A-3

September 16, 1980

NOTE FOR: Warren Minners, NRR

FROM: R. M. Scroggins, RES

Enclosed for your use is our Action Plan Safety Bases for the TMI Action Plan items for which RES has the lead. This is being done in accordance with memorandum from the EDO dated July 11, 1980 and per recent discussions of the TMI Action Plan Steering Group. Safety rationale for the following Action Plan items are included:

I.A.4.3
I.A.4.4
I.D.5
I.E.3
I.E.8
II.B.5
II.C.1
II.C.2
II.D.2
II.E.2.2
II.H.2
II.H.4
III.D.2.4
IV.E.1

If there is additional information required please contact me.

RMS/je

R. M. Scroggins

Enclosures:
As stated

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ACTION PLAN SAFETY BASES

Item No. I.A.4.3

Title:

Feasibility Study of Procurement of NRC Training Simulator

Description of Action:

In addition to the increased use of industry simulators for training of NRC staff, a feasibility study of the lease or procurement of one or more simulators to be located in the NRC headquarters area will be performed.

Bases for Action:

In order to enhance NRC staff's capabilities by familiarization with reactor operation in order to assess the effectiveness of operating and emergency procedures and to gather data on operator performance, increased use of training simulators by NRC staff would be desirable. The use of training simulators near NRC headquarters could possibly be cost effective and result in the training of greater numbers of NRC staff than possible using simulators operated by industry throughout the country. The proposed feasibility study would investigate this approach and compare with other methods of providing such training for NRC personnel.

ACTION PLAN SAFETY BASES

Item No. Task I.A.4.4

Title: Feasibility Study on Upgrading of Reactor Plant Simulators

Description of Action:

1. Procure two Ad-10 special purpose computers with the host minicomputer and convert the existing BWR transient code (RAMONA-III) for operation on AD-10, to quantify the resulting increase in computation speed. Expected speed of computation is between 10 to 30 times faster than the real time and over 100 times faster than runnings on the CDC-7600 general purpose computer.

2. Arrange for involvement of the manufacturers of the training simulators to ensure that the above hardware and software packages can be absorbed in the framework of the existing simulators and those under construction.

3. Implement, on the above described hardware, the small break version of RAMONA-III code, when it becomes available.

4. Recast existing thermal hydraulic models for PWR small break analyses into the format suitable for optimal implementation on the above mentioned hardware assuring, at the same time, that the resulting hardware and software packages are compatible with the exiting (training) simulators. The idea is that those portions of the hardware and software residing in the existing simulators, which currently limit the simulator capabilities, would be replaced by the hardware and software developed as part of the above described effort.

5. Upon demonstrating the feasibility as well as the mode of operation, the simulator manufacturers would be able to perform the necessary upgrades of their products.

Bases for Action

In the wake of the TMI-2 incident, attention was focused on the ability of the existing plant simulators to describe the plant behavior during a small-break LOCA. The reasons were:

1. The simulators are used for plant operator training. Hence, it is important that the information computed by the simulator and transmitted to the operator via the control room panel reflects a reaslistic course of events.

2. The simulators must have predictive capabilities responding to a variety of operator actions and for a variety of the simple and multiple failure conditions. This precludes the use of canned instructions obtained a priori from some computer code and pre-programmed into the simulator.

3. Consideration of multiple failures and a variety of possible operator actions, especially for accidents/transients that are of considerable duration, demands real time (or faster) simulation of the whole plant and not just of the primary coolant system. Plant simulators that have (realistic) predictive capabilities are ideally suited for such explorations.

Our review of the existing PWR simulators has shown that predictive capabilities do not exist for transients or accidents that involve flashing or phase-change within the primary coolant system.

The aim of this program is to explore the use of the advanced technology currently utilized in the aerospace industry and incorporated in the special purpose computers designed to simulate complex dynamic processes with ultra-fast computational speed. If the thermo-hydraulic models needed for a predictive capability can be programmed into such special purpose computers then it may be possible to use them as replacements of the corresponding hardware/software in the existing simulators, thereby upgrading their capabilties. The BWR simulators could also benefit from this work.

ACTION PLAN SAFETY BASES

Item No. I.D.5

Title: Improved Control Room Instrumentation Research

Description of Action:

Research has been initiated in a number of areas aimed at developing new instrumentation to enhance the performance of the control room operator. Tasks are underway to improve operator-machine interfaces including studies of alarms and annunciators, plant status and post-accident monitoring systems, an online reactor surveillance system and disturbance analysis systems. In addition, new concepts for measuring safety-related physical parameters; such as, core water level, gas bubbles and low system flow rates are being investigated.

