IMPACT OF PLANT DESIGN CHANGES ON THE LIMERICK

GENERATING STATION SEVERE ACCIDENT RISK ASSESSMENT (SARA)

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ACCIDENT RISK ASSESSMENT (SARA)

1. INTRODUCTION

As part of the severe accident risk assessment (SARA) (NUS, 1983) the risk from potential fire incidents was considered. This assessment took into account specific plant design features such as the integrity of floors, walls and ceilings which surround independent fire and flood areas, and the rating of fire barriers which protect individual cable raceways. However, since the analysis was performed several major changes in the design of the fire protection measures have been made.

The fire analysis presented in SARA was performed on the basis of the fire protection measures described in Revision 1 of the LGS Fire Protection Evaluation Report (FPER) (Peco, 1981). These provisions are briefly described in Section 4.2 of SARA. The current design, which is assessed below, will be described in Revision 4 of the FPER (Peco, 1983) and has been submitted in response to the draft Limerick Generating Station Safety Evaluation Report (NRC, 1983).

An assessment impact of these design changes on the core melt frequency and risk resulting from fire incidents has been performed and is summarized below.

The fire analysis described in SARA is divided into two stages, the screening analysis and the detailed fire progression analysis. The impact of the design changes on the conclusions of each analysis stage are assessed in sections 2 and 3. The overall conclusions are given in section 4.

2. ASSESSMENT OF THE IMPACT OF DESIGN CHANGES ON THE SCREENING ANALYSIS

The purpose of the screening analysis was to identify fire locations in which fires may contribute significantly to core melt frequency. At this stage core melt frequencies were determined with the assumption that if a fire occurs within a fire zone then all equipment within the fire zone is damaged. The only type of design change which could affect the conclusions of this stage of the analysis would be a modification of the fire area boundaries such that contents of fire areas were changed. This occurs in only one case, namely the Auxiliary Equipment room (fire area 25). This room is subdivided such that the remote shutdown panel will now be located in a separate fire area. Since cabling associated with the remote shutdown panel runs through the auxiliary equipment room (although protected by a 3 hour barrier) the postulated worst case consequences of a fire in that area remain unchanged and the auxiliary

equipment is still identified as a potential significant fire area which must be considered further. The newly created fire area, (26) containing the remote shutdown panel, is not a significant contributor since the frequency of fires is low, and several redundant systems, including the feedwater/condensate system, would remain undamaged so that the plant could be shut down. The proposed changes to the fire protection measures thus have no significant impact on the conclusions of the screening analysis.

3. ASSESSMENT OF THE IMPACT OF DESIGN CHANGES ON THE DETAILED FIRE PROGRESSION ANALYSIS

The second stage of the fire study was a detailed analysis of those potentially significant fire areas namely:

13 KV Switchgear Room - fire area 2
Static Inverter Room - fire area 20
Cable Spreading Room - fire area 22
Control Room - fire area 24
Auxiliary Equipment Room - fire area 25
Safeguard System Access Area - fire area 44
CRD Hydraulic Equipment Area - fire area 45
General Equipment Area - fire area 47

Its objective was to assess the probability of the resulting damage to equipment required for reactor shutdown from various stages of fire growth. Since the proposed fire protection design measures in the above areas are substantially different from those analyzed in SARA there is a significant impact on this second stage of the analysis. Each of the fire areas will now be evaluated in turn. A description of the specific design changes is given followed by a qualitative discussion on precisely how these changes affect the analysis.

3.1 13 KV SWITCHGEAR ROOM - FIRE AREA 2

This area contains cables serving equipment associated with all four shutdown methods A, B, C and D (see Table 1). In the design previously analyzed, cables associated with all safety related equipment were routed in rigid steel conduit. Cables associated with shutdown methods A and B equipment (see Table 1) were protected by a 1" thick ceramic fiber blanket rated as a ½ hour fire barrier. In the present design all safety-related cables will remain in conduit but only cables associated with shutdown method B equipment will be protected by a fire blanket which will be a 3 hour rated fire barrier.

