SONGS-1 Long Term Service Seismic Reevaluation Program

Status Report for all Action Items Identified from the NRC Letter dated March 27, 1985

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In the NRC Letter LS05-85-03-29 to SCE, dated March 27, 1985, the NRC summarized the preliminary review results related to the Long Term Service seismic reevaluation program for SONGS-1. To address the action items identified by the NRC in this letter, SCE has made an additional submittal (April 15 submittal) and presentations at the April 2 and 3, 1985 meeting and the April 30 and May 1, 1985 meeting.

The purpose of this report is to summarize the current status of all the action items identified in the NRC letter dated March 27, 1985. For unresolved items, additional information is provided or future submittals are identified. Also included in this report are the proposed criteria and methodology charts for the structures, systems and components within the scope of SONGS-1 LTS seismic reevaluation program. This was requested by the NRC in the NRC letter dated March 27, 1985.

ACTION ITEM 1.1 (From NRC letter dated March 27, 1985)

For large-bore piping, the seismic/non-seismic decoupling criteria, support stiffness criteria, and envelope response spectrum method appear to be acceptable (LTS Section 3.1).

RESPONSE:

SCE agrees with the NRC position. The criteria and methodology described in Section 3.1 of the LTS Criteria and Methodology Document [1] will be applied

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 1.2 (From NRC letter dated March 27, 1985)

The method for generating new artificial ground motion time histories is acceptable, provided that the results satisfy the criteria in Sections 3.7.1 and 3.7.3-3 of the Standard Review Plan (SRP, NUREG-0800) (LTS Section 4.1.1).

RESPONSE:

The methods described in Section 4.1.1 of the Criteria and Methodology satisfy the criteria established by the SRP. These results were provided to the NRC at the April 30, 1985 meeting.

ACTION ITEM 1.3 (From NRC letter dated March 27, 1985)

The methods and criteria for small-bore piping (and tubing) are acceptable, provided that they are verified by confirmatory analyses and engineering evaluations, as described in the staff's February 8, 1984 evaluation for the Return to Service (RTS) plan (LTS Sections 3.2 and 4.3).

RESPONSE:

Confirmatory analyses and engineering for evaluations have been performed. Results have been summarized in a report titled "SONGS-1 LTS Program, Review and Development of Small-Bore Piping and Tubing Criteria," Report No. 01-0310-1385, Revision 0, which was submitted to the NRC on 05/01/85.

As concluded in the report, the RTS small-bore criteria were reviewed and enhanced with additional guidelines for LTS applications. A walkdown checklist was also generated and provided in the report.

ACTION ITEM 1.4 (From NRC letter dated March 27, 1985)

The methods and criteria for the evaluation of mechanical equipment appear to be acceptable (LTS Sections 3.5 and 4.6).

RESPONSE:

SCE agrees with the NRC position. The methods and criteria described in Sections 3.5 and 4.6 of the LTS Criteria and Methodology Document [1], will be applied.

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 1.5 (From NRC letter dated March 27, 1985)

The criteria for penetrations appear to be acceptable, provided that the associated piping criteria intended are found acceptable (LTS Section 3.8).

RESPONSE:

SCE agrees with the NRC position. The criteria described in Section 3.8 of the LTS Criteria and Methodology Document [1] will be applied.

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 1.6 (From NRC letter dated March 27, 1985)

The multiple-level response spectrum method is acceptable provided that the computer code used for this analysis is appropriately "bench-marked" for the intended applications (LTS Section 4.2.1.2).

RESPONSES

SCE will provide results of analyses to show that SUPERPIPE's MLRS option: (i) satisfies the three part recommendation for MLRS in NUREG-1061, Volume 4 (issued December 1984), and (ii) will be verified with a benchmark study. Response to these two action itmes are summarized as follows:

(i) NUREG-1061 presents recommended procedures for the combination of piping responses from multiple levels, modes and directions of excitation and from inertia and pseudostatic components. Any SUPERPIPE analysis will satisfy these NUREG procedures when the user specifies the appropriate options available in the program. Project instructions will provide appropriate guidelines to analysts.

