressing accident mitigation, emphasis has been placed on operator recognition of potentially hazardous operating conditions. It is essential for an operator to possess knowledge and skills necessary to consistently analyze "integrated systems operations" and through conditioned thought processes readily recognize those conditions during which the plant is most vulnerable to accidents. He must be aware of the status of plant equipment, constantly alert for off-normal conditions and cognizant of his alternatives in the event of equipment malfunction.

Some of the materials and specific details needed to adequately train in all areas of these guidelines may not be readily available. Completion of work being done by NSSS vendors and Owners Groups in the areas of special studies and analyses related to mitigating the consequences of severe core damage should provide much of the needed material. Information needed for training in some topic areas outlined should be available at the plants. Some participation by the engineering groups may be needed to assemble accurate data concerning instrumentation response under severe accident conditions.

1. Course Objective

To ensure that plant operators, appropriate staff engineers and management personnel possess the knowledge and skills necessary to recognize potentially severe accident conditions that have resulted or could result in core damage and to mitigate the consequences of such incidents.

2. Introduction

The course material outlined in these recommendations, when taught in-depth and in plant-specific form, should enable a nuclear plant staff to adequately cope with an accident resulting in a severely damaged core. In preparing these guidelines, it is assumed there is no deformation of core geometry sufficient to result in lower vessel melt-through.

In addition to post-accident-related training, the scope includes areas which better enable operators to prevent severe accident occurrences. If adequate training in such areas has been previously done and documented, it may be deleted from this course.

In order to accomplish the objectives of this course, it will be necessary for training departments to prepare plant-specific lesson plans even though many of the topics are of a generic nature. Areas generic in nature may be reactor type, plant size, selected instrumentation, general hazards, operational philosophies and optimum core cooling methods.

Detailed lesson plans should be prepared and training provided for all persons in appropriate classifications including plant management. Some classifications may require more detailed training. For example, chemical engineers and radio-chemical analysts should receive more detailed instruction in the area of chemical analysis procedures for determining the extent of core damage.

Analyses must be examined closely and care taken to ensure that accurate information is disseminated during the training process. Critical parameter instrumentation should be examined to determine its failure modes in cases of loss of power and/or exposure to accident environments. When there is inadequate information available onsite to the trainers and instrument engineers, the instrument vendors should be asked to provide the facts needed.

Training should relate to the as-constructed plant and existing procedures. Subsequent plant modifications, such as head vent installation and procedure changes related to mitigating the consequences of severely damaged cores should be addressed in training as they are completed.

3. Scope

The scope of training should include the following topics along with sub-topics listed in the course curriculum.

Core Cooling Mechanics

Potentially Damaging Operating Conditions

Gas/Steam Binding Affecting Core Cooling

Recognizing Core Damage

Hydrogen Hazards During Severe Accidents

Monitoring Critical Parameters During Accident Conditions

Radiation Hazards and Radiation Monitor Response

Criteria for Operation and Cooling Mode Selection

4. Course Outline

This course outline is provided as typical, rather than requisite, and is developed in a logical sequence for presentation. All topic areas outlined should be addressed in all programs unless training in a specific area has been provided previously.

Approximate hours are provided for each major topic and are based on a best estimate of the time needed to achieve the desired depth of training for licensed plant operators. Actual hours may vary somewhat with the type of plant and the audience to which training is presented.

4.1 <u>Core Cooling Mechanics</u> Approx. Hours - 4

Objective: The trainee will be able to a) describe the different means available for cooling the core to prevent degradation, b) state which methods are most effective for specific plant conditions.

Typical Subject Areas:

- Alternate methods of core cooling
- Hot leg vs. cold leg injection
- Core spray, core cooling effects
- The mechanics of natural circulation
- Heat removal paths including heat sinks
- Steam vs. water cooling
- Effects of boron precipatation
- Quenching effects on fuel cladding

4.2 <u>Potentially Damaging Operating Conditions</u> Approx. Hours - 4

Objective: The trainee will be able to recognize plant operating conditions in which the plant is most vulnerable to multiple failures.

