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DOCKET NUMBER
PROPOSED RULE PR 50
45FR65474

Secretary of the Commission
Attention Docketing and Service Branch
U. S. Nuclear Regulatory Commission
Washington, DC 20555

December 31, 1980

DOCKETED
USNRC
JAN - 6 1981
Office of the Secretary
Docketing & Service
Branch

Dear Sir:

10CFR50, DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES; CONSIDERATION OF DEGRADED OR MELTED CORES IN SAFETY REGULATION, ADVANCE NOTICE OF PROPOSED RULEMAKING (45FR65474), OCTOBER 2, 1980 AND (45FR70474), OCTOBER 24, 1980

We are pleased to submit the attached comments on the advance notice of proposed rulemaking, as described above.

Stone & Webster appreciates this opportunity to comment on the proposed rulemaking and to provide our assistance in developing the new regulations.

Very truly yours,

R B Bradbury

R. B. Bradbury
Chief Licensing Engineer

RECEIVED
JAN 14 1981
U.S. NUCLEAR REGULATORY COMMISSION

Enclosures

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L-4, #.50

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DEGRADED CORE COOLING COMMENTS

GENERAL COMMENTS

The ANR is necessary to clear the air with the public, Congress, and the nuclear industry. It is necessary to dispel once and for all the public's belief that the "China Syndrome" can occur. The best way to accomplish this is to develop a realistic analysis of a nuclear accident. It may be determined that no easily engineered passive core catcher feature is practical but that plant safety evaluation changes could result in cost and risk effective modifications. The analysis must be perceived by the public as an honest effort to address public risk.

The Nuclear Regulatory Commission (NRC), in its explanation of why a degraded core rule-making is in process, presented a long list of regulatory requirements as well as excerpts from reports on the Three Mile Island (TMI) accident. Missing from this background is the recognition that there is urgent need for a realistic analysis base that would show both the degree of conservatism in existing analyses and the less obvious interactions that would be involved in a postulated plant accident. The consequence of this recognition was evident at TMI where operators were not familiar with a realistic condition and deliberately defeated the systems that were adequate to fully prevent that condition from progressing to damaging consequences.

The proposed rule-making appears to be extending design requirements and analyses in a conservative fashion without any attempt to understand the processes in a realistic sense. To pursue this trend is to continue to impose requirements in excess of any plant safety need and to inadvertently hide areas or conditions in need of actual safety improvements. This course is evident from the specific considerations enumerated in the ANR, wherein it is assumed without any basis that one set of conditions automatically leads to very adverse further conditions. This is contrary to what is already known about some interactions and effects. For example, if there is core damage, there is no reason or expectation that this condition of itself would endanger the public health and safety. As another example, there are statements concerning the requirement of additional features to control iodine releases, when pertinent evidence from TMI, government test facilities, and the past 100 years of laboratory chemistry do not support the assumption that airborne iodine will be available for leakage from the containment in quantities currently required in NRC analyses. These are examples of "conservative" requirements and assumptions leading to the incorporation of overdesigned or unnecessary systems. These added systems may be increasing the overall risk through interactions with other safety equipment and additional containment penetration leakage paths. In order to assess the systems, analyses, or design changes that are important to safety, it is necessary to recognize the realistic effects and conditions involving reactor plant accidents.

There is an equal need to establish a safety goal that is meaningful. NRC is in the process of establishing such a safety goal. This is a critical and required step in revising regulations in order that the industry and the regulators have a firm basis on which to make decisions.

A substantial amount of the ANR relates to extending design and analysis efforts to include mitigating the effects of a degraded core. It is our belief that sufficient means of mitigating the effects of a degraded core are already in place through existing designs and already identified (post TMI) plant changes. We believe that this ANR action does not recognize that the nuclear industry and plant owners are totally committed to preventing accidents from progressing to core damaging consequences. We urge the Commission to more sharply focus and direct the proposed rule-making toward ensuring that accidents are prevented or terminated before core degrading occurs. It is advisable to evaluate the effects of a degraded core with respect to public health and safety, in order to determine the extent of protection currently available. Such evaluations properly conducted can assist in further identifying means of prevention/termination.

In summary, we believe that the proposed rule-making can be of benefit to all parties concerned; however, the greatest benefit will accrue to all if realistic evaluations are used in conjunction with a well-founded safety goal. This will provide the basis for any design change and to affect such changes in the manner most appropriate to plant and public safety.

If NRC decides to proceed as indicated in the ANR, the following comments relative to the specific considerations listed by NRC are provided.

