Evaluation of Temporary Loads

Approach to Justify Larger Loads with Less Effort

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ABSTRACT

Methods are described to effectively and efficiently evaluate temporary loads applied to piping and structures in nuclear power plants. Adressed are the application of temporary loads on piping systems, components and structures, together with recommended evaluation criteria and methods for adjusting the applicable design basis loadings. Recommendations are provided that will result in the justification of larger loads while minimizing the requisite evaluations and maintaining the plant's design basis.

Justifying the use of larger temporary loads significantly benefits maintenance, testing and modification activities. For example, the use of more temporary lead shielding will reduce worker radiation exposure. Effective and efficient evaluations will also benefit the use of rigging, scaffolding, temporary support removals and additions and other activities necessary to the maintenance, operation, and modification of operating nuclear power stations.

INTRODUCTION

Temporary loads are a frequent occurrence resulting from operation, maintenance and modifications. These loads are in place for a short duration, typically six months or less. Examples of temporary loads include: lead shielding; rigging loads; and loads resulting from maintenance, such as temporary support removal and addition, and temporary system modifications, such as equipment disassembly.

Further, increased maintenance activities are being performed during plant operation in order to reduce outage durations. During this time, the configuration of piping systems may be altered from their design basis conditions, for short periods of time, to perform these activities. These altered conditions can result in unanalyzed temporary loadings.

A diverse range of methods has been used to evaluate temporary loads. In some instances overly conservative acceptance criteria are used. This needless conservatism can have detrimental results. For example, overly conservative criteria would artificially limit the amount of temporary lead shielding that could be placed on piping, which in turn would needlessly increase personnel radiation exposure. This conservatism can be avoided by using evaluation criteria and load cases that account for the short duration of the temporary loads.

The use of adjusted load cases and reduced seismic loadings, corresponding to the short duration of the temporary loads, significantly benefits the load evaluations. This in turn benefits the activities that result in the loadings.

A logical approach is presented for adjusting the design basis load cases used for temporary load evaluations. These load cases are adjusted to correspond to the plant and system conditions applicable to the period of time the loads are applied. Further, a quantitative procedure has been developed for using site-specific annual seismic hazard curves to determine the acceleration levels corresponding to the temporary load durations. Use of this procedure enables the use of reduced seismic acceleration levels, which enables the effective use of available design margins for the application of temporary loads. Using this procedure, a time limit for which seismic effects need not be considered can also be determined.

These methods have been successfully used to benefit maintenance, testing and modification activities in operating nuclear plants.

LOAD SETS FOR TEMPORARY LOADS

The following are several common examples of maintenance and testing activities that result in temporary loads and therefore will benefit from effective evaluation criteria.

- placement of temporary lead shielding on piping;
- use of rigging for equipment removal and installation, or the application of lead shielding;
- support removal to provide access for component (e.g., valve) maintenance;
- temporary scaffolding used for maintenance, modifications, testing and support of shielding; and
- removal of snubbers for testing.

Temporary loads can result in unanalyzed conditions that could have a potentially detrimental effect on a plant's design basis. Therefore, the effects of temporary loads need to be evaluated in accordance with the requirements of the Code of Federal Regulations 10 CFR 50.59, "Changes, Tests, and Experiments," to verify that the application of loads does not involve an unreviewed safety question.

Accounting for the short duration of temporary loads, and for the plant and system operating status applicable to the load duration, will remove some needless conservatism and thereby avoid some of the resulting adverse effects. Another example of accounting for a load's short duration is the relaxed criteria often utilized for temporary test loads.

Load sets can be adjusted to correspond to the plant and system operating conditions applicable to the duration of the applied loadings. This together with the use of seismic loads reduced to account for the short load duration, effectively makes use of the margin available in the design of the piping, components and structures affected by the temporary loads. Effective use of the available margin can enable the use of simplified evaluation methods and/or the justification of larger temporary loads. Larger allowable temporary loads result in significant benefits, e.g., larger allowable temporary loads would enable the use of more temporary lead shielding, thereby resulting in reduced worker radiation doses.

Evaluation criteria provided herein will benefit applications that result in temporary loads by enabling faster and more effective evaluations. Evaluations can be completed faster because fewer loadings need be considered, and the evaluations will be more effective because fewer loads and reduced seismic loads will free available design margin for use to justify the application of temporary loads.