Typical Subject Areas: Trainers and other knowledgeable persons select plant conditions

or transients and identify the component or system the failure of which would make the plant most vulnerable to core damage. Operator errors may be used as failures. Examples of initial conditions are:

- Loss of offsite power while one onsite power train is out of service
- Extended station blackout
- Stuck open PZR safety valve (PWR)
- Stuck open ADS valve or safety valve (BWR)
- Loss of normal heat sink following reactor/turbine trip
- Loss of DC control power to a 4160V (6900V) ESF bus
- Address damage thresholds such as: clad and fuel melt temperatures, boiling in the core, time-dependent effects and core material deformation criteria

4.3 Gas/Steam Binding Affecting Core Cooling — Approx. Hours - 2

Objective: The trainee will be able to state the symptoms, probable causes and effects on core cooling capability of steam/gas binding.

Typical Subject Areas:

- Natural circulation
- Sources of gas/steam vapor during accident conditions

- Symptoms and effects of gas/steam binding in the vessel/generator tube areas and recommended corrective actions
- Symptoms and effects of gas/steam binding on coolant pump operation
- Possible effects of introducing nitrogen into the primary system during small break LOCA (PWR)

4.4 <u>Recognizing Core Damage</u> Approx. Hours - 4

Objective: The trainee will be able to demonstrate the ability to quickly ascertain whether or not significant core damage has occurred.

Typical Subject Areas: The presentation should stress early detection in order to be most useful in determining optimum cooling modes and emergency actions. A rapid means of analysis to determine that core damage has occurred should be included. A brief description of more detailed radio-chemical analyses and criteria for determining the extent of damage should be provided, recognizing that in most cases fuel vendor assistance may be needed for analyses to ascertain details.

Ascertaining transient critical parameter peak values:

- Use of excore neutron detectors for determining coolant levels
- Use of core thermocouples; range needed for adequate use and alternate methods when underranged; readouts and recorders
- Plant computer capabilities for data acquisition, including time in and out of limits and alarm setpoints
- Use of incore (movable and fixed) neutron detectors for determining peak core temperatures
- Review of existing "post-accident" critical parameter instrumentation capabilities

Damage Verification Methods:

- Use of any installed "failed fuel" detector or similar systems
- Use of installed radiation monitoring systems to assess extent of damage as well as radiation/contamination levels
- Isotopic analysis, threshold for high probability that some clad failure has occurred
- Isotopic analyses indicating clad damage, fuel pellet deformation, and fuel in the coolant from severe clad damage
- Use of thermocouples for locating blocked flow channels

- Use of neutron detectors
- Overview of procedures for determining extent of damage

4.5 Hydrogen Hazards During Severe Accidents — Approx. Hours - 2

Objective: The trainee will be able to:

a. List the sources of hydrogen and oxygen within the primary system and containment.

b. State the hazardous concentration ranges of explosive and flammable mixtures of hydrogen and oxygen.

c. Describe the means of concentration measurement and control for hydrogen and oxygen.

Typical Subject Areas:

- Hydrogen/oxygen sources
- Hazardous concentrations and characteristics of hydrogen explosions
- Hydrogen/oxygen concentration measuring equipment and alternate means during containment isolation
- Hydrogen recombiners or other means of limiting buildup in containment
- Primary system gas venting
- Radioactive gas accumulation in containment following a break in the primary system

4.6 <u>Monitoring Critical Parameters During Accident Conditions</u> Approx. Hours - 6

Objective: The trainee will be able to:

a. Describe the factors that affect the reliability and potential failure of instrumentation associated with critical parameters.

b. Describe the probable failure modes and degree of accuracy of critical instrumentation when exposed to an accident environment including loss of instrument power.

c. Describe alternative means of determining values in the event of instrument failures.

Typical Subject Areas:

NOTE: Critical instrumentation should include the following: primary system pressure-temperature- level, containment pressure-temperature-level, neutron level, steam generator level (PWR).

- Instrument failure mode during loss of instrument power or other predictable failure (e.g., loss of reference leg)
- Containment pressure, temperature, radiation and moisture effects on readings
- Expected degree of accuracy following parameter return to normal value
- Alternate means of determining approximate value for critical parameters assuming

the primary method of measurement has failed (This may entail utilizing pressure-temperature relationships, level-temperature relationships and liquid inventory balancing considering appropriate tank and containment levels.)

