SOME RADIATION PROTECTION IMPLICATIONS OF THE THREE MILE ISLAND INCIDENT

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In many cases in the past, the design of Nuclear Power Plants (NPP) in the area of system safety and accident analysis has considered the radiation protection aspects mainly under conditions of normal operation including anticipated operational occurences. The Regulatory Guide 8.19 which was published recently by the USNRC (7) provides an example.

The Three Mile Island (TMI) incident and the recovery operations which followed it, focus attention on additional aspects which require careful considerations in the design of NPP:

(a) Safety related systems should be available for operation without any delay, even though a significant amount of fuel failures have already occurred in the reactor core.

(b) The operating personnel should be able to conduct recovery operations without undue exposures even when an accident has resulted in some fuel damage.

(c) Radiation-protection instrumentations should provide useful information even in the case of accidents which produce high radiation fields in the area of their reading.

High radiation fields that can be expected during severe accidents have been considered in the past mainly with respect to radiation measuring instrumentation (2,8) and radiation qualification of components in the containment (3). Only conditions of large-break LOCA (loss of Coolant Accident) were used to estimate the radiation fields (2). The desgin of shielding to allow access to safety systems and other vital equipment was in many cases based only on normal operating radiation levels (4).

In the next sections we discuss these safety problems, the reccommendations (5,6) made by the Nuclear Regulatory Commission (NRC) and by the Kemeny Commission (1) to treat these problems and arrive at some additional conclusions and suggestions.

SOME SAFETY PROBLEMS REVEALED IN THE TMI RECOVERY OPERATIONS

Our review of the recovery operations which followed the accident (1,5,6) revealed some safety problems. These safety problems may be divided into four general groups:

(a) Delay or prevention of the use of safety systems important to the recovery operations:

The Decay Heat Removal System is the main system planned for operation to maintain the reactor in the cold-shutdown mode; however, it was realized during the accident that this system is not sufficiently leak-tight for use with highly radioactive primary water.

Therefore, the main Reactor Coolant Pumps were used in their place even though they were not intended for cold shutdown operation. Thus, further contamination of the Auxiliary Building and radioactive fission product release to the environment were prevented.

During the accident it was required several times to enter the Auxiliary Building to align valves, start pumps or acquire samples from the containment atmosphere. Several of these operations were delayed or were not completed. The radiation fields within that building only allowed for a short stay of several minutes, which were insufficient to complete the required assignments.

(b) Undue exposures of operating personnel:

The review of the recovery operations reveal that some operations are needed more frequently than others. Among these are:

- Reactor Coolant sampling for boron analysis
- Operation of equipment from radwaste panels
- Change of filters
- Surveillance of equipment, monitors and instrumentations.

These operations have resulted in personnel exposures approaching the quarterly dose limit at each entry, and resulted in high extremity doses. Such high doses may be warranted in nonroutine one-time assignments and should be avoided in operations required on a frequent basis.

(c) Failure of radiation-protection instrumentation and monitors to provide correct information.

Radiation-protection instrumentation and monitors have been designed mainly to control normal operation including conditions of anticipated operational occurrences. Postulated accidents were also considered, but all protective systems were assumed to perform successfully and to reduce the fission product release. The TMI experience reveals many cases of monitors which were driven out of range. It also points out cases of monitors which measured the background radiation created by large amounts of noble gases rather than iodine or particulates being released through them. In the last case the monitors were exaggerating the actual release.

It should be pointed out that the measuring equipment operated successfully from the electro-mechanical point of view in most cases. i.e., the equipment was available and redundant equipment reached their set points within several minutes.

(d) Failure of evaluating radiation protection measurements, alarms and other information to determine the actual reactor situation:

In spite of much instrumentation going out of range, there were quite a number of high radiation alarms, high level measurements by the containment dome monitor (which did not go out of range) or by operators surveilling the Auxiliary Building. In addition the gaseous effluent monitoring system was indicating high effluent discharge (exaggerated by radiation from the noble gases). These measurements could be related to core conditions and fuel failuers in the core. During the TMI incident the above information was not correctly interpreted to indicate that significant fuel failure was taking place in core. It was rather explained as steam generator leakage to containment atmosphere combined with some steam generator tube failures. This indicates a need for improved training of personnel to distinguish radiation feilds indicating abnormal occurrences from normally encountered fields.

RECOMMENDATIONS MADE BY INVESTIGATING COMMITTEES

Several investigations into the TMI incident were performed. The NRC investigation (5,6) and the Kemeny Commission investigation (1) resulted in some recommendations related to radiation protection from the system safety point of view.

With respect to the safety problem (a) above, it is recommended by the NRC (5,6) to improve the integrity of systems outside containment likely to contain radioactive materials. No design improvements are required for, at least, the short term. The recommendations call for implementation of all practical leak reduction measures for the systems and performance of leakage rate tests on a periodic basis to keep the leakage rate at a constant level.

With respect to safety problem (b) above, it is recommended by the NRC (5) to perform a design review of the radiation fields and the shielding in the spaces arround systems that may contain highly radioactive materials. The design review should identify vital areas and equipment required during post-accident recovery operations. Measures to be taken to provide adequate access to vital areas should include post-accident procedural controls, permanent or temporary shielding and when required also redesign of facilities, components or systems. A quantitative source-term is suggested for the design review, i.e., the Regulatory Guide 1.3 source term (9).

With respect to safety problem (c) above it is recommended by the NRC (5) that no high range radiation monitors for noble gases in plant effluent lines and in the reactor containment be installed. In addition instrumentations for the monitoring of radioiodine and particulate effluents under accident conditions would also be provided.

With respect to safety problem (d) above it is recommended by the NRC (5,6) to improve post-accident sampling capability. A design and operational review of the reactor coolant and containment atmosphere sampling systems should be performed to determine the capability of personnel to obtain a sample within an hour under accident conditions, without incurring a radiation exposure exceeding the quaterly dose limit to whole body or extramities for radiation workers. Timely information from such samples can be important for an early understanding of core conditions.

The Kemeny Commission recommendations (1) are more qualitative in nature. They call on the NRC to include as part of its licensing requirements plans for the mitigation of consequences of accidents, including the cleanup and the recovery of a contaminated plant. The Kemeny Commission urges correcting inadequacies in equipment required for the mitigation of the accident (i.e., safety problem (a) above). It recommends that consideration should be given to overall gas-tight enclosure of systems processing highly radioactive water during the accident and the recovery phases. It urges improvements of radiation monitors and the provision of the capability to take and quickly analyze samples of containment atmosphere and reactor coolant.

SUMMARY

This paper presents four safety problems and the recommendations made by the NRC and the Kemeny Commission to treat them. It can be seen that the recommendations respond adequately to the safety problem mainly, in the above mentioned problems (b) and (c).

In its recommendations the NRC provides a source term to allow for more quantitative design review and for determination of cases which require some improvements. It is suggested here to add two supplemental steps to this quantitative approach:

(a) The use of specific scenarios of postulated accidents to determine the required recovery operations, which are the vital plant areas for post accident access and the required systems and equipment during the recovery phase. In particular, such scenarios may include, in additions to a large break LOCA, the small break LOCA, an ATWS event, a steam line break case and a control rod ejection followed by a small break LOCA.

(b) The use of a dollar value per man-rem as a criterion for determination when design imporvements are required rather than procedural controls.

The design review of the NPP will therfore include the assomption of a Reg. Guide 1.4 source term and a specific postulated accident scenario. Design improvements which have the potential for dose reduction both to personnel or to the population, would be judged by their dollar value per man-rem reduced. The criterion may be a lower dollar value then used for ALARA purposes today.

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