ADJUSTMENT OF LOAD SETS

Evaluation criteria for temporary loads should account for both the plant and system operating status existing while the loads are applied and for the short duration of the applied loads.

Typically, larger loads can be justified with less effort for conditions when both the plant (i.e., unit) and the system are not operating. The temporary loads that can be justified decrease, and the evaluation effort increases, when the unit and/or system are operable. This is because the number of design basis loadings that must be considered in the evaluation increases. Additional loadings increase the evaluation effort and decrease the margin available for temporary loads. These relationships are illustrated in Figure 1.

The relationships between unit and system operating status and the applicable design basis loadings for different categories of piping systems and their associated components and structures, are delineated in Table 1. Note that these relationships are for purposes of illustration; they generally are applicable, however, there will be exceptions to these relationships.

The relationships in Table 1 demonstrate how load sets can be adjusted to correspond to the unit and system status applicable to the period the temporary loads will apply. This adjustment involves removing loads from the load set used for the evaluation, that do not apply to the unit and system operating status when the temporary loading exists. The allowables used in the evaluations should also be adjusted to reflect the required or potential use of the system while the temporary loads are applicable.

Development of the load sets in Table 1 was based on a logic of maintaining the design basis while maximizing the amount of temporary loads that can be justified and minimizing the related evaluation effort. To cover all possible conditions, five combinations of unit and system operating status were included. The unit operating, system operating status reflects the design basis. The only margin available for this status is whatever margin happens to exist in the designs. However, a significant amount of this margin can be used for temporary loads when these loads are evaluated using seismic accelerations reduced to correspond to the temporary load duration.

Note that in Table 1, "System Operational" refers to either the system is actually operating during the period the temporary loads are applied, or the system may be required to operate during this period. "System Not Operating" refers to situations where the system is not in operation and it will not be required to operate during the period the temporary loads apply.

As Table 1 illustrates, the applicable load sets are dependent not only on the unit and system status, but also on the system classification and function. A system's function is dependent on its own and the unit's operational status. For example, the High

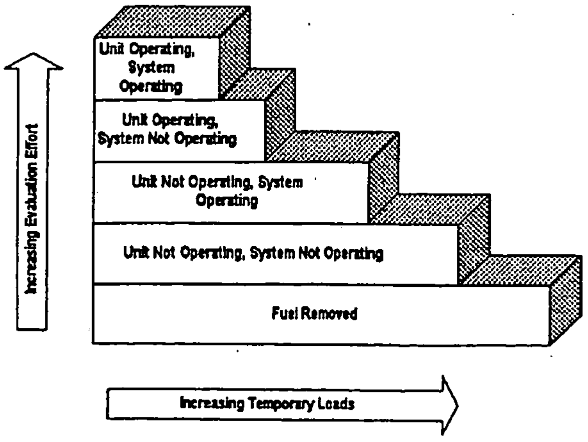

Figure 1. Allowable Temporary Loads vs. Unit and System Operating Status

Table 1

Sample Piping System Design Basis Loads vs Unit and System Status

Unit & System Status	Piping System Classification and Applicable Design Basis Loads				
	Essential	S.R. Class 1	S.R. Non-Class 1	Non-S.R. Seismic	Non-S.R.
Unit Operating, System Operating	N, S, A	N, S, A	N, S, A	N, S	N
Unit Operating, System Not Operating	Wt, S, A	Wt, S, A	Wt, S, A	Wt, S	Wt
Unit Not Operating, System Operating	N, S	N, S	N	N	N
Unit Not Operating, System Not Operating	Wt	Wt, S	Wt	Wt	Wt
Fuel Removed	Wt	Wt	Wt	Wt	Wt

Keys:

Design Basis Loads

Wt - Weight loads
N - Normal operating loads; e.g., weight, pressure, thermal expansion
S - Seismic loads
A - Postulated accident loads

Piping System Classification

Essential - Systems required to shut down the reactor and maintain it in a safe shutdown condition
S.R. Class 1 - Safety related piping directly attached to the reactor vessel with no method of isolation
S.R. Non-Class 1 - Safety related piping isolated from the reactor vessel by isolation valves or other means
Non S.R. - Seismic - Non safety-related piping that has been designed for seismic loads
Non-S.R. - Non-safety-related piping

Pressure Core Spray (HPCS) in a BWR is an essential system when the unit is operating, but its function is (temporarily) not required when the unit is not operating. Therefore, the applicable load sets and response allowables can be adjusted accordingly.