- The use and capability of the plant computer in monitoring and analyzing critical parameters

4.7 Radiation Hazards and Radiation Monitor Response — Approx. Hours - 2

Objective: The trainee will be able to:

a. Describe anticipated radiation hazards associated with a damaged core

b. Describe the effect of an accident environment on radiation monitoring systems

c. Describe alternate means of estimating radiation levels within the containment from external measurements

Typical Subject Areas:

- Actuation of Radiological Emergency Plan
- Identification of plant areas normally used that may become high radiation areas
- Primary coolant and containment atmosphere sampling precautions
- Anticipated response from radiation monitors within containment

- Method of determining radiation levels by direct measurement of detector output signal
- Methods for reading radiation levels exterior to containment and calculating interior values
- Radiation monitor failure modes

4.8 <u>Criteria for Operation and Cooling Mode Selection</u> Approx. Hours - 4

Objective: The trainee will be able to:

a. List the factors to be considered in selecting a core cooling mode and describe how each factor would affect the selection process.

b. Describe the hazards to be considered in choosing a core cooling mode.

c. Describe the emergency procedures including the basis for specific actions.

Typical Subject Areas:

- Optimum core flow rate with severely damaged fuel cladding
- Criteria for coolant pump operation
- Consideration for indications of flow channel blockage and core hot spots
- Probability of offsite release
- Reliability of selected heat sink
- Reliability of cooling mode equipment and power supplies under accident conditions

- Effectiveness and disadvantages of "feed and bleed" method of core cooling
- Considerations prior to using normal shutdown cooling mode
- Importance of maintaining the containment isolated
- Corrosion effects on equipment within containment including expected time to failure in the case of submerged equipment
- Brief review of emergency procedure use to address the unexpected condition for which no procedure exists

ATTACHMENT VI

Interim Methods for High Level Releases

Interim Methods for Measuring High Level Releases

Midrange and high level effluent monitors described previously in this section have been designed and components ordered. In the interim period before these monitors are operating, the following procedures will be adopted for measuring high level releases.

Interim Methods for Noble Gases

An ion chamber radiation monitor will be installed on the side of the plant vent at about elevation 150. This location is above the entrance elevations of all gaseous effluent lines routed to the plant vent. All major radioactive gaseous effluents from the plant pass through the plant vent with the exceptions of the atmospheric steam dumps and the blowdown tank.

This unit can respond to photon energies as low as 80 kev, and thus is sensitive to the 80 kev gamma emission of Xe-133 It will have a readout at a location remote from the plant vent, with telephone communications to the control room. If the normal plant vent gas monitor (R-14) goes off scale, a person will be stationed at the high-level monitor remote readout to report radiation levels.

The radiation exposure dose rate will be converted to radioactivity concentrations in the plant vent effluent with the following equation:

$$C = \left[\frac{t^{0.25}}{K} \right] D$$

C = Concentration of radioactivity in plant vent effluent, (uCi/cc)

D = Radiation exposure dose rate (R/hr)

t = time after reactor shutdown (hours)

$1 \leq t \leq 24$ hours

K = $[2.8 \exp(-0.02d) + 1.1 \exp(-0.2d)]$

d = distance from side of vent to detector sensitive volume (inches)

$1 \leq d \leq 36$ inches

With d = 1 inch, K = 3.6 and the above relationship reduces to:

$$C = \left[\frac{t^{0.25}}{3.6}\right] D$$

This relationship was derived on the basis of shielding calculations using a computer model of the finite volume source represented by the plant vent. The source term was a mixture of noble gas radionuclides representing unfractionated core inventory following one year of full power operation.

The release rate of radioactivity in the plant vent effluent is then calculated from the following equation:

$$R = (4.72 \times 10^{-4}) \quad C \quad F$$

R = release rate of radioactivity in plant vent effluent (curies per second)

C = concentration of radioactivity in plant vent effluent (microcuries per cubic centimeter)

F = flow rate in plant vent (cubic feet per minute)

4.72×10^{-4} = conversion factor from CFM to cc/sec and from uCi to curies = $\left[\frac{472.}{10^{6}}\right]$

The flow rate in the plant vent will be determined by the presence or absence of the following major effluent inputs:

Auxiliary Building Ventilation System	
Mode 1 (normal)	73,500 CFM
Mode 2 (normal plus engineered safety ventilation)	147,000 CFM
Mode 3 (engineered safety ventilation only)	73,500 CFM
Fuel Handling Area	
All modes	35,750 CFM
Containment Purge	55,000 CFM

Interim Methods for Radioiodines

The normal plant vent iodine monitor (R-24) has a particulate prefilter followed by a charcoal cartridge for iodine collection, which is viewed by a NaI crystal and photomultiplier assembly. It is enclosed within a steel-clad lead shield effectively three inches thick. It is sensitive to 10^{-7} uCi/cc, and is described in Section 11.4 of the Diablo Canyon FSAR.

