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THE ACCIDENT AT THE THREE MILE ISLAND UNIT 2 FACILITY AND THE ENSUING ACTIONS BY THE NRC

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ABSTRACT

The accident at Three Mile Island Unit 2 on March 28, 1979, is clearly a major milestone event for nuclear power with worldwide impact. The full impact of the accident technically and otherwise is now beginning to emerge as the findings of various investigative groups (by industry and the government) become available. A Lessons Learned Task Force was established in the Office of Nuclear Reactor Regulation to make early recommendations regarding actions to be taken following the accident. The actions of the Task Force are discussed in the context of short- and long-term phases which involve new and specific requirements for nuclear power plants and to consider the more fundamental issues of nuclear reactor safety based upon the experiences gained from the accident. In addition to the activities of the Task Force, additional actions are being considered in an overall integrated Action Plan now under development by the NRC. The plan will conform significantly to the Presidential Commission's recommendations as well as those of the ACRS and the NRC's Special Inquiry Investigation following reviews by the ACRS and the Commission.

GENERAL

On March 28, 1979, the Three Mile Island Unit 2 (TMI-2) nuclear power plant experienced a loss of feedwater transient that led, through a series of events, to a partially mitigated loss-of-coolant accident with significant core damage. The sequence of events involved equipment malfunctions, design deficiencies and human errors, each contributing in varying degrees to the ultimate consequences of the accident.

Over the past year since the accident at the TMI-2 facility, the NRC staff has been conducting an intensive review of the design and operational aspects of nuclear power plants and the emergency procedures for coping with potential accidents. The purpose of these efforts was to take certain actions in the short-term that would reduce the likelihood of the recurrence of a TMI-2 accident as well as to improve the overall level of safety in nuclear power plants. It is clear that major actions are necessary to ensure a low likelihood of a repeat of the TMI-2 accident. Some of these actions were in use at the time of the February 26, 1980 incident at Crystal River Unit 3 which lends support to their effectiveness.

There are a number of other investigations concerning the TMI-2 accident. As a result of these efforts, a number of reports [1] [2] [3] [4] have been published by the NRC that deal with certain safety aspects of the accident and

bear on the broad question of safe nuclear power. The Presidential Commission issued its report in late October 1979 [5]. The NRC's Special Inquiry Group issued its report in January 1980 [6]. In addition, several Congressional inquiries are in progress and the industry is evaluating major aspects of the accident. Generic reports have recently been issued by the staff that deal with the results of the Bulletins and Orders Task Force generic reviews of feedwater transients, small break LOCAs and other TMI-2 types of events [7] [8] [9] [10].

The NRC realized that it was not necessary to await the outcome of these investigative groups to identify some of the significant lessons resulting from TMI-2. Consequently, in May 1979, a TMI-2 Lessons Learned Task Force was established. It was an inter-disciplinary team consisting of 22 professionals from the Office of Nuclear Reactor Regulation, Nuclear Regulatory Research, Inspection and Enforcement, and Standards Development. Its purpose focused on the identification and evaluation of those safety concerns originating from the TMI-2 accident that require licensing actions. The work of the Task Force was essentially completed in October 1979.

In general, the TMI-2 Lessons Learned Task Force focused on identifying actions which go beyond those clearly specified in IE Bulletins and (Commission) Orders [directed toward the operating B&W plants] and which would be applicable not only to operating plants but also to pending operating license (OL) and construction permit (CP) applications.

The Task Force was charged to review and evaluate investigative information, staff evaluations of responses to IE Bulletins and Orders, Commissioners' recommendations, ACRS recommendations, staff recommendations from NUREG-0560 [1], and recommendations from outside of the NRC. In addition, the Task Force was charged to identify, analyze and recommend changes to licensing requirements and the licensing process for nuclear power plants based on the lessons learned. The scope of the Task Force included the following general technical areas:

- Reactor operations, including control rooms, operator training and licensing;
- Reactor transient and accident analysis;
- Licensing requirements for safety and process equipment, instrumentation, and controls;
- Onsite emergency preparations and procedures;
- NRR accident response role, capability and management; and
- Feedback, evaluation, and utilization of reactor operating experience.