Postulated accident loadings are also removed from the evaluation load sets when the plant is not operating. When the plant is not operating, the high pressure and temperature conditions are not present to cause the dynamic loadings associated with a postulated accident, such as a high energy pipe break.

Additionally, seismic loads have been removed for most applications when the unit and system are not operating. Although a seismic event could still occur during these conditions, the indicated systems need not withstand the effects, since the unit is already shutdown and is in a safe operating condition. This assumes that if a earthquake should occur, then prior to restarting the unit, the affected systems would need to be evaluated and/or inspected to verify that they were not detrimentally affected by the seismic loadings occurring in conjunction with the temporary loads.

Seismic loads are included in the evaluations for piping directly attached to the reactor pressure vessel (RPV), during the unit and system not operating status, to verify that the RPV integrity is maintained as long as there is fuel in the vessel. When fuel is removed from the RPV, then all systems need only be evaluated for weight loads.

Table 2 provides an example of the adjusted load sets and corresponding response allowables used for evaluating placement of temporary shielding on a Reactor Water Cleanup (RWCU) piping subsystem in a Boiling Water Reactor (BWR). Note that this is an example only, applicable loadings and allowable responses are determined on a case-by-case basis. This table delineates the design basis loadings and allowable response limits that correspond to different unit and system operating conditions. The seismic loads in these load sets are reduced based on the duration of the temporary loads, as described in the following section.

CALCULATION OF REDUCED SEISMIC ACCELERATIONS

A quantitative procedure for using available site-specific annual seismic hazard curves to determine the acceleration level for evaluation of a temporary condition of known short duration

TABLE 2

Sample Adjustment of Load Sets for Temporary Shielding Evaluations
RWCU Piping Outside Containment (BWR)

OPERATING CONDITIONS				RESPONSE CALCULATIONS							ALLOWABLE RESPONSES		
Unit Op.	System Op.	Fuel Removed	Plant Operational Modes	Wt	Th	Pres	OBE Iner.	OBE SAM	SSE Iner.	SSE SAM	Pipe Stress	Equipment & Support Loads	Notes
Y	Y	N	1, 2, 3	✓ ✓	✓ ✓	✓ ✓	✓		 ✓		9B 9C	Upset Emergency	1, 2
Y	N	N	1, 2, 3	✓ ✓	✓ ✓				 ✓		9B 9D	Upset Faulted	1, 2, 3
N	Y	N	4	✓ ✓	✓ ✓	✓ ✓			 ✓		9B 9D	Upset Faulted	1, 2
N	N	N	4, 5	✓							9B	Upset	
N	N	Y	N/A	✓							9B	Upset	

Key

Y, N - Yes, No
Unit Operational Modes - The unit operational mode(s), according to Technical Specifications, that corresponds to the unit and system operating conditions.
Wt - Piping weight (including contents and insulation) plus temporary shielding weight loads.
Th - Piping thermal expansion (temperature and anchor movements reduced, as appropriate, to reflect plant and system operating conditions)
Pres - Internal pressure of piping (pressure reduced, as appropriate, to reflect plant and system operating conditions)
OBE Iner. - Operating Basis Earthquake inertia loadings (reduced for temporary loads, as appropriate)
OBE SAM - Operating Basis Earthquake seismic anchor movements (reduced for temporary loads, as appropriate)
SSE Iner. - Safe Shutdown Earthquake inertia loadings (reduced for temporary loads, as appropriate)
SSE SAM - Safe Shutdown Earthquake seismic anchor movements (reduced for temporary loads, as appropriate)
Pipe Stress - ASME Boiler and Pressure Vessel Code, Section 3, Equations for Piping: 9B - Upset condition allowable stress; 9C - Emergency condition allowable stress; 9D - Faulted condition allowable stress.
Equipment & Support Loads - Allowables are either the design basis analysis loads increased by 10%, or allowable loads that have been increased to accommodate temporary shielding.