Question 1

If loss of core cooling and resultant core damage occur in a nuclear power plant, there are certain predictable consequences. Can these consequences be mitigated substantially, and the risk of severe public health danger thereby reduced substantially, by practicable design improvements? If not, why not; or if so, what design improvements can be made and at what estimated cost? How would your recommendations affect other safety considerations?

Question 1 Response

The question predetermines that a degraded core involves substantial or severe public risk leading to a requirement for design changes to mitigate the consequences. The probability of the loss of core cooling or the inadequacy of core cooling must be established before any design modifications can be validly proposed. It is clear, for example, that the core damage at TMI was a direct result of the operators defeating the safety systems and not a result of inadequate safety systems. It is necessary to have a realistic assessment of the adequacy and reliability of the core cooling systems prior to finding that system changes are needed. It is also necessary to determine that severe risk to the public occurs due to a damaged core before design changes are warranteed.

Question 2

The TMI accident was terminated after the core was damaged severely but before substantial melting occurred, a condition beyond the current design-basis-accident events considered in the safety analysis. Should the NRC require that events of this type be considered in future safety analyses? If not, why not; or if so, what criteria would you impose to judge design acceptability?

Question 2 Response

Such events can be analyzed and the consequences determined; however, this should be done in a realistic manner, to preclude utilizing an unrealistic condition leading to designs impossible to implement. It is becoming evident from experimental work and theoretical studies that an accident carried to a certain point and then allowing realistic events to proceed thereafter results in generally minimal additional consequences. In fact, the core degradation at TMI was terminated when the core cooling systems were returned to their intended accident-mitigating mode. It would appear, based on present evidence, that substantially more damage could have occurred to the TMI core and that core degradation could have been terminated by reinstituting core cooling at a later time.

Since the TMI accident did not cause consequences that approached the siting criteria limits of 10CFR100, including such events as plant-specific requirements in safety analysis for off-site doses is not warranted.

We do believe that degraded core analyses should be performed to verify further that existing plant design capabilities are fully adequate to protect the public. Such evaluations should be generic and accomplished using realistic assumptions and conditions. These evaluations should be part of developing a better understanding of the consequences of complete core melting.

Question 3

Although the consequences of core-melt accidents have been considered to some extent in assessing nuclear power plant safety, such as in requirements for siting, emergency response plans, and certain engineered safety features, explicit consideration of the capability of current designs and casualty procedures to cope with core-melt accidents has not been a part of safety analysis scrutiny by the NRC. Should core-melt accidents be specifically evaluated in safety analysis reviews, and, if so, to what extent; or, if not, why not?

Question 3 Response

It would appear fully appropriate to perform analyses following a core accident all the way through complete melting and its deposition into containment. However, such analyses should be based on realistic conditions in order to understand the response of the plant and to determine the level of failure of current safety systems to reach the increasingly severe core damage points. Plant-specific analyses should not be required. Generic scenarios and analyses should be performed to evaluate the event.

It is pertinent to state again that the nuclear industry has responded in a positive manner to the TMI accident. Particularly, the training of plant operators has been dramatically upgraded in conjunction with increased plant capabilities to accommodate and terminate such accidents. Based on economic self-interest alone, it is obvious that plant owners must be committed to preventing accidents from developing into damaging events like TMI.

The ANR questions ignore this aspect of post-TMI developments and, in effect, largely focus on increased post-accident mitigation capability. A more substantial commitment to safety is clearly achieved by understanding such events and how such events can be prevented. This type of understanding can only be achieved through realistic analyses of the event and of the plant response to the accident conditions that, in turn, enable accurate assessments of plant capabilities and operator response requirements.

In this sense, the realistic generic analyses of core-damaging accidents are appropriate to ensure that plant capabilities and operator response terminate the accident before severe core damage occurs.

Question 4

Recognizing that there can never be complete assurance that only analyzed events as delineated in a Safety Analysis Report will occur, what additional analyses, procedures, or design features would you propose to mitigate fuel damage accidents in the range from extensive clad perforation without oxidation through a few percent clad oxidation, through extensive oxidation to full core meltdown? Would you recommend different and perhaps overlapping design features, depending on the severity of core damage to be coped with?