Bases for Action:

During the TMI-2 accident sequence, reactor operators either were incorrectly interpreting certain instrument indications or did not have available to them indications of many important safety related parameters. The need was clearly identified for improved measurement of important safety-related parameters and display of these parameters to the operator to enhance his ability to diagnose system performance and take appropriate actions to mitigate the consequences of an accident. The research being performed is to develop such improved instrumentation and display systems for use in upgrading control room information capability.

ACTION PLAN SAFETY BASES

Item No. I.E.3

Title: Operational Safety Data Analysis

Description of Action:

Operational safety data analysis entails the collection and statistical analysis of data on component failures affecting safety functions in operating commercial nuclear power plants. Generic and plant-specific component failure rates are obtained as are rates of occurrence of multiple component failures of common cause.

Bases for Action:

1. Why: Component failures are expected to be among the principal causes of nuclear power plant accidents.

2. Objectives: Individual and multiple component failure rates are needed to assess the likelihood of serious accidents, and to identify patterns of frequent failures warranting regulatory action to mandate alterations in component selection, maintenance, surveillance or operating procedures.

3. Accomplishment, scope and timing:

   The data analysis is being accelerated to bring it up to date. It will keep pace with accumulating experience thereafter. The scope embraces failures or errors affecting safety related systems.

4. Alternatives: None.

5. Related actions: AEOD (see I.E.1) is engaged in the detailed, mechanistic assessment of selected operational occurrences, which complements the statistical analysis of operational failure events described here. Failure rates obtained in this program are employed to flag high frequency failures, in risk assessments such as IREP (see II.C.1 and 2) and in system reliability analyses (see, e.g., II.E.1).

ACTION PLAN SAFETY BASES

Item No. I.E.8

Title: Human Error Rate Analysis

Description of Action

Human error analysis embraces the collection and analysis of statistical data on errors by reactor operators and maintenance personnel at operating nuclear power plants and in reactor control room simulators.

Bases for Action:

1. Why: Human errors are expected to be among the principal contributors to serious nuclear accidents; they played an important role in the accident at TMI.

2. Objectives:

   a. Collect estimates of human error probability.
   b. Identify contexts in which human reliability in nuclear plant operations affecting safety is low.
   c. Develop predictive models of human reliability.
   d. Identify "performance shaping factors" then influence human error likelihood.

3. Method of accomplishment, scope and timing:

   Instances of human (operator or maintenance) error affecting nuclear plant safety are being drawn from Licensee Event Reports, i.e., from actual reactor experience and supplemented by simulator data and studies in non-nuclear contexts. The scope embraces the test, maintenance and operation of safety systems. Data on operator response to upsets or hypothetical accidents are drawn from simulators. The program will survey experience data reaching and keeping up with current experience.

4. Alternatives: None

5. Related activities: IA, IC, ID, IE, IIC.1 and 2.

ACTION PLAN SAFETY BASES

Item No. Task II.B.5

Title: Research on Phenomena Associated with Core Degradation and Fuel Melting

Description of Action:

Analysis of the phenomena resulting from severe accidents in which the nuclear core loses its original geometry, of the cooling of such cores, the behavior before and after cooling, the mitigation of such accidents including those that proceed to core melt, and the response of the containment system to that load. Research to be performed will focus on studies of severely damaged fuel (in-pile studies, hydrogen behavior, post-accident coolant chemistry, fuel models) and core melt behavior (fuel debris, fuel interactions with structure and soil, radiological sources, fuel-coolant interaction, and mitigation features).

Bases for Action:

Analyses of TMI 2 accident sequences for both the Kemeny and Rogovin Committees showed that had restoration of cooling been delayed a little longer than it was, substantial melting of the core would be expected. As it is, some predict that a portion of the core formed a molten material (eutectic) as well as the major amount of crumbling or rubble formation. Evaluation of core melt accidents for Zion and Indian Point revealed major phenomenological uncertainties that render the evaluation of mitigation features (designed to accommodate core melt accidents) difficult to do on a "best estimate" basis and difficult to impossible to implement on an "evaluation model" basis. Moreover, use of "evaluation models" may be non-conservative or lead to actions not in the best public interest for predominant accident sequences.