Notes ,

1. Allowable responses apply to the safety related portion of piping. Seismic responses of the non-safety-related piping are compared against operability stress limits for piping, faulted limits for supports, and equipment load checks are not completed.
2. Seismic loads used to evaluate the temporary loads, are reduced based on the duration the loads are applied.
3. Piping thermal expansion responses consider thermal anchor movements and the elevated temperature only for the portion(s) of the system that have elevated temperature contents.

(several days or months in a year) is described in this section. Results are relatively insensitive to the choice of hazard curves for sites in the eastern United States since the procedure depends on the shape of the curves rather than on the probability values. Also described is use of the procedure for determining a short duration limit for which seismic effects need not be considered. Site specific results are presented and discussed.

Nuclear power plants are designed for two levels of seismic load: Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE). The design-basis qualification of piping, components and structures considers resulting seismic effects in various combinations with other significant parameters, such as dead load, operation effects, and accident effects. Detailed structural analysis for full seismic effects on structures, systems, or components for temporary conditions can be costly and overly conservative. In order to properly account for such conditions, it is appropriate to include the duration effect on seismic load when structures and components are evaluated for a temporary condition.

A quantitative procedure was developed for considering the duration effect of short-term loads when seismic loading is being considered. The procedure uses available annual seismic hazard curves to obtain the acceleration level applicable to a prescribed load duration. The derived acceleration, expressed as a fraction of design-basis SSE or OBE acceleration, is relatively insensitive to the specific hazard curve, from among those available for use in this type of calculation. Approach and reasoning are also provided to determine a very short duration limit for not considering seismic as a load set. The implementation issues related to the procedure are also discussed.

DURATION-DEPENDENT SITE ACCELERATION

The calculation of site acceleration as a function of a prescribed short duration utilizes site-specific annual hazard curves (plots of the probability of exceedance per year against peak horizontal ground acceleration). The availability of annual hazard curves for nuclear plant sites, the distribution function of site acceleration, and selection of an acceleration level from the distribution function are described below.

Availability of Annual Hazard Curves

Most nuclear plant sites in the United States have recently developed annual hazard curves available either because of studies related to their response to Individual Plant Examination for External Events (IPEEE) or because of resolution of the eastern seismicity issue related to the Charleston Earthquake. For sites east of the Rocky Mountains, the annual hazard curves are available from two sources:

- Lawrence Livermore National Laboratory (LLNL) Study (Bernreuter et al., 1989)
- Electric Power Research Institute (EPRI)/Seismic Owners Group (SOG) Study (McGuire et al., 1989)

Three items are noteworthy regarding the LLNL and EPRI/SOG hazard curves relative to this paper: (1) these curves were developed through extensive studies involving groups of seismicity and ground motion experts, and formal procedures for considering the experts' judgment; (2) both procedures used a Poisson process for the occurrence of earthquakes in each seismic zone; and (3) the hazard curves from these studies were used by the United States Nuclear Regulator Commission (USNRC) and the industry to formulate solutions to seismic issues in nuclear power plants (e.g., the USNRC used LLNL and EPRI/SOG curves to put 69 plants in the eastern United States into two seismic bins for the purpose of addressing the seismic portion of IPEEE).

Figure 2 shows seismic hazard curves for a specific site from LLNL and EPRI/SOG studies. It is well-known that for the same acceleration value, the probability of exceedance from the curves of the two studies vary widely. The procedure to be discussed depends on the shape of hazard curves rather than on absolute probability values. For this reason, the results tend to be less sensitive to the source of the hazard curve that is used in the calculation.