The Task Force set its work into two distinct phases; a short-term and long-term plan. The first phase dealt with the development of recommendations for short-term actions which when combined with other requirements, e.g., the IE Bulletins on TMI-2, would establish short-term requirements to ensure the safety of plants already licensed to operate and those to be licensed for operation in the near future.

The second phase considered broader and more fundamental questions in the design and operation of nuclear power plants and in the licensing process. The issues considered are grouped in four general categories: general safety criteria, system design requirements, nuclear power plant operations and nuclear power plant licensing. Recommendations for near-term changes in off-site emergency preparedness and other licensing are under development by others.

SHORT-TERM RECOMMENDATIONS

The Task Force in determining which safety issues required short-term licensing action versus those that could be deferred for further evaluation by the Task Force or others considered engineering evaluation and qualitative professional judgment of the safety significance of the various issues. In this regard, the Task Force selected items for "short-term action" if their implementation would provide substantial, additional protection required for the public health and safety. The Task Force recommendations presented in NUREG-0578 consisted of 23 specific requirements in 12 broad areas (nine in the area of design/analysis and three in the area of operations). They are all to be implemented in two stages by January 1981 in operating plants, plants under construction, and pending construction permit matters except for three items which involve rulemaking action. Two of these dealing with hydrogen were deferred to the long-term program. The other dealing with operation is being processed by the Office of Standards Development in rulemaking proceedings.

The ACRS considered the short-term recommendations on several occasions and issued a letter to the Chairman on August 13, 1979, indicating that the Committee agrees with the intent and substance of the Task Force recommendations. In addition the Committee indicated that a more flexible implementation schedule should be followed to more realistically give merit to certain operational situations such as timely refueling outages rather than some arbitrary date. The Task Force agreed to this recommendation. In addition the Committee recommended three additional instrumentation requirements for short-term action, i.e., containment pressure, containment water level, and containment hydrogen monitors. An additional requirement was added by NRC for remote capability for reactor coolant system venting of system high points.

The Office of Nuclear Reactor Regulation met with the Commission on September 6, 1979, to review the current licensing situation and outlined its proposed plan to proceed. Included in the plan were the overall short-term recommendations described above. Letters were sent on September 13, 1979, to the utilities discussing the short-term program as well as other required actions. These matters have been implemented on individual operating plants.

The short-term Task Force items are listed in the following table; however, there are other lessons learned that are being carried out by other Task Force Efforts. These include the Bulletin & Orders Task Force that deals mainly with the operating plants and the auxiliary feedwater system, the Emergency Preparedness Task Force dealing in the area of emergency planning,

SHORT-TERM TMI-2 ACTIONS
FOR ALL NUCLEAR POWER PLANTS
(NUREG-0578 et al)

Sect. No.	Action	Sect. No.	Action
2.1.1	Emergency Power Supply Requirement	2.1.8.c	Improved Iodine Instrumentation
2.1.2	Relief and Safety Valve Testing	2.1.9	Transient & Accident Analysis
2.1.3.a	Direct Indication of Valve Position	(ACRS)	Containment Pressure Monitor
2.1.3.b	Instrumentation for Inadequate Core Cooling	(ACRS)	Containment Water Level Monitor
2.1.4	Diverse Containment Isolation	(ACRS)	Containment Hydrogen Monitor
2.1.5.a	Dedicated H_2 Control Penetrations	(NRR)	RCS Venting
2.1.6.a	Systems Integrity for High Radioactivity	2.2.1.a	Shift Supervisor Responsibilities
2.1.6.b	Plant Shielding Review	2.2.1.b	Shift Technical Advisor
2.1.7.a	Auto Initiation of Auxiliary Feed	2.2.1.c	Shift Turnover Procedures
2.1.7.b	Auxiliary Feed Flow Indication	2.2.2.a	Control Room Access Control
2.1.8.a	Post Accident Sampling	2.2.2.b	Onsite Technical Support Center
2.1.8.b	High Range Radiation Monitors	2.2.2.c	Onsite Operational Support Center

particularly with respect to off-site preparations, and the Operating Training Task Force which is emphasizing better training in dealing with casualty-type situations by training with reactor simulators as well as improvements in the qualification program. In addition the industry is developing organizations to provide better training and evaluations capabilities for the operations groups; i.e., the Institute of Nuclear Power Operators and the Nuclear Safety Analysis Center.