The intent of this program is to supply the technical basis for regulatory action.

The scope and timing of the program are addressed in a detailed program plan now being reviewed by NRC staff in RES and NRR. The program has been discussed with the ACRS. While the scope is probably sufficient, detailed schedules within the scope may need revision both initially, and as knowledge is developed. It is unlikely that major results can be developed in the most desirable time scale unless significantly greater resources can be devoted to the program.

Alternative courses depend on relying largely on prevention of serious accidents. Although this is a desirable goal, it does not appear likely that major regulatory concerns will be addressed by such a course alone. Such work as Human Factors, Operational Safety, etc., that is aimed at accident prevention, as well as the NREP program, clearly interact with this program to effect an overall improvement.

ACTION PLAN SAFETY BASES

Item No. II.C.1

Title: Interim Reliability Evaluation Program (IREP)

Description of Action:

This program will utilize event tree/fault tree methodology to develop a taxomony of accident sequences for selected operating reactors. A tentative quantification of sequence frequency and radioactive release possibilities will be performed to distinguish risk dominant sequences.

Bases for Action:

1. This program is necessary since it will provide added insights regarding the relative safety significance of plant operational and design features and will produce reliability models which can be later used to evaluate comparatively alternative proposals for decreasing reactor risk. The need for an improved systems-oriented approach to determine those accident sequences which dominate plant risk, and to determine if regulatory initiative is necessary to reduce the level of risk, has been identified by several sources, including the Special Inquiry Group and the President's Committee on Three Mile Island.

2. This program will provide the reliability models necessary to develop improved systems-level insights regarding plant safety. It is intended to identify risk outliers in the selected plants, expand NRC capability in the use of this methodology, provide analytical tools for future utilization, and to develop broader perspectives on the overall risk.

3. The detailed analyses of plant systems and potential accident sequences using probabilistic risk analysis techniques identifies the dominant contributors to the calculated risk and this, in turn, can improve the basis for regulatory decisionmaking. This initial phase of the program is limited by available manpower resources and the current state-of-the-art in the use of the methodology. Previous efforts in this regard do not indicate that a more expeditious program is warranted. The present program is developing the details of applying the methodology that will make later developments possible.

4. We are aware of no alternative means to identify the risk significant accident sequences at nuclear power plants other than performing individual plant analyses. Where it appears a pattern of several plants having similar characteristics evidences that one or more accident sequences might dominate plant risk, special sequence specific analyses similar to the auxiliary feedwater study referenced in Section II.E.1 of this Plan will be initiated.

5. Related actions: II.C.2, II.E, I.E.3, I.E.8, IV.E.1

ACTION PLAN SAFETY BASES

Item No. II.C.2

Title: Continuation of IREP

Description of Action:

Following completion of the initial Interim Reliability Evaluation Program (IREP) (II.C.1), IREP studies on the remaining plants will be initiated.

Bases for Action:

1. This program will apply the methodology developed and tested in the initial IREP program on a broad basis to the remaining operating plants. This will identify potential risk outliers and provide a better foundation on which to base regulatory decisionmaking.

2. The purpose is to extend the objectives of the IREP program to all operating plants, and develop risk perspectives throughout the industry and NRC.

3. As in Item II.C.1, the detailed analyses of accident sequences for all operating plants will permit a structured evaluation of the current level of plant risk and provide analytical tools which can be used to evaluate the need for and value of proposed modifications.

4. Various alternative means of accomplishing this task are under consideration. These center primarily upon the degree of industry participation and the need to analyze plants under construction. The resolution of these alternatives is incorporated into this task.

5. The task will utilize the methodology application techniques developed under the IREP program (II.C.1) and its success and direction will be directly associated with the experience gained in the earlier phases of the IREP program.

ACTION PLAN SAFETY BASES

Item No. II.D.2

Title: Research on Relief and Safety Valve Test Requirements

Description of Action:

Monitor and analyze the planned industry valve testing and analytical program and develop methods of determining the adequacy of safety and relief valves to pass two-phase and solid water flow.

Bases for Action:

1. As a result of the TMI-2 incident, it is evident that the primary safety and relief valves may be required, under certain transients and accident conditions, to pass two-phase or solid water. The valves and systems have not been designed for this type of service. Since there are insufficient data available to analyze the existing installed valves and systems, the Lessons Learned Task Force requested that the industry qualify, by testing, the valves and systems to perform adequately under these unusual conditions.