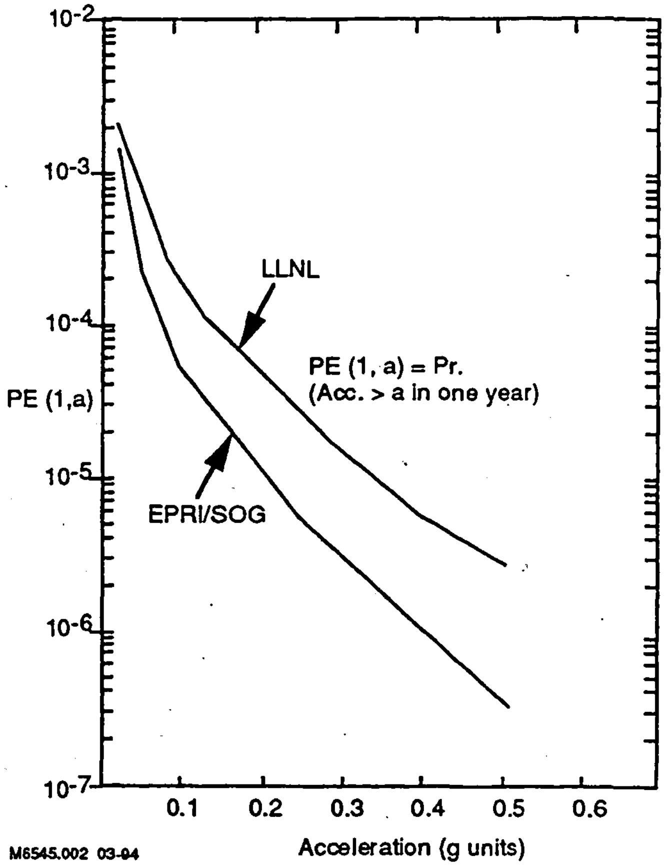

Figure 2. Sample Median Annual Hazard Curves for a Site

Distribution Function of Site Acceleration in t_d

Consider a short duration t_d (fraction of a year), and adopt the following assumptions:

1. Seismic acceleration at the site has a probability distribution function

$$F_A(a) = \Pr.[A \le a] \qquad (1)$$

where A = random site peak horizontal acceleration, a = a specific value of acceleration, and Pr. [.] denotes the probability of the event described within the bracket.

2. The earthquakes at the site occur in accordance with a stationary Poisson process at a yearly rate ν (average number of earthquakes per year).

Define duration-dependent hazard curve (PE) as

$$\begin{aligned} PE\,(t_d,a) &= \Pr.\,[A_{max} > a \text{ within } t_d] \\ &= 1 - \Pr.\,[A_{max} \le a \text{ within } t_d] \end{aligned} \qquad (2)$$

where A_{max} = maximum site acceleration during t_d. Based on assumptions 1 and 2, the hazard function is (Cornell, 1968)

$$PE\,(t_d,a) = 1 - e^{-\nu t_d[1 - F_A(a)]} \qquad (3)$$

Since νt_d = average number of earthquakes affecting the site in duration t_d (Cornell, 1968), it is usually much smaller than unity. Also since $F_A(a)$ is a probability distribution function, $1 - F_A(a)$ is smaller than unity. It follows that

$$PE\,(t_d,a) \approx t_d \nu\,[1 - F_A(a)] \qquad (4)$$

Equation 4 implies

$$PE\,(t_d,a) = t_d\, PE\,(1,a) \qquad (5)$$

where PE (1,a) = annual hazard curve. Consequently, by specifying a short duration t_d as a fraction of a year, the duration-dependent hazard curve can be constructed by scaling the annual hazard curve according to Equation 5. Figure 3 shows hazard curves constructed from the EPRI/SOG curve of Figure 2 for t_d = 0.5 (6 months), 0.333 (4 months), 0.167 (2 months), and 0.083 (1 month).

Site Acceleration for t_d

The specification of an acceptable probability level for selecting an acceleration from the hazard function and the choice of a unique hazard curve given this selected probability are controversial. In order to circumvent these difficulties, plant design basis accelerations [i.e., $a_{SSE}(1)$ = for SSE peak ground acceleration and $a_{OBE}(1)$ = for OBE peak ground acceleration] and their corresponding annual probabilities are used.

Consider $a_{SSE}(1)$, for example. Given a specific annual hazard curve, the ordinate at this acceleration, i.e., PE $(1,a_{SSE})$, yields the probability of exceeding this acceleration. Since the plant is *deterministically* designed for $a_{SSE}(1)$, it is logical to treat $PE(1,a_{SSE})$ as an acceptable probability of exceedance. This probability is used to determine $a_{SSE}(t_d)$ from the associated duration-dependent hazard curve. The construction for t_d = 0.167 is shown in Figure 3, assuming $a_{SSE}(1)$ = 0.2 g. The value of $a_{(SSE)}$ (0.167) is read as 0.09 g.

