Key Issues Paper

THE NECESSITY OF PERIODIC FIRE SAFETY REVIEW

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1. INTRODUCTION

Nuclear power is clearly a very important commodity in the global community. And, as the 1986 Chernobyl disaster demonstrated so clearly, fire events in nuclear plants can have far-reaching consequences well beyond the plants' physical boundaries. We all share a grave responsibility to ensure that a minimum level of fire safety is provided and maintained in nuclear power plants. This responsibility can best be met by the continual, periodic monitoring of fire safety measures within the plants.

2. DETERMINING FIRE SAFETY LEVELS

Because each plant's resources are limited, the resources available for fire safety efforts must be allocated wisely. Various methods are available to the practicing fire safety engineer for determining how much fire safety is needed. One can approach the problem using basic engineering judgment. This subjective approach can result in wide variation in the level of fire safety achieved, depending on the experience of the engineer and the accuracy of his/her judgments. This is the approach used by a number of plant designers years ago, before fire was identified as an event with significant potential for affecting nuclear safety. The reliance on individual engineering judgment ultimately resulted in levels of fire safety ranging from excessively conservative in some specific plant areas, to a fair overall level in some nuclear plants, to almost no fire safety in other plants.

In consequence, regulatory authorities have developed requirements to establish minimum levels of fire safety which must be provided in nuclear plants. Some of these guidelines are broad, performance-based regulations while others are more prescriptive and offer few choices for the designer. Specific prescriptive-type codes and standards such as those published by the National Fire Protection Association, the Loss Prevention Council, and others offer detailed requirements on the design and arrangement of specific elements of fire safety once a decision has been made to install passive measures or active fire extinguishing systems.

More and more frequently during the past two decades, systematic fire safety analyses have been performed to determine the required level of fire safety in nuclear plants. The analysis often takes the form of a deterministic-type fire hazard analysis (FHA). This comprehensive document can be either qualitative or quantitative in nature; usually it is a combination of the two approaches. Currently, fire safety analyses are being approached using the fire probabilistic safety assessment (PSA) method. This method, which identifies dominant risk contributors, often is used to supplement a deterministic FHA. It can be used as a means for comparing options for risk reduction based on the probability of a specific initiating event leading to a fire of a magnitude sufficient to result in core damage. By screening out less significant events, this method focuses attention on those events which have the highest probability of affecting plant nuclear safety. The broad goal of each method is to ensure nuclear safety for the plant. As the analytical methods in use increase in sophistication and level of detail, one expects that the level of safety will also increase and that the scarce resources available for fire safety will be utilized more efficiently.

After the Brown's Ferry Nuclear Plant fire in the USA some 20 years ago, there was a certain tendency in some plants to "throw money" at the problem of fire safety without always taking the time to ensure that the money was being thrown in the right direction. More recently, fire safety efforts have been much more focused, with detailed fire safety analyses (both FHAs and fire PSAs) helping to place attention on areas and systems in the plant which make a significant contribution to fire safety and to identify those areas where previous fire safety levels may have been overly conservative, if any.

3. FIRE SAFETY OBJECTIVES

To further complicate the situation, a number of different objectives must be considered for providing a specific level of fire safety in a nuclear power plant. Obviously, the primary objective is to ensure plant nuclear safety as defined in the IAEA's *Fire Protection Design Guide*, 50-SG-D2 [1]. The capability to achieve and maintain safe plant shutdown must be assured. Nonetheless, to overlook other issues related to fire safety would be a mistake.

These issues include limiting property damage as a result of fire and maintaining continuity of operations for the benefit of the public. That is, fire safety engineers should not be satisfied with a level of fire safety which allows a plant to be shut down safely during a fire emergency but remain in a shutdown state for 1–2 years or even indefinitely, due to extensive fire damage which was not "safety related." The minimum level of fire safety needed to ensure plant nuclear safety must be identified and provided—but design engineers should not stop at that point. We have an obligation to the global community to do a much better job than that.