2. The purpose of the action is to ensure that the test program will provide adequate information to ensure that the valves and systems meet the required conditions.

3. INEL has been contracted by RES to monitor and ensure the technical adequacy of the industry programs. EPRI is running the program for the PWR Owner's Group and GE is running the program for the BWR Owner's Group. Both owner's groups were committed to having the program completed by July 1, 1980. INEL will also identify methods of analysis for NRC to use to evaluate existing and future valve and piping system designs.

4. The only apparent alternative would be to rely upon analysis of the valves and systems. Since there are only limited data available to use as a basis, the actual testing of full-size valves and piping systems provides the best means to ensure that the components and systems are adequate.

ACTION PLAN SAFETY BASES

Item No. II.E.2.2

Title: Research on Small-break LOCA's and Anomalous Transients

Description of Action:

This research effort focuses on producing experimental results on small-break LOCA's with variations in break sizes, locations and status of plant components and ECCS from scaled experimental systems (integral experiments). Small-break transients are investigated with reactor coolant pumps on and off to support the NRR position on the status of reactor coolant pump during a small LOCA transient. In addition, a study of anomalous system transients being preferred to investigate transients such as station blackout, loss of feedwater, over and undercooling transients and steam generator tube ruptures. A number of experimental investigations to provide experimental data on phenomena that occur in specific reactor components (separate effect experiments) are being performed. These include core uncovering and recovery heat transfer, steam generator response, two phase level small and two phase material circulation.

Bases for Action:

Based on the initiating events, valve opening size for the LOCA and the break location that resulted in the TMI-2 accident the NRC research programs have been redirected for large-break LOCA research to small-break LOCA's and anomalous transients. Experiments in both integral and separate effect facilities are being performed to obtain a better technical understanding of ECCS performance and to ensure that the uncertainties associated with the prediction of ECCS performance are properly treated in both small-break LOCAs and anomalous transients. Several areas of concern resulting from the TMI-2 accident and analyses perform as a result of TMI are being addressed by these research programs. Small-break experiments with reactor coolant pumps on and off are being performed to confirm the adequacy of power plant analytical and the requirements stated in the bulletin to all operating PWR to initiate a normal trips of the reactor coolant pump in the event of a LOCA. Also a wider range of small-break LOCA transients with variations in break size, location (including the pressurizers), and digital ECCS are being performed. These experimental series were identified as a result of investigations of the TMI-2 accident, alternate TMI-2 accident sequences and results of the IREP studies. Small-break and anomalous transients being investigated are only a few of a wider spectrum of possible alternate accident sequences. The focus on these experiments has been to provide experimental data over a wider range of accident sequences that have resulted from request from NRR, sequences identified by PAS and these which were most probable. This data is then to be used to perform computer code assessment which can then be used to address a large spectrum of accident sequence in the PWR and BWR plants.

ACTION PLAN SAFETY BASES

Item No. II.H.2

Title: Obtain Technical Data on the Conditions Inside the TMI-2 Containment Structure

Description of Action:

Pertinent technical information is to be obtained about conditions in the TMI-2 reactor facility as cleanup operations proceed. The technical data will be gathered through NRC participation (RES lead) in a joint DOE/NRC/GPU/EPRI TMI-2 Information and Examination Program task force. Certain efforts are directed toward gathering information prior to opening up the primary system which include fission product transport and deposition in the containment and auxilliary buildings, instrumentation and electrical equipment evaluation, technology required for decontamination and waste disposal, damage assessments, sump debris identifications, etc. After opening the primary system the steam generators, pumps, reactor vessel, etc., will be evaluated, a non-destructive assay will be made of fuel in the primary system, a new evaluation will be made of criticality control, and the fuel/reactor core and internals will be examined in place and in detail at selected laboratories.

Bases for Action:

The program is undertaken to carefully gleen valuable technical data of interest to NRC and the nuclear community which may otherwise be lost during cleanup operations. The cooperation of the DOE and the utilities is essential to assure adequate funding of operations and coordination of data gathering activities during the short periods of time available in the cleanup sequence. The information gained will enable a corrected scenario of events inside and out of the reactor to be compiled for the most accurate and realistic assessment of radioactivity dispersal under accident conditions. It will also enable careful assessment of instrumentation and electrical equipment survivability, mechanical and system component degradation and reliability, and reactor vessel and reactor core damage assessments to improve understanding and modeling of future potential accident situations.