In summary, the acceleration value corresponding to short duration t_d (for SSE or OBE evaluation) is the acceleration value that will have the same probability of being exceeded during t_d as the design value [$a_{SSE}(1)$ or $a_{OBE}(1)$] has in one year. Note that a year is used as a base period because of the way hazard curves are now available to the plants. Any duration other than a year could be used for the base period. A more directly relevant value would be the duration of a refueling cycle. Any such choice is not expected to affect the results significantly.

Table 3 summarizes the ratio of SSE acceleration for t_d, $a_{SSE}(t_d)$, to SSE acceleration for one year, $a_{SSE}(1)$, for the two site hazard curves of Figure 2. For this comparison $a_{SSE}(1)$ = 0.2 g. Considering the appreciable difference in the ordinates of the two hazard curves in Figure 2, the acceleration ratios in Table 3 from the LLNL and EPRI/SOG are very close. This table shows the relative insensitivity of the procedure to the choice of LLNL or EPRI/SOG hazard curves.

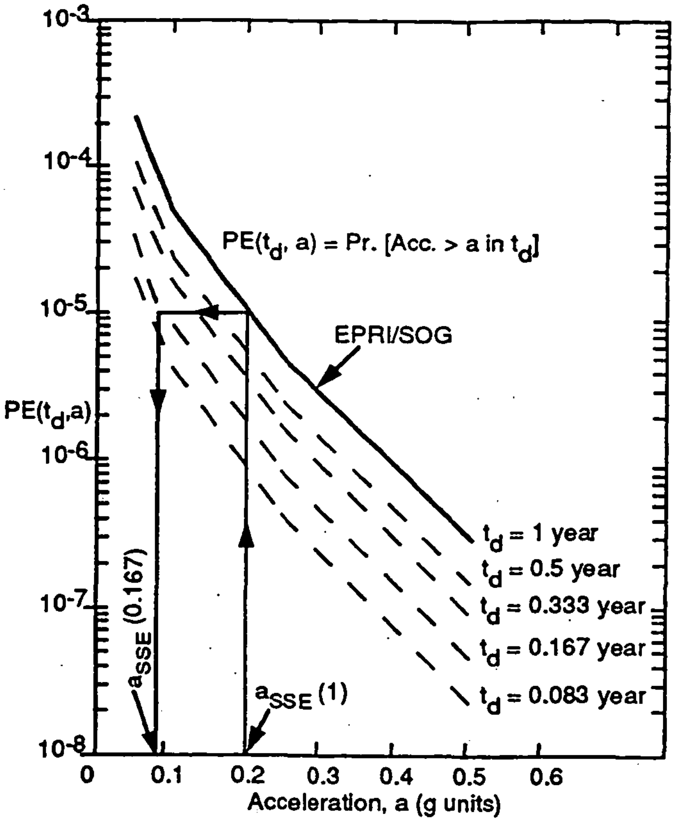

Figure 3. Duration-Dependent Hazard Curves for EPRI/SOG Curve in Figure 1 and Construction of a_{SSE} (t_d) Using a_{SSE} (1)

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After the ratio $a_{SSE}(t_d)/a_{SSE}(1)$ is determined for a prescribed short duration, the effective accelerations for component evaluation can be calculated using the applicable response spectra reduced by the above ratio. The SSE allowables will be utilized to complete the evaluation for SSE. If necessary, a similar calculation can be performed on the component with $a_{OBE}(t_d)/a_{OBE}(1)$ ratio and the corresponding OBE allowables.

Duration for Not Considering Seismic as a Load Case

The value of site acceleration decreases as the corresponding duration becomes smaller, as shown in Table 3. It is of practical interest to calculate a duration corresponding to each hazard curve, such that, for durations smaller than this value, seismic effects do not have to be considered as a load case. A practical approach to this is to specify an acceleration threshold that is acceptably small so as not to require a specific seismic evaluation.