Referring to the fire growth event tree for fire area 2 (see Figure D-9 of SARA) probabilities of events D and E will be affected. Event D represents the random failure of reactor shutdown equipment that is served by protected cable raceways (and is thus not damaged at the second fire growth stage). The probability of this event will increase since only shutdown method B equipment will be undamaged at this stage whereas previously, equipment associated with both shutdown methods A and B were undamaged. The core melt sequence, ACD, which is a combination of fire damage and random equipment failure is increased. Event E represents the probability that the fire is not suppressed before protected cable raceways are damaged. Since the cable raceway fire blankets have been substantially upgraded, from a ½ hour to a 3 hour fire rating, the probability of Event E is significantly reduced. Thus, the frequency of the core melt sequence AEF resulting from fire damage to all reactor shutdown equipment, which in the design previously analyzed was the dominant contributor to core melt frequency from fires in this area, is also significantly reduced.

Overall the design changes result in a reduction in the core melt frequency due to fires in the 13 KV switchgear room.

3.2 STATIC INVERTER ROOM - FIRE AREA 20

Located in this fire area are dc power distribution panels serving equipment associated with shutdown methods B and D together with cable raceways serving shutdown methods A and C. However, there are no equipment or cables which, if damaged by fire, would cause closure of the MSIVs or failure of the feedwater/condensate system. In the design as assessed by the SARA study all raceways associated with shutdown method A were protected by a 2" thick ceramic fiber blanket having a 1 hour fire rating. The present design will provide a fire blanket around shutdown method A raceways which will be a 3 hour rated fire barrier.

Referring to the fire growth event tree for the static inverter room (Figure D-10 of SARA) only Event E is affected. Event E is the probability of the fire damaging protected cables serving shutdown method A equipment. Since the fire blankets which protect shutdown method A cables have been substantially uprated, from 1 hour to 3 hours, the probability of Event E is significantly reduced. As a result the frequency of core melt sequence AEF, which results from fire damage to the equipment associated with the four shutdown methods A, B, C and D coupled with random failure of the feedwater/condensate system, is also significantly reduced. This sequence is the major contributor to the core melt frequency from fires in the static inverter room and thus the new fire protection design results in a significant reduction in the overall contribution from this fire area.

3.3 CABLE SPREADING ROOM - FIRE AREA 22

Cables serving equipment associated with the four shutdown methods A, B, C and D are located in this fire area. However, shutdown method A equipment may be controlled from the remote shutdown panel which is completely independent of cabling or components in the control room, cable spreading room and auxiliary equipment room.

In the design assessed by the SARA study cables serving shutdown methods A and B equipment were protected by a 1" thick ceramic fiber blanket rated as a ½ hour fire barrier. A total flooding, CO_2 suppression system was provided which was actuated by heat detectors. The current design does not include any fire blanket protection for cable raceways. However, the automatic CO_2 suppression is retained and, in addition, a fusible link wet pipe sprinkler system is provided.

Referring to the fire growth event tree for the cable spreading room (Figure D-11 of SARA), it was previously assumed that because cable raceways associated with mutually redundant divisions in this area are only separated 3 feet vertically and 1 foot horizontally, the probability of fire progressing from the first to the second fire growth stage was unity. That is Event C was assigned a probability of 1. This represents the fire growing from the raceway in which the fire originally starts to the stage at which all unprotected raceways in the fire area suffer damage. This obviously conservative assumption was acceptable since equipment associated with shutdown methods A and B still remained operable at the second fire growth stage and the contribution to core melt was not significant. However, if the same assumptions were made under the new design, cable raceways in this fire area which serve shutdown methods A and B would also suffer damage at the second fire growth stage and the only equipment remaining available to shut down the plant would be that which is capable of being controlled from the remote shutdown panel. This assumption would mean that given any fire in the cable spreading room all cable raceways in that area would be damaged with a probability of one. Even under this highly conservative assumption the evaluated core melt frequency is approximately 1×10^{-6} per year. A more refined analysis would indicate that the contribution is significantly less than this value.

3.4 CONTROL ROOM - FIRE AREA 24

There are no proposed changes to the fire protection measures previously evaluated in the SARA study and thus the contribution to core melt from fires in this area remains unchanged.