4. MAINTAINING FIRE SAFETY LEVELS

Regardless of the defined design objectives or the analytical methodology used, once the required level of fire safety is identified, maintaining that level of safety is essential. One of the most effective means to accomplish this is to conduct periodic assessments to verify that the appropriate level of fire safety is being maintained in the plant. Analysis and identification of fire safety requirements are essential elements, but they represent only the first step in what must be a continuing process throughout the operational life of the plant. The periodic fire safety review process ensures that a consistent level of fire safety is maintained day after day and year after year—long after the initial glamour and attention of analytical studies has faded.

Nuclear plants expend significant time and valuable resources focusing on the analysis of low probability/high consequence events such as seismic, high wind, flooding and large fires, and rightly so. So it really is no surprise that fire safety is sometimes taken for granted in the day-to-day operation of the plant. It is all too easy to forget that small fires are a high probability/fairly high frequency event in nuclear plants—and small fires grow into large ones. For this reason, plant operators must continue to focus attention on maintaining the appropriate level of fire safety in each plant.

Maintaining fire safety in a complex industrial environment such as a nuclear power plant is a difficult task even where conditions are constant and unchanging. The difficulty is exacerbated by the fact that the nuclear power industry is not static. Individual nuclear power plants are very dynamic entities. Improvements in power plants seem to be a never-ending process. Improvements mean change; and changes result in modifications such as cable re-routing, penetrations to passive fire rated barriers, and increases in fire load. A continuing program of fire safety reviews and inspections will verify that design changes and plant modifications have been adequately assessed for fire safety impact. A comprehensive 10-year review of fire safety is appropriate and necessary, but it is not enough. A focused review of fire safety elements should be performed annually.

5. BENEFITS OF PERIODIC FIRE SAFETY REVIEWS

What benefits can be expected from performance of periodic fire safety reviews? These annual assessments will verify the operability of extinguishing systems whose function has been determined (through the FHA and/or fire PSA) to be critical to plant nuclear safety. The assessments will ensure that the combustible fire load does not exceed the level identified in the FHA. They will verify that the plant's fire prevention program is effective in controlling potential sources of ignition. They will also document the level of manpower, equipment and training provided by the fire brigade and assess the brigade's state of readiness for fire response.

Two examples will serve to illustrate the value of periodic fire safety reviews. The first example involves the case of a nuclear plant where it was determined that a fire extinguishing system was necessary to protect the bearings of the turbine generator. A carbon dioxide system was designed, installed, and maintained to satisfy the requirement. During a subsequent periodic fire safety review, the inspector noted that the carbon dioxide system was arranged to discharge its extinguishing gas outside the turbine shroud, rather than inside the enclosure where the majority of the oil hazard existed. Obviously, this fire protection system was totally ineffective; and the time, money and effort of installing the system was largely wasted. Had an oil fire involving the turbine bearings developed, the thermal detectors associated with the carbon dioxide system could have activated, uselessly discharging the system's gas into the large turbine building, while the lubricating oil continued to burn inside the turbine shroud and also spread onto the floor below via unprotected floor openings.

In another example, an interior standpipe system (or rising main) was installed in the reactor building of a nuclear plant for use by the fire brigade. During a periodic fire safety review, one of the fire hoses was chosen at random to verify the water flow available for fire brigade use. The control valve was opened, and an acceptable flow of water discharged from the nozzle for about 30 seconds—and then slowed to a bare trickle. Upon closer examination, it was discovered that the nozzle was totally blocked by clam shells. The plant obtained its water supply from an open water source (a river) which recently had become infested by Asiatic clams. These clams had entered the fire protection piping system and thrived. Fortunately, by discovering this problem during the periodic fire safety review, the plant was able to evaluate the situation, take appropriate action, and solve the problem prior to using the standpipe system in an emergency fire situation.