Table 3

Ratio SSE Acceleration for t_d to Design Basis SSE Acceleration for Hazard Curves in Figure 2

	$a_{SSE}(t_d)/a_{SSE}(1)$	
Duration t_d	LLNL	EPRI/SOG
1 year	1.00	1.00
6 months	0.72	0.77
4 months	0.58	0.64
2 months	0.42	0.46
1 month	0.29	0.33

A site acceleration of 0.02 g may be considered a reasonable threshold under which detailed seismic evaluation is not required, as described later. Let t_d (0.02) denote the duration for a 0.02-g acceleration. Applying Equation 1 and using $PE(1,a_{SSE})$ as the acceptable probability level, t_d (0.02) is given by

$$t_d(0.02) = \frac{PE(1,a_{SSE})}{PE(1,0.02\ g)} \quad \text{(in years)} \qquad (6a)$$

$$= \frac{8760\ PE(1,a_{SSE})}{PE(1,0.02\ g)} \quad \text{(in hours)} \qquad (6b)$$

When Equation 6b is evaluated using $a_{SSE}(1) = 0.2$ g and the annual hazard curves in Figure 2, the resulting values of $t_d(0.02)$ are 69 hours for EPRI/SOG hazard curves and 206 hours for LLNL curves. The application of this procedure to the curves of several stations shows the following:

- The shortest duration is always calculated from the median hazard curves of EPRI/SOG.
- The calculated duration t_d (0.02) always exceeds 24 hours, which implies that a 24-hour duration is conservatively short enough so as not to require evaluation of seismic effects; duration longer than 24 hours may be acceptable at specific sites.

Justification for 0.02 g

Two generic justifications that support 0.02 g as being a low enough acceleration not to require a seismic evaluation are provided below.

Reference to Correlation of MM Intensity with Peak Ground Acceleration. Figure 4 shows correlation of Modified Mercalli (MM) intensities with peak horizontal ground accelerations provided by a number of investigators (Murphy and O'Brien, 1977). For intensity V, acceleration varies from 0.012 g to 0.07 g. For intensity VI, the corresponding acceleration range is from 0.024 g to 0.12 g. The 0.02-g ground acceleration is near the low end of acceleration for intensity V, and it is less than the low point acceleration for intensity VI. Recalling that intensity V shaking is felt and small unstable objects get displaced, but damage to structures or movement of large objects does not occur, it follows that 0.02-g acceleration is sufficiently low enough as to not require a specific seismic calculation to show acceptability.

Reference to Threshold of Damage from Construction Vibrations. Wiss provides information on the threshold of possible damage to buildings caused by construction activities (Wiss, 1981). In terms of peak ground velocity, this threshold for residential buildings is 2 in./sec. The velocity threshold for commercial buildings is higher (4 in./sec). Values to correlate peak ground velocity to peak ground acceleration for seismic motions are 48 in./sec/g for competent soil and 36 in./sec/g for rock (Newmark and Rosenblueth, 1971). Combining this information to obtain a lower bound for damaging acceleration level yields

$$a_{\text{lower bound}} = (2\ \text{in./sec}) \div (48\ \text{in./sec/g}) = 0.042\ g \qquad (7)$$

This lower bound value justifies using 0.02 g as the acceleration level that requires no specific seismic qualification.