During the interim period, the charcoal cartridge will be replaced by a silver zeolite cartridge which has a very low retention efficiency for noble gases. This will prevent high levels of noble gases from being collected on the cartridge and interfering with the measurements of radioiodines.

In the event of a release where the high alarm for this monitor is activated, a person will be sent to the monitoring location where local readout and recorder are provided. This person will be equipped with a portable radiation monitor, and will be trained in good health physics practices and safe monitoring techniques, including the proper use of time, distance and shielding. These practices and techniques will be followed while approaching the monitoring location and during the entire stay there.

The portable radiation monitor will be used to determine general background levels of radiation intensity in the vicinity of the monitor. The sampling flow from the plant vent will be turned off and the time noted for later use in calculations.

If radiation intensity levels are high, an initial estimate of radioiodines can be made using the portable radiation monitor without opening the cartridge door. The quantity of radioiodines collected on the cartridge can be estimated from the radiation exposure dose rate measured outside the shield using the following equation. This equation is based on a source term involving a mixture of radioiodines representing unfractionated core inventory following two years of full power operation.

$$Q = 60\ D\ (d)^2$$

Q = quantity of radioiodines collected on cartridge (curies)

D = measured radiation exposure dose rate less general background level (R/hr)

d = estimated distance from center of cartridge to point where exposure dose rate is measured (meters)

A more accurate estimate can be made, if radiation intensity levels permit, by opening the cartridge door but without removing the cartridge. This permits the radiation exposure dose rate to be measured without intervening shield. the following equation is used, with the terms having the same meaning as above.

$$Q = 1.3\ D\ (d)^2$$

If radiation intensity levels permit, the cartridge can be removed from the monitor and transported to a location where the general background level is low enough to permit the above equation (for open cartridge door) to be applied more accurately. The cartridge can then be transported for more detailed onsite laboratory analysis.

A fresh cartridge should be installed in the monitor and the sampling flow turned on to begin a new period of monitoring.

The release rate of radioiodines in the plant vent effluent is then calculated from the following equation. The time over which the release rate is averaged should be taken as the time during which the cartridge was installed in the monitor and sampling flow turned on and the effluent instrumentation was off scale. Some judgement must be exercised to properly estimate this time period.

$$R = \left(\frac{Q}{T}\right) \left(\frac{F}{Fs}\right)$$

R = release rate of radioiodines in plant vent effluent (curies per second)

Q = quantity of radioiodines collected on cartridge (curies)

T = time over which release rate is averaged (seconds)
See above discussion

F = flow rate in plant vent (cubic feet per minute)
See discussion under Interim Methods for Noble Gases

Fs = sampling flow rate (cubic feet per minute)
Normally equal to 1.0 CFM

ATTACHMENT VII

Status of Current Operating Organization

A. Shift Technical Advisor

The Company has hired six shift technical advisors, a number sufficient for shift coverage and relief. By September 1980, they will have completed a specialized training course taught by Westinghouse designed to enhance their accident and operating experience assessment function.

B. Staffing and Shift Manning

In our June 9, 1980 letter to Mr. A. Schwencer, five alternatives were described in detail for satisfying the staff requirements for shift manning during the startup test program while operating in modes 1, 2, 3, and 4. These alternatives were:

1. Schedule testing to minimize required total number of licensed personnel

2. Improve the pass/fail ratio

3. Supplement the management and training staffs

4. Increase the number of cold license candidates

5. Additional shift coverage

By considering these alternatives, the Company believes that it has an adequate number of personnel available to assure a safe and efficient startup program in accordance with all applicable requirements.

C. Management and Technical Organization

Our June 9, 1980 letter described the establishment of the Nuclear Power Generation Department. As of July 1980, current staffing levels by department are as follows:

The Nuclear Plant Operations Department consists of 23 people with a goal of 45. The Nuclear Projects Department staff is 27 permanent and two temporary with a goal of 31 permanent positions. The Quality Assurance Department has a staff of 29 with a goal of 32.

D. Radiation and Process Monitors

The Company has hired 21 Radiation and Protection Monitors. Currently, 14 are onsite with the remaining seven starting in August. When their radiation protection and chemistry training is complete, a total of 10 RPMs will be ANSI qualified and site trained.