In addition to valuable troubleshooting, another immediate benefit of a fire safety review is the free and open exchange of fire safety knowledge and ideas between the fire safety assessor and the plant staff. Open communication should be encouraged at all levels of the plant. The intent of the review is definitely not to find fault nor to assign blame to a specific individual or group. Plant staff should be encouraged not to be defensive or worried that the assessor will identify a problem in their work area. An adversarial atmosphere is counterproductive. The atmosphere should be one which heightens fire safety awareness of plant staff and which promotes lively discussion on ways to improve fire safety. To be sure, one important objective of the fire safety review is to verify that the level of fire safety identified in design basis documents (such as the FHA, fire PSA, or the final safety analysis report) is being maintained. However, the overall intent of the review is to improve fire safety for the plant, not to take a narrow, legalistic approach which finds satisfaction in exposing deficiencies. The reviewer should make every effort to maximize the benefit to the plant, while minimizing any adverse effects on plant operations.

When problem areas are identified, they should be considered seriously and addressed promptly. A periodic fire safety assessment can identify small problems when they are not especially significant to nuclear safety, before they grow into crisis situations. On occasion, the management of a nuclear plant will mistakenly assume that the only correct resolution to fire safety problems is to establish a new working committee or administrative division, resulting in a virtual mountain of paperwork and documentation. Resolution of fire safety deficiencies may entail a certain amount of

paperwork (after all, this is the nuclear power business). However, the intent of periodic fire safety reviews is not to create a paperwork nightmare; it is, quite simply, to improve fire safety.

Years of experience in performing fire safety reviews in nuclear power plants indicate that the initial one or two inspections at a plant will likely result in a number of findings. Some of these will be significant to plant nuclear safety, and many others will be of a minor nature. Subsequent inspections at the same plant usually show a marked reduction in findings (both in quantity and significance). Even so, such periodic reviews provide valuable assistance to the plant in continuing to improve the overall level of fire safety year after year.

6. FIRE SAFETY REVIEW PROCESS

The fire safety review should begin with a review of records and documentation. This documentation includes design basis documents such as the FHA and fire PSA, administrative procedures and policies related to the fire prevention program, and plant arrangement drawings. Discussion with plant staff at all operating levels is an important element throughout the review process. Maintaining open channels of communication is critical to allowing free exchange of ideas and information. Finally, an essential element of the review process is to conduct a field walkdown of accessible plant areas. The importance of this phase of the process cannot be overstated. Review of paperwork is necessary but should never be considered a substitute for visual observation in the field. Fully 30%–40% of the time allocated to the fire safety review should be spent in the field looking at actual plant conditions and talking directly with plant engineers, operators, maintenance staff, and fire brigade personnel.

It is important to recognize that effective fire safety reviews do not have to involve a major time commitment. A full-scale review of all elements of fire safety at a nuclear plant should require only about 100–200 manhours (for example, two engineers on site for two weeks each). An annual in-house review by qualified plant staff can be effective; however, occasional review by an independent, outside expert can bring in a fresh perspective. This independent review should be considered at intervals not exceeding 3–5 years.

The key to minimizing time and maximizing effectiveness of fire safety reviews is to choose personnel who are highly qualified and experienced. This is essential whether using in-plant staff or outside consultants. An option which provides a new, fresh perspective at a reasonable cost to the plant is to make arrangements with another nuclear plant to "trade" fire safety personnel for the purpose of conducting an independent review. This approach can be very effective in the exchange of new ideas and technology while at the same time meeting the need for an independent fire safety review at no additional cost to the plant.

7. SUMMARY

Effective fire safety requires the coordinated integration of many diverse elements. Clear fire safety objectives are defined by plant management and/or regulatory authorities. Extensive and time-consuming systematic analyses are performed. Fire safety features (both active and passive) are installed and maintained, and administrative programs are established and implemented to achieve the defined objectives. Personnel are rigorously trained. Given the time, effort and monetary resources expended to achieve a specific level of fire safety, conducting periodic assessments to verify that the specified level of fire safety has been achieved and is maintained is a matter of common sense. Periodic fire safety reviews and assessments play an essential role in assuring continual nuclear safety in the world's power plants.

REFERENCE

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Fire Protection in Nuclear Power Plants: A Safety Guide, IAEA Safety Series No. 50-SG-D2 (Rev. 1), IAEA, Vienna (1992).