3.5 AUXILIARY EQUIPMENT ROOM - FIRE AREA 25

As discussed in Section 2.1 the major design change in the fire area is to enclose the remote shutdown panel with 3 hour rated fire walls and thereby create a new fire area, 26. Cables associated with the remote shutdown panel which pass through the auxiliary equipment room will be protected by 3 hour rated fire blankets. The purpose of this design change is to ensure that even if all equipment and cabling located in the auxiliary equipment room suffered fire damage, with the exception of the protected remote shutdown panel cables, then shutdown equipment controlled from the remote shutdown panel will still remain operable. Since the contribution to core melt frequency from fires in this area was previously assessed to be very low (approximately $4x10^{-7}$ per year) the new design changes will serve to reduce the contribution to a negligible level.

3.6 SAFEGUARD ACCESS AREA - FIRE AREA 44

Cable raceways and motor control centers serving equipment associated with all four shutdown methods A, B, C and D are located in this area.

The fire protection design, as assessed in the SARA study, relied on the separation of cables and components serving shutdown methods C and D on the east and west sides of the fire area, respectively. Where cable associated with shutdown method C equipment was found to be separated from cable associated with shutdown method D by less than 20 feet then both of the raceways were protected by a 1" thick ceramic blanket having a ½ hour fire rating. In the present design locations within the fire area which contain cable and components associated with mutually redundant shutdown methods C and D will be separated by 20 foot wide combustible free zones created by enclosing all cable trays that pass through that zone with 1 hour rated fire barriers. One exception to this occurs in the western portion of the fire area where there are some cable raceways which serve shutdown method C in close proximity to shutdown method D raceways. These shutdown method C raceways will be enclosed in a 3 hour rated fire barrier. A fixed, manually initiated, suppression system of the water curtain type will be installed within each combustible free zone.

The new fire protection provisions will substantially increase the burning time required for a fire to propogate such that both shutdown methods C and D are damaged by a single fire, and thus the probability of this event is reduced. Referring to Figures 4-5, 4-6 and 4-7 of the SARA study, Event E is the probability evaluated for precisely this occurrence. The dominant contribution to core melt frequency from fires in this area in SARA was sequence AEF, which describes the failure of all components capable of achieving reactor shutdown due to fire damage alone. Since the probability associated with Event E has been significantly reduced the overall contribution to core melt from fires in this area is also significantly reduced.

3.7 CRD Hydraulic Equipment Area and the General Equipment Area - Fire Areas 45 and 47

The fire protection design changes to these fire areas are similar to those described above for the safeguard access area. The effect is also similar; that is the probability of a single fire damaging equipment associated with mutually redundant shutdown methods is reduced. In both cases a significant reduction in the core melt frequency is achieved.

4. CONCLUSIONS

The design changes to the LGS fire protection measures significantly reduce the overall contribution to core melt frequency from in-plant fires. Whereas the analysis of the original design indicated the majority of the fire induced core melt frequency came from fires which themselves damaged all methods of plant shutdown, the assessment of the present design indicates a higher proportion of the contribution from fires comes from a combination of fire damage and random equipment failures. It is estimated that the reduction in the core melt frequency due to fires that was given in SARA is approximately a factor of 5.

TABLE 1

SYSTEMS OR COMPONENTS ASSOCIATED WITH SHUTDOWN METHODS

Shutdown Method	System or Component
[a]Method A	RCIC ADS RHR train A RHR-SW train A ESWS train A Standby diesels A and C
[a]Method B	HPCI ADS RHR train B RHR-SW train B ESWS train B Standby diesels B and D
[a]Method C [b](equivalent to alternate method A)	ADS RHR trains A and C RHR-SW train A ESWS train A Standby diesels A and C
[a]Method D [b](equivalent to alternate method B)	ADS RHR trains B and D RHR-SW train B ESWS train B Standby diesels B and D

[a]As defined in the LGS Fire Protection Evaluation Report (Revision 3)

[b]As defined in the LGS Fire Protection Evaluation (Revision 1)