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## Appendix 4D - Maximum Risk Increase Associated With EP Relaxations

RG 1.174 provides guidance on the allowable increase in the frequency of large early release associated with a proposed change to the licensing basis. In accordance with RG 1.174, if the baseline LERF is less than 1E-5 per year, plant changes can be approved that increase LERF by up to 1E-6 per year. Relaxations in EP requirements do not impact the frequency of events involving a large early release (i.e., SFP fire frequency) but instead could increase the consequences associated with the large release. Hence, in applying the ΔLERF concept to plant changes that impact consequences it is necessary to translate the allowable increase in LERF into an allowable increase in risk.

The risk increase associated with a ΔLERF of 1E-6 per year can be bounded by considering the consequences for a worst case large early release sequence, in conjunction with the maximum allowable frequency increase (i.e., 1E-6 per year). This approach provides an upper limit on the increase in risk that might be approved in accordance with RG 1.174 principle of permitting only small increases in risk. The allowable increase in risk will be plant specific since the allowable increase in LERF of 1E-6 per year applies to all sites irrespective of such factors as population and meteorology. However, risk-significant differences between sites will tend to similarly impact both the SFP and reactor accident consequences. Hence, the comparisons of SFP risks to the allowable risk increases derived for Surry should be generally applicable to other sites.

The consequences associated with the source term that produced the greatest number of early fatalities in the NUREG-1150 study for Surry are provided in Table 1 below. The consequences are reported separately for internal events and seismic events and are discussed in more detail in the appendix regarding the PPG. The risk measures reported for seismic events are based on the LLNL hazard curve and are about an order or magnitude more severe than those based on the EPRI hazard curve. The maximum allowable level of risk increase is the product of the consequences (in this case, the consequences for the worst seismic event since it is bounding) and the allowable frequency increase of 1E-6 per year. This risk increase is provided in the last column of Table 1.

It should be noted that the Commission's Quantitative Health Objectives (QHOs) correspond to an individual early fatality risk of 5E-7 per year and an individual latent cancer fatality risk of 2E-6 per year. Thus, the risk increase values inferred from RG 1.174 for individual early fatality risk (8.7E-8 per year) and individual latent cancer fatality risk (6.9E-8 per year) represent about 17 percent and 4 percent of these QHOs, respectively. This margin reflects the strategy taken in establishing the acceptance guidelines for risk increase in RG 1.174. Specifically, in RG 1.174 the NRC adopted more restrictive acceptance guidelines than might be derived directly from the Commission's Safety Goal Policy Statement. This policy was adopted to account for uncertainties and for the fact that safety issues continue to emerge regarding design, construction, and operational matters.

Table 2 summarizes the bases for evacuation modeling for each of the major contributors to SFP fires. The effectiveness of EP was characterized is such a way to maximize the value of formal EP in the "full EP" case and minimize the value of ad hoc EP in the "relaxed radiological preplanning" case. As such, the resulting estimates of the risk increase associated with EP relaxations represent an upper bound on the potential risk increase.



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The consequences associated with each of the events leading to SFP fires are provided in Table 3 for the "full EP" case and "relaxed radiological preplanning" case. The consequences are based on results of calculations reported in Appendix 4A. In several cases where MACCS2 runs were not available, the results for the closest corresponding calculation were used as an approximation. The risk increase associated with the EP relaxation is the product of the event frequency and the change in consequences, summed over all contributors.

The sensitivity of the risk increase estimates is strongly dependent on the assumptions regarding the effectiveness of emergency evacuation in seismic events, since these events dominate the SFP fire frequency. In NUREG-1150, evacuation in seismic events was treated either of two ways depending on the peak ground acceleration (PGA) of the earthquake:

- for low PGA earthquakes (<0.6g), the population was assumed to evacuate however the evacuation was assumed to start later and proceed more slowly than evacuation for internally-initiated events. A delay time of 1.5 times the normal delay time and an evacuation speed of 0.5 times the normal evacuation speed was assumed for this case.

- for high PGA earthquakes (>0.6g), it was assumed that there would be no effective evacuation and that many structures would be uninhabitable. The population in the emergency response zone was modeled as being outdoors for the first 24 hours, and then relocating at 24 hours.