In addition to the foregoing actions, a key lesson is that a better understanding and use of operating experience can be effective in improving the safety of nuclear plants. It is to be remembered that several precursor events took place on similar reactor plants prior to the TMI-2 accident. Although some preliminary studies of these events were performed, the full significance was not determined. A staff of experienced interdisciplinary people has been established whose sole job is to evaluate operating experiences and to ensure that the plant operators understand them and include such experiences into their training program and emergency procedures.

Other short term lessons learned actions include the development of an overall NRC Action Plan that covers those matters raised by the various review groups including the Presidential Commission and the NRC Special Inquiry Group. The plan will form the basis for establishing new additional licensing requirements for both the operating plants and near-term OL requirements. The new requirements for the operating plants deal with shift manning, licensing examinations, operating experience, B&O task force generic review items and control room habitability. New requirements for the near-term OL licenses include greater emphasis on the operating organization and management, an onsite safety engineering group, a review of control room designs, training for degraded core training, a review by the NSS vendor of emergency procedures and an NRR review of selected emergency operating procedures. In addition new requirements have been established for the preoperational start-up stage, i.e., training during low power testing and monitoring of power ascension testing.

The staff is currently engaged in improving the capabilities of its NRC operations Center at Bethesda, Maryland, in order to provide the Commission and senior staff members with vital plant parameters and information from licensed nuclear plants in the event of incidents or accidents. Improved capabilities which are under consideration for the center will include automatic data processing, data storage, data display and data recall capability to be achieved through the use of digital computers. This will enable the staff to monitor and evaluate the situation and potential hazard, advise licensees, and in an extreme case, to be able to issue orders governing such operations.

LONG-TERM PROGRAM

The requirements established for the short term are intended to address those matters where a short-term improvement in safety can be made. TMI-2 has raised a number of other significant questions and policy issues. These became the considerations for the long-term program.

The Task Force is completing its efforts for the long-term program that deal with the broader and more fundamental issues of reactor safety that emerged from the TMI-2 accident. The report of the Task Force dealing with the long-term aspects was published in October 1979. The long-term efforts are discussed in four areas: (1) Design Basis Accidents; (2) System Design Requirements; (3) Nuclear Power Plant Licensing; and (4) Nuclear Power Plant Operations.

DESIGN BASIS ACCIDENTS

The underlying philosophy of nuclear reactor safety is that protection against the release of radioactivity should not rely solely on one means of protection but requires multiple levels of protection, i.e., the concept of defense-in-depth. This concept has been implemented through the technique of specifying design basis events and associated acceptance criteria which conservatively assure that the desired levels of protection are attained. At Three Mile Island, the multiple levels of protection prevented the release of all but a small amount of radioactivity despite a number of equipment and human failures. However, the sequence of events at TMI included events such as operator error, unexpected system response, and extensive core damage, were beyond previously specified design basis events and violated current acceptance criteria. This does not necessarily indicate that the defense-in-depth concept is unsound. But the experience indicates to some the need to more seriously consider modifications of our criteria so as to extend the current design basis events to explicitly include significant degradation of core cooling, such as occurred at TMI, or perhaps even core meltdown, for some aspects of the design of nuclear power plants. In this regard, two specific changes to nuclear power plant design should be promptly considered and openly, perhaps, debated in a rulemaking framework. The first is the capability for containments to cope with the hydrogen gas generated by the metal-water reaction of a significant fraction (if not all) of the fuel cladding in a loss-of-coolant accident. The second is the capability for filtered venting of containments to ameliorate and delay the offsite consequences of a core meltdown by reducing the containment pressure peak for such an event. Such considerations are now being made for the Indian Point Unit and 3 and Zion Units 1 and 2 plants mainly because of their locations near highly populated regions, i.e., New York City and Chicago.