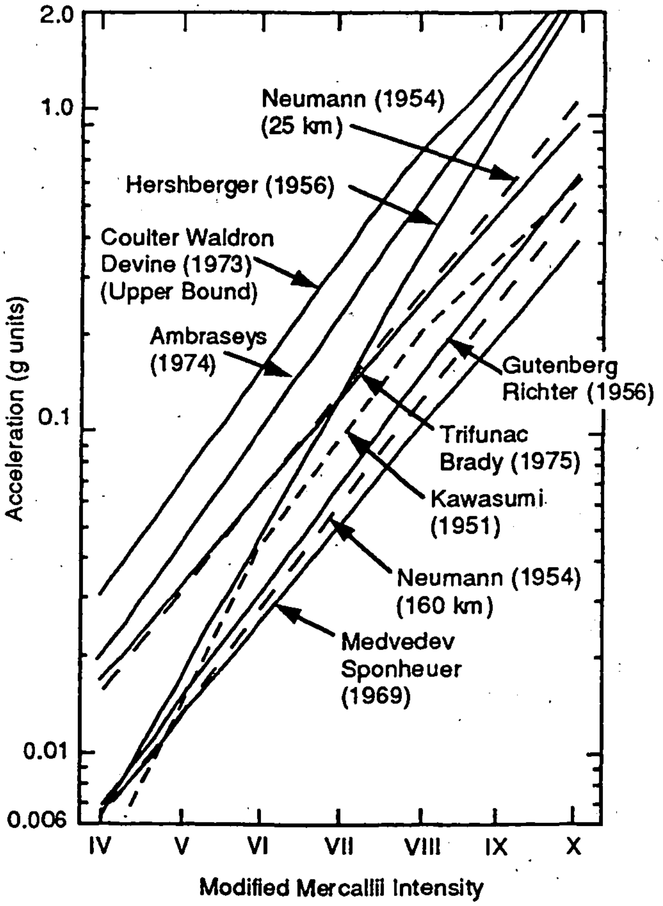

Figure 4. Selected Intensity/Acceleration Correlations from Murphy and O'Brien (1977)

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IMPLEMENTATION ISSUES

The following two issues are of particular interest when the described procedure is applied to the evaluation of a specific temporary condition.

Duration, t_d, and Start Time

A conservative duration (t_d) for each temporary condition should be estimated to preclude future reevaluation, should the anticipated duration of the activity be exceeded; this t_d should be used to determine the applicable acceleration for making the necessary evaluations. The start time of this duration can be any time in a given year or in a refueling cycle. Because the procedure is based on the Poisson process for occurrence of earthquakes and since the Poisson process is a memoryless process, if in a given application (due to unforeseen factors) the estimated duration expires before the work is completed, the evaluation remains valid for a subsequent duration equal to t_d. However, this Poisson assumption should not be misused by underestimating the duration t_d when the work is being planned.

Applicability of Poisson Assumption

As noted earlier in this paper, modern site-specific annual seismic hazard curves are determined by utilizing considerable expert studies and judgment. These studies all use the Poisson assumption as a suitable and convenient tool to provide data for engineering evaluations. The resulting hazard curves are considered to provide stable estimates of site seismicity. On this basis, using the annual hazard curves to consider duration-dependent acceleration seems to be reasonable without becoming concerned with the invalidity of the Poisson assumption during foreshocks and aftershocks of a main seismic event. It is presumed that significant changes in seismicity will be appropriately incorporated in the future seismic hazard curves.

SUMMARY AND CONCLUSIONS

Temporary loads in nuclear power plants are a common occurrence resulting from operation, maintenance and modifications. Methods have been developed to facilitate effective and efficient evaluations of these temporary loads. These methods maintain a plant's design basis while making effective use of the design margin existing in the affected piping, components and structures.

Use of these methods result in significant benefits, including the justification of larger temporary loads and evaluation cost savings. For example, these techniques have been used to increase the use of temporary lead shielding, thereby reducing worker radiation doses, and to avoid the need for seismic evaluations for very short duration loads, thereby saving evaluation costs.

Accounting for the temporary loads' short duration is the premise of the methods used for effective evaluations. This includes adjusting the load sets and associated response allowables to correspond to the unit and system status, and to the required function of system during the period the temporary loads apply. This adjustment reduces the applicable loadings and can enable the use of larger response allowables. This effectively utilizes plant design margin and reduces the evaluation effort.

The seismic accelerations used for the evaluations can also be adjusted to correspond to the short duration of the temporary loads. This will reduce the applicable accelerations and thereby both simplify the evaluations and further enable effective use of existing design margins. A quantitative procedure was developed for using available site-specific annual seismic hazard curves to determine an acceleration level for evaluating a temporary condition of known short duration (several days or months in a year). The plant design basis SSE or OBE acceleration is used to determine, from the annual hazard curves, the acceleration applicable to the short duration. The procedure depends on the shape of the annual hazard curves and it is relatively insensitive to the choice of hazard curves from LLNL and EPRI/SOG studies for the sites in the eastern United States.

Application of the procedure for a sample site demonstrated that for the SSE conditions, and durations of 6 months and 1 month in a year, the corresponding acceleration values are 77% and 33% of the design basis SSE ground acceleration, respectively. Given an acceleration level that is low enough as not to require a specific seismic evaluation, this procedure can also be used to determine short-duration limits such that for durations less than this limit, seismic effects need not be considered as a load case.

Reduced load sets and seismic acceleration levels will significantly benefit operating, maintenance and modification activities that result in temporary loads. These methods of accounting for the short duration and applicable period that the temporary loads act, have been used and have resulted in the significant benefits that result from justifying larger temporary loads with less effort.

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