Since the SFP fire frequency is driven by seismic events with PGA several times larger than the SSE, the assumption that there would be no effective evacuation was adopted in developing the baseline estimate of the risk. This is consistent with the expert opinion provided in Appendix _ regarding the expected level of collateral damage within the Emergency Planning Zone given a seismic event large enough to fail the SFP. Specifically, for ground motion levels that correspond to SFP failure in the Central and Eastern U.S., it is expected that electrical power would be lost and more than half of the bridges (including those housing communication systems and emergency response equipment) would be unsafe even for temporary use within at least 10 miles of the plant. This assumption is also consistent with previous Commission rulings on San Onofre and Diablo Canyon in which the Commission found that for those risk-dominant earthquakes that cause very severe damage to both the plant and the offsite area, emergency response would have marginal benefit because of its impairment by offsite damage.
This same assumption is applied to the full EP and the relaxed EP cases. The net effect is that EP, as well as relaxations in EP, do not impact the risk associated with seismic events that result in SFP failure. A sensitivity case was also performed to explore the impact on risk increase if the seismic event only partially degrades the emergency response, as discussed below.

In the sensitivity case, it was assumed that evacuation would be carried out consistent with the NUREG-1150 model for low g earthquakes if current EP requirements are maintained, i.e., the population evacuates, but the evacuation delay time is increased by 50 percent and the time to complete the evacuation is doubled. This is extremely optimistic given the damage to communication and notification systems, buildings and structures, and roads that would accompany any seismic event severe enough to fail the SFP. With no preplanning for radiological accidents, the evacuation delay time was further increased to three times the normal

delay time.
For purposes of assigning consequences in the seismic sensitivity case, the "full EP" case was represented by the results from the early evacuation case (i.e., evacuation is started and completed prior to the release) and the "relaxed preplanning for radiological accidents" case was represented by the results from the late evacuation case (i.e., evacuation is not started until after the release has occurred). This maximizes the effectiveness of evacuation in the full EP case and minimizes its effectiveness in the relaxed preplanning case, thereby tending to maximize the risk increase associated with EP relaxations.

The estimated risk increases associated with the EP relaxation are summarized in Table 4. The results indicate that relaxation of the requirements for radiological preplanning would result in an increase of about 1.5E-5 early fatalities and 2 person-rem per year, which is about a factor of 15 and five below the allowable increase inferred from the RG 1.174 LERF criteria. The other risk measures are also substantially lower than the allowables from RG 1.174. Since the SFP fire frequency assumed in these comparisons (2.4E-6 per year) is about a factor of four lower than the PPG of 1E-5 per year, a plant operating nominally at the PPG would have a smaller margin to the allowable risk limits for the reference plant but would still be at or below the limits under the above assumptions.

The results of the sensitivity studies indicate that even under the most optimistic assumptions regarding the value of EP in seismic events, the change in risk associated with relaxation of the requirements for radiological preplanning is still relatively small. The increases in early fatalities and individual early fatality risk remain below the maximum allowable for each risk measure. Population dose and individual latent cancer fatality risk are about a factor of two higher than the allowable value inferred from RG 1.174. This increase in individual latent cancer risk represents about nine percent of the QHO, thus, considerable margin to the QHO would still remain.

It must be kept in mind that the evacuation effectiveness assumed for "Full EP" in the sensitivity case is unrealistic for high g earthquakes, and that the risk increase associated with the EP relaxations would be closer to the baseline value. Also, the risk reduction estimates are based on the LLNL seismic hazard frequencies and the high ruthenium source term, and would be substantially lower if either the EPRI seismic hazard frequencies or the low ruthenium source term were used. Finally, the above comparisons are based on the risk levels one year after shutdown.

The impact of the above factors on the maximum risk increase for the EP relaxations is shown in Figures 1 and 2 for early fatalities and population dose (person-rem). Use of either the EPRI seismic hazard frequencies or the low ruthenium source term would reduce each of the risk measures by about a factor of 10, to values which are well below the RG 1.174 allowables. The risk impact will decrease in later years due to reduced consequences as fission products decay further.

Table 1 - Allowable Level of Risk Increase In Accordance With RG 1.174 ΔLERF Criterion (Based on Surry)

| Risk Measure | Consequences -- conditional upon source term that produces greatest early fatalities (per event) | | Allowable frequency increase in accordance with RG 1.174 (events per year) | Allowable risk increase (per year) |
|---|---|---|---|---|
| | Internal Events | Seismic Events | | |
| Early fatalities | 15 | 250 | 1E-6 | 2.5E-4 |
| Population dose (p-rem within 50 miles) | 3.6E6 | 1.1E7 | 1E-6 | 11 |
| Individual early fatality risk at 1 mile | 2.9E-2 | 8.7E-2 | 1E-6 | 8.7E-8 |
| Individual latent cancer fatality risk at 10 mile [1] | 5.5E-3 | 6.9E-2 | 1E-6 | 6.9E-8 |