Question 4 Response

The question again presupposes that current plant designs and operator responses (post-TMI) are inadequate. The determination of safety level requirements (safety goals) is necessary as a basis for adding new or overlapping design features. The question also ignores the essential element basic to safety, namely, providing adequate core cooling. Trying to design features which address core damage in the event of inadequate core cooling is an open-ended task. There is no limit to the design features that could be proposed relative to an ever-increasing amount of core damage. The basic mitigating feature for fuel damage is to ensure that adequate cooling is reinstituted. Thus, the reliability of the core cooling systems available during an accident is the basic essential feature. This would appear to be a case of unrealistic mitigation requirements taking precedent over prevention. If core-damaging events are assumed and mitigation (other than core cooling) is considered, then those mitigating features must be found outside the primary system and take forms such as isolation of containment.

In summary, the question has no real meaning or answer until current capabilities to prevent, terminate, and mitigate such accidents are fully understood on a realistic basis.

Question 5

To what extent should reactor design and reactor safety analysis account for engineering safety features not working at all, not working well, or being defeated by the operator, resulting in severe core damage? What limits should be placed on multiple failure and operator error assumptions made in safety analyses, and how should probabilistic risk assessment be used to determine these limits?

Question 5 Response

The extent to which engineered safety features are to be considered ineffective through not working or being defeated can only be addressed through a probabilistic risk assessment process. In addition, a safety goal or standard must be established in order to judge or decide what conditions are satisfactory or unsatisfactory.

To focus on operator defeat of safety systems is to ignore the TMI event results. A more pertinent consideration would be to focus on operator actions that anticipate automatic safety system actuation.

The existing plant design bases have resulted in safe plants. TMI demonstrated that, in the face of significantly more adverse conditions than assumed, the public safety was well protected. There is need to recognize that small, high probability events can lead to adverse consequences. Use of probabilistic risk assessment can identify and provide insight into such scenarios. This is an essential step in identifying where changes are required. Plant conditions that have high probability for common mode failure should not be allowed. The purpose of probabilistic risk assessment would be to identify any such inappropriate conditions, so that corrective action can be implemented.

Question 6

Should the NRC require construction, at each nuclear reactor plant site, of a new structure for controlled filtering venting of the reactor containment structure? Would you limit the function of such a new structure to filtering particulates, elemental iodine, and inorganic iodine, or would you include adsorption bed systems using charcoal or other processes so that organic iodine and noble gases could also be trapped? What quantities and release rates of gases and particulates would you design such a structure to handle, and at what removal efficiency and cost? Do the potential reductions in risk expected from such a structure offset potential increases in risk that may materialize from incidents such as inadvertent operation or the concentration of hydrogen in the filtering apparatus?

Question 6 Response

This appears to be a feature looking for a need. Iodine chemistry, the results of thousands of laboratory experiments, measured iodine releases from NRC test facilities, and the results of the TMI accident clearly show that iodine does not pose a hazard of the magnitude currently required to be assumed in accident analyses. Plants already have extensive features to control iodine. Some of these features, if considered in a realistic accident scenario, might be shown to be not only unnecessary but also detrimental to the overall safety of the plant. There may be containments that are inadequately designed for large hydrogen concentrations. However, there appears to be an overreaction to the hydrogen problem that arises from assuming that all of the hydrogen that theoretically could be generated will be, and will be generated in such a way as to yield a maximum pressure condition in the containment. The need for any extra containment features, such as control filtered venting, can only be assessed after a need to reduce risk has been clearly demonstrated. That need must be based on realistic accident assessment and probabilities and a firmly-based safety goal against which to judge acceptability.

Question 7

Should the NRC require incorporation into containment design of systems for controlling combustion of hydrogen? Do you favor methods of control that suppress combustion or do you favor controlled burning? If you favor suppression of combustion, what techniques would you recommend and should they vary as a function of the design capability of current containments? If you favor controlled burning, do you recommend open flames, spark plugs, catalytic combustors, or some other means? What percent of zirconium oxidation in the core and at what rate would you design for? Would you respond differently for different reactor or containment types? If so, what differences would you recommend?

Question 7 Response

Previous responses have emphasized the necessity to preclude events reaching the point of severe core damage. If, however, significant amounts of hydrogen are assumed to be generated, the following comments are appropriate.

Since initiators for burning can be installed relatively simply and set for initiation by clearly identified events, then such a system is viable. Controlled combustion is preferable to suppression, since suppression requires active injection of large material quantities, and there is always the inherent risk of failure of the suppression mechanism. Controlled combustion is the simple, direct way of ensuring that the process is controlled, while eliminating any potential interaction between the suppression substance and other safety systems (primarily environmental effects).

Assuming that combustion of hydrogen is the solution, the amount and weight of hydrogen release becomes unimportant in terms of the system. The hydrogen will distribute itself rapidly and, at a well known concentration, an ignition system will cause combustion. The percent of zirconium oxidation in the core will determine only the length of time during which combustion periodically occurs.