SYSTEM DESIGN REQUIREMENTS

The system design subgroup is reexamining the adequacy of current system design requirements. In examination of these requirements, the subgroup is considering modification of current requirements to include use of event tree, fault tree, and/or relative reliability methods to supplement the current deterministic licensing criteria. In addition, consideration is being given to methods to incorporate in the safety analysis operator action [inactive or error] and the role of operating procedures with relation to the system design requirements.

The subgroup is also evaluating the current system safety classification methods and is considering modifying these requirements to include additional

systems in the safety grade classification as well as developing other system safety classifications. One classification system being considered is based on identifying systems important to safety, establish a rank of their order of importance and developing design requirements and criteria for various classifications. Recent operating experiences are showing the effects of failure of nonsafety grade types of equipment and the resulting challenges to plant safety features.

NUCLEAR POWER PLANT LICENSING

The Lessons Learned Task Force considered several specific topics within the general framework of how the NRC carries out its licensing activities. The areas in which recommendations include backfitting criteria, NRR organizational concepts and objectives, NRR emergency preparedness, and NRR evaluation and application of operating experience. With respect to backfitting a proposal was made for definitive criteria based on a required level of safety be articulated in the regulations and that the NRC finally put into its regulations that we require more from plants than the minimum requirements to meet the regulations. Organizationally the desirability of an integrated, interdisciplinary review team approach and added emphasis on operational safety aspects were emphasized. Our recommendations on emergency response addressed both the informational needs required as input and provision for a rapid NRR response and evaluation capability.

NUCLEAR POWER PLANT OPERATIONS

The Lessons Learned Task Force provided recommendations in a number of areas. A review of human factors in all operating control rooms has been recommended that would identify needed improvements in plant status assessment, improvements in safety system status monitoring, improvements in control and instrumentation hardware and reassessment of the number of required operator actions. In addition, it was recommended that the reactor operating experience evaluation programs that was recently required of all utilities be tied into a nationwide network for evaluation of reactor operating experience.

Recommendations for personnel included the recognition of present efforts underway by the industry's recently announced Institute for Nuclear Power Operations. We will emphasize improvements in training of nonlicensed operating plant personnel and independent verification of qualifications of nonlicensed operating plant personnel. The need for position task analysis and clearer definition of acceptable training programs for operating plant personnel will also be discussed.

SUMMARY AND STATUS

The staff is presently developing an overall NRC Action Plan that will incorporate all significant recommendations regarding the lessons learned from the TMI-2 accidents. Varous inputs including the Kemeny [5] and Rogovin [6] reports will be given proper attention. The overall Plan will address four major areas: (1) Operational Safety; (2) Siting and Design; (3) Emergency Preparedness and Radiation Effects; and (4) NRC Organization, Management,

Practices and Procedures. In conjunction with the development of the overall Action Plan, additional requirements for near-term operating licenses will also be specified. The staff will discuss the plan with ACRS and Commission to ensure proper promulgation and allocation of resources on a systematic basis. A resumption of licensing activities following the recent pause imposed by the NRC has taken place with the recent issuance of the Sequoyah low power operating license.

It is clear that nothing in the world of nuclear power generation will be the same as it was before March 28, 1979. The accident at Three Mile Island becomes a historical landmark, a watershed event whose worldwide technical, legal and societal implications are only now beginning to emerge. Safe and reliable operation of nuclear power plants goes beyond the acceptance of whatever the NRC requires. Clearly the responsibility rests with the industry and the utility to accommodate and respond to the lessons learned from the TMI-2 accident. It is also important that we follow-up on any significant experiences that bear on assessing the effectiveness of the ensuing lessons learned actions, the February 26, 1980 event at the Crystal River 3 facility.

REFERENCES

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