1 - Values shown include a factor of three adjustment to account for differences in the cancer risk model used for NUREG-1150 and SFP accident calculations

Table 2 - Evacuation Modeling for Major Contributors to SFP Fires

| Event Type | Major Contributor | Freq (per year) | Minimum Time to Release at One Year (h) | Timely Notification of Off-Site Authorities? | Intact Infrastructure for Emergency Response? | Evacuation Model | |
|---|---|---|---|---|---|---|---|
| | | | | | | Full EP | Relaxed Preplanning for Radiological Accidents |
| Boildown | LOOP (severe weather) | 1.8E-7 | >200 | No | Yes | Late | Late |
| Rapid Draindown | Cask Drop | 2.0E-7 | ~10 | Yes | Yes | Early | Late |
| | Seismic [1] | 2.0E-6 | ~10 | Yes | No | No evacuation Relocation at 24 h | No evacuation Relocation at 24 h |
| | Seismic Sensitivity [2] | | | | | 1.5x normal delay 0.5x normal speed (Model as Early) | 3x normal delay 0.5x normal speed (Model as Late) |

1 - Evacuation model for full EP case is consistent with NUREG-1150 assumptions for high acceleration earthquakes
2 - Evacuation model for full EP case is consistent with NUREG-1150 assumptions for low acceleration earthquakes

Table 3 - Estimated Risk Increase Associated With Relaxing EP Requirements at SFP Facility (at one year)

| Event | Freq (per year) | Consequences Per Event with Full EP | | | | Consequences Per Event with Relaxed Preplanning for Radiological Accidents | | | | ΔRisk Per Year from EP Relaxation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EF | p-rem | Ind Risk of EF | Ind Risk of LCF | EF | p-rem | Ind Risk of EF | Ind Risk of LCF | ΔEF | Δp-rem | ΔInd Risk of EF | ΔInd Risk of LCF |
| Boildown [1] | 1.8E-7 | See Note 1 | | | | See Note 1 | | | | 0 | 0 | 0 | 0 |
| Cask Drop | 2.0E-7 | 0.95 | 1.1E7 | 1.50E-3 | 4.33E-3 | 77 | 1.9E7 | 3.46E-2 | 8.49E-2 | 1.5E-5 | 1.6 | 6.6E-9 | 1.6E-8 |
| Seismic [2] | 2.0E-6 | See Note 2 | | | | See Note 2 | | | | 0 | 0 | 0 | 0 |
| Total | 2.4E-6 | | | | | | | | | 1.5E-5 | 1.6 | 6.6E-9 | 1.6E-8 |
| Seismic Sensitivity | 2.0E-6 | 0.95 | 1.1E7 | 1.50E-3 | 4.33E-3 | 77 | 1.9E7 | 3.46E-2 | 8.49E-2 | 1.5E-4 | 16 | 6.6E-8 | 1.6E-7 |

1 - Risk results with and without EP would be comparable for boildown sequences since the failure paths in these sequences involve failures to notify offsite authorities and would not be impacted by EP

2 - Risk results with and without EP would be comparable for large seismic events since emergency response would have marginal benefit because of its impairment by offsite damage

Table 4 - Comparison of Risk Increase with RG 1.174 Allowable (at one year)

| Risk Measure | Risk Increase Due to EP Relaxation (per year) | | RG 1.174 Allowable Risk Increase (per year) |
|---|---|---|---|
| | Baseline [1] | Seismic Sensitivity [2] | |
| Early Fatalities | 1.5E-5 | 1.6E-4 | 2.5E-4 |
| Population Dose | 1.6 | 17.6 | 11 |
| Individual Early Fatality Risk | 6.6E-9 | 7.3E-8 | 8.7E-8 |
| Individual Latent Cancer Fatality Risk | 1.6E-8 | 1.8E-7 | 6.9E-8 |

1 - Assumes no effective evacuation in seismic events, regardless of pre-planning
2 - Assumes maximum effectiveness of emergency planning (i.e., early evacuation) when EP requirements are maintained, and minimum effectiveness (i.e., late evacuation) when EP requirements are relaxed

Figure 1 - Maximum Early Fatalities Averted by Full EP **(Insert Here)**

Figure 2 - Maximum Person-Rem Averted by Full EP **(Insert Here)**