With respect to different reactor or containment types, the necessary condition is that the effects of combustion not disrupt the containment integrity. Therefore, if combustion of hydrogen is to be utilized, then the containment must be able to withstand the effects of such combustion.

Question 8

Would you recommend that all nuclear power plants operate with a nitrogen-enriched containment atmosphere, as some BWR plants currently do? Why or why not, and if not, to which types of containment, if any, would you limit required nitrogen enrichment?

Question 8 Response

Inerting would be inappropriate for plants requiring significant maintenance or testing activities inside containment. In addition, the amount of hydrogen assumed to be generated may still be incompatible with inerted containment design pressure (see Question 9 Response).

The condition whereby large amounts of hydrogen could be generated must be prevented through adequate core cooling.

Question 9

Should the NRC require incorporation into containment design of a core retention system to mitigate the consequences of core meltdown by, for example, increasing resistance to molten core debris penetration and thereby substantially reducing gas, vapor, and aerosol generation to less than that which occurs when core debris is allowed to interact with concrete? Assuming a core retention system is required, do you favor a device that permanently retains core debris within the containment building? If you favor delay of core melt-through, do you recommend refractory materials (such as MgO, ZrO_2) to protect the containment concrete basemat, or do you recommend some other means? If you favor permanent retention of core debris, do you recommend using refractory materials in combination with cooling systems that rely either on natural convective cooling or forced pumping of coolant around the extremities of the refractory material, or do you recommend some other concept? Would you respond differently for different containment types. If so, what difference would you recommend? How do your recommendations affect other safety considerations?

Question 9 Response

This should not be a requirement. Realistic analyses of meltdown scenarios would be required before the usefulness of such devices could be evaluated. Research and analysis of the effects of molten core materials with containment water should demonstrate that the concept of an uncoolable core residing on the containment mat is totally unrealistic. In addition, the direct effects of molten core-water effects (steam explosions) and hydrogen produced from iron-water reaction may be far more consequential with respect to containment integrity than consideration of some small mat interaction delay that a core catcher may theoretically provide.

The ANR is looking at details of a device that must not be needed. Whatever improvements in core cooling that may be necessary to preclude this situation must be determined and implemented. Designing systems to mitigate melt-through of the containment mat is inappropriate emphasis, in that prevention is necessary to preclude an accident progressing to that stage.

Question 10

Should the NRC require design changes to account for increased radioactive material that may be transported during an accident by systems normally functioning with much lower levels of radioactivity such as the steam and residual heat removal systems and the containment drainage system?

Question 10 Response

There is reason to reexamine the capabilities of various systems with respect to their use with increased radioactive material transport. Such reexamination should consider the effects of considerable fission product release from degraded fuel and the capability of systems to shut down, cool down, and provide long-term cooling for the core. An appropriate radioactive material transport should be included in their design bases.

Question 11

Should the NRC require more extensive operator training, strict literal compliance with new and improved detailed operating procedures, increased reliability of emergency cooling, or decay heat removal capability, and expanded control room minimum manning as alternatives or supplements to degraded cooling design improvements?

Question 11 Response

The upgrading measures sited in Question 11 which follow from the TMI action plan would probably be shown through risk assessment to be suitable alternatives to improvements in degraded core cooling. Increasing the reliability of safety systems is more pertinent and appropriate to ensuring public safety than adding design requirements to mitigate an accident afterwards.

If decreased risk is required in a particular plant, increasing the reliability of the emergency cooling and decay heat removal and/or improving operator interface would be more appropriate than additional mitigating features.

Question 12

Should the NRC require an alternate, add-on, self-contained decay heat removal system to prevent degradation of the core or to cool a degraded core, in contrast to the previously discussed schemes which are aimed toward mitigating the consequences of degraded core cooling? How would such a decay heat removal system affect other safety considerations?

Question 12 Response

Plants currently have several systems or paths available to ensure adequate decay heat removal. That reliable decay heat removal must be assured is clearly necessary. However, prior to adding new systems, those currently available must be evaluated to compare the merits of upgrading existing systems with new systems. The necessity of increased reliability should be evaluated prior to changes being required.

New or additional systems should be avoided in general, since system interaction problems frequently lead to a decrease in overall safety.

Question 13

Should the NRC require systems such as the makeup and purification systems to be located in a leak-tight building? Would such a requirement add to or detract from overall plant safety?