The plans developed for the data gathering and examinations are the results of planning teams setup with expert representatives from NRC, DOE, EPRI and the reactor vendors, laboratories, and consultants. As of September 1980 the planning stage has been completed for most all of the items in seven major action areas identified and priorities have been set to assure obtaining the most valuable information in each case within the time frame available. Careful planning has also taken place to assure thorough reporting and access to the data as well as a system of archival storage for any potential future reevaluations. Data gathering and examinations are ongoing at the moment, while cleanup progresses, and will not be completed until a system and equipment re-qualification period has been terminated.

In the event that the utility is successful is attempt to cleanup the plant rapidly for its own financial health without regard to data taking or if some of the TMI data is questionable a similar reactor transient from full power can be arranged at Crystal River to provide another source of such data - or verification of TMI-2 data - or verification of improvements made since TMI-2.

ACTION PLAN SAFETY BASES

Item No. II.H.4

Title: Determine Impact of TMI on Socioeconomic and Real Property Values

Description of Action:

RES is sponsoring the following studies: (1) effect of the TMI accident on the value of real property in the Harrisburg area, and (2) the socioeconomic impact of the TMI accident on the region in South-Central Pennsylvania which surrounds TMI. These are separate studies being conducted by different contractors.

Bases for Action:

This research is needed to fulfill NRR responsibilities in the licensing process. Information stemming from these studies will be used in the hearings on re-opening TMI-1, and also in upcoming licensing actions at other nuclear power stations. These studies will provide scientifically obtained information on attribution of impacts to the TMI accident. It will preclude the necessity of relying on general information developed on an unscientific basis. Timing is clearly sufficient as studies will use data from the periods immediately prior to and following the accident. Both studies were begun within one year after the accident, one study was started in the month following the accident. Scoping is adequate as it allows for adequate man-years of effort to complete the studies in a timely manner.

ACTION PLAN SAFETY BASES

Item No. III.D.2.4

Title: Offsite Radiation Dose Measurements-Instrumentation

Description of Action:

Additional means for determining offsite radiation dose rates and radiation doses associated with large accidental releases of radionuclides.

Bases for Action:

This research supports proposed revisions to Regulatory Guide 1.97. In FY 1981 RES will initiate an engineering study to determine the feasibility and desirability of deploying systems of environmental monitoring instrumentation capable of measuring rates of exposure to noble gases and radioiodines coupled with a means for rapid communication for transmitting the information from remote measuring systems to either a control room or a technical support center. The start of this research effort was postponed due to lack of resources in FY 1980. The results will be reported to the Commission with recommendations and alternatives in FY 1982.

ACTION PLAN SAFETY BASES

Item No. IV.E.1

Title: Expanded Research on Quantification of Safety Decisionmaking

Description of Action:

The Office of Nuclear Regulatory Research is developing techniques with which to objectify, systematize, and quantify safety decisionmaking, including safety-cost tradeoffs. Included are: a) the application of quantitative decision theory to regulatory issues, b) formulation of quantitative criteria of acceptable risk for Commission consideration and adoption, and c) methods to assess compliance with reliability-based and risk-based decision criteria.

Bases for Action:

1. Why: The several inquiries into the TMI accident and many other parties have urged that the Commission adopt more objective, better documented, and more consistent regulatory decisionmaking practices.

2. Objectives:

   a. Quantify safety objectives in terms of criteria for safety system reliability, accident likelihood, or of the risk posed by radiological releases.

   b. Enlist diverse talents in the peer review and evaluation of hypothetical criteria.

   c. Develop methodologies to assess compliance with the criteria and to objectify regulatory decisions and tradeoff studies.

3. Method, scope and timing:

   See NUREG-0660 IV E.1 for methods and scope. Current budget projections are consistent with the publication of draft criteria and the inception of peer review in FY1981.

4. Alternatives: a) Inaction, b) Commission adoption of quantitative risk criteria without prior research, or c) groundwork on research by entities other than the Office of Nuclear Regulatory Research (RES). RES has the charter, the background, and personnel resources for the basic research and peer review management needed. Other parties are contributing as noted below.

5. Related activities: The Commission has requested that the Office of Policy Evaluation develop a program plan for the foundation of risk criteria. The ACRS is also participating in studies of hypothetical risk criteria. RES is enlisting the assistance of several national and professional societies, laboratories, etc., to participate in the generation, review and critique of criteria and methods.