Question 13 Response

The use of systems outside the reactor contaiment for safety functions involving high levels of radioactivity should be evaluated in a realistic manner to assure leakage paths to the environment are essentially eliminated and that personnel shielding is sufficient for long-term recovery and maintenance operations. Environmental considerations may require air-conditioned facilities for some new plants to allow normal plant operation at high ambient temperatures. This, however, presents a problem for high energy pipe rupture effects inside these facilities which must also be evaluated. Interfaces between leak-tight buildings also present problems. These issues should be evaluated prior to committing to leak-tight facilities.

Question 14

What design, quality, and seismic criteria would you recommend for any additional systems to prevent the potential breeching of containment such as systems for controlled filtered venting, hydrogen combustion control, and core retention mentioned in previous questions? Do you favor evaluating designs of such systems on a realistic basis, as opposed to the conservative method used to evaluate engineered safety features? Do you favor establishing design criteria for such systems that are equally stringent, less stringent, or more stringent than those applied to engineering safety features? Please explain your response in terms of criteria you would recommend, including consideration of redundancy, diversity, testability, inspectability, and structural design limits (including seismic requirements).

Question 14 Response

Additional systems should be added only if realistic analyses indicate a need after comparison of results with safety goals.

Such systems should be evaluated and designed to meet realistic bases and should be classified as engineered safety features. These features should not be required to be seismic or redundant unless probabilistic risk assessment shows their necessity. Realistically based cost/benefit studies should also be included in determination of the appropriateness of such systems.

Question 15

Can probabilistic analysis be used both as an aid in determining and comparing the adequacy and usefulness of the several features mentioned in previous questions and as an aid in determining the design criteria and reliability requirements for these features? How do you view the utility of quantitative risk analysis in better understanding the safety advantages and disadvantages of the several features mentioned in previous questions?

Question 15 Response

Probabilistic analyses are necessary to understand the importance and potential interaction effects of the features mentioned.

Question 16

In weighing the costs of design and operational improvements to cope with degraded core cooling against the benefits of their use, what quantitative methods or other guidance would you suggest to facilitate preparation of a useful value-impact assessment? Would you consider useful or appropriate comparisons between nuclear power plant risks and other risks to which people are exposed?

Question 16 Response

Cost/benefit considerations have two constituencies: (1) the public health and safety, and (2) the plant owner. Accident prevention/termination systems are usually of high cost/benefit value to the utility owner while also meeting public safety objectives. As is recognized, failure to terminate the TMI accident early resulted in high costs for both GPU and the public. Cost/benefit analysis of mitigation systems must be compared to cost/benefit analysis of termination/prevention systems. Some mitigation systems are prudent; however, it must be recognized that termination/prevention systems are of more value to the public and the plant owners than additional mitigation systems.

In comparison of risks, the alternative ways of producing electricity are the proper and rational bases on which to make choices. However, to be meaningful and acceptable to all parties, the methods by which cost/benefit analyses are to be made must be mutually agreed upon.

Question 17

What aspects of degraded cooling or melted-core accidents are sufficiently unknown or uncertain as to impede design and analysis of mitigating systems, thus requiring additional research or experimentation?

Question 17 Response

The assumptions and resulting scenarios used in analyses of such accidents can only be established by a realistic and probabilistic basis. To attempt otherwise would be totally unbounded and would not add (except by chance) to the understanding of any real process.

Resolving uncertainties and unknowns necessary to fully support design and analysis of mitigating systems would be an inappropriate expenditure of resources. These resources would be more appropriately utilized (improving safety) directed toward ensuring that such potentially damaging events are prevented or terminated before severe core damage occurs.

Question 18

The NRC has under way a separate rule-making procedure concerning reactor siting, and an emergency planning rule has recently been approved. If you are familiar with these separate activities, how would you modify present and proposed requirements for emergency planning and reactor siting if accidents beyond the present design basis were to be considered in nuclear power plant safety analyses?

Question 18 Response

The NRC's rule-making procedure is indeed out of order in logic and importance.

The order of proceeding in the overall effort should be:

1. Develop safety goals

2. Degraded core cooling

3. Engineered safety feature standards

4. Reactor siting criteria

5. Emergency planning

The above order is logical and would prevent duplicative expenditure of resources. The current order of proceedings is almost the reverse of logic and could well result in incompatible sets of regulatory requirements.

Hopefully, the end point of these proceedings is to bring order and reason to the regulatory process, not to continue disjointed proceedings that have resulted in confusion, destabilization, and past criticism of the regulatory process. We urge the commission to reconsider the order of procedures currently in progress and to recognize the necessity to establish safety goals as a first priority.