SONGS-1 piping will be evaluated in accordance with the NUREG recommendations, with the following exception:

> When it is demonstrated that the pipe system responses due to individual levels of input motion are independent of one another (i.e., correlation coefficient for the input motions is between plus or minus 0.16), the multiple level responses will be combined by SRSS in lieu of the absolute summation method.

(ii) The SUPERPIPE MLRS option has been fully validated by Impell and used for the analysis of piping systems at several nuclear facilities. For example, its use has been formally documented in the FSAR for the South Texas Project (see two attached pages).

Impell received the NRC benchmark sample problems on 05/14/85. As stated by the NRC (Mr. Tom Cheng), as a minimum, the Test Problems 2 and 4 should be used for the benchmark. A SUPERPIPE MLRS benchmark verification for Test Problems 2 and 4 is in progress. The results will be submitted to the NRC in early June, 1985.

3.7.3A.7 Combination of Modal Responses. For Seismic Category I components in the BOP scope, the combination of modal responses for the response spectrum analyses is performed by the SRSS implemented in accordance with RG 1.92.

3.7.3A.8 Analytical Procedures for Piping. Analytical procedures for piping are discussed in Subsections 3.7.3.3.1 and 3.7.3.9.

3.7.3A.9 Multiply-Supported Equipment and Components with Distinct Inputs. A dynamic response spectrum analysis is made assuming no relative displacement between support points. When a system is supported at different elevations in the same building with support points having different response spectra, or supported between buildings, a response spectrum which envelopes all the applicable response spectra has been used in the response spectrum analysis.

In certain cases, such as with auxiliary piping connected to the reactor coolant loop, multiple spectra have been used to reduce the excessive conservatism in applying enveloped spectra over the entire length of piping.

The effect due to differential seismic movements of piping supports in a piping system is included in the piping stress analysis in accordance with the requirements of NB-3650 in Section III ASME Code for Class 1 piping and NC/ND-3650 for Class 2 and Class 3 piping. The piping stresses, deflections and support loads induced by the differential seismic movements are computed 34
using the most critical combination.

The effect of differential seismic movement of components interconnected between floors or buildings is considered statically in the integrated system analysis and in the detailed component analysis. For components, the differential motion is evaluated as a free-end displacement. Examples of a free-end displacement are motions "that would occur because of relative thermal expansion of piping, equipment, and equipment supports, or because of rotations imposed upon the equipment by sources other than the piping."

The effect of the differential motion is to impose a rotation on the component from the building. This motion, then, being a free-end displacement and being similar to thermal expansion loads, will cause stresses that are evaluated with ASME Code methods, including the requirements of NB-3227.5 used for stresses originating from restrained free-end displacements.

The results of the dynamic inertia analysis and the static differential motion analysis, have been combined by the SRSS method with due consideration for the ASME classification of the stresses.

3.7.3A.10 Use of Constant Vertical Static Factors. Whenever it is justified, constant vertical load factors are used as vertical response loads for subsystems, instead of multimass dynamic analyses. This procedure is adopted for both rigid and flexible components. Zero period accelerations are used for rigid components. For flexible components or for components with unknown natural frequency, 1.5 times the load corresponding to the peak of the applicable response spectrum curve is used to qualify piping and supports in accordance with the piping stress analysis criteria.

quantity of interest induced by differential seismic motion of the support is computed statically by considering the building response on a mode-by-mode basis. For piping systems interconnected between buildings, worst-possible differential displacements between supports are taken.

In the response spectrum dynamic analysis for evaluation of piping systems supported at different elevations, the most severe floor response spectrum corresponding to the support locations is used.

3.7.3.9 Multiple-Supported Equipment Components with Distinct Inputs. A dynamic response spectrum analysis is made assuming no relative displacement between support points. The response spectra used in this analysis are the most severe floor response spectra for the same building. In cases where there are multiple supports between buildings, with support points having different response spectra, an envelope reponse spectrum has been used in the analysis.

In certain cases, such as with auxiliary piping connected to the reactor coolant loop, multiple spectra have been used to reduce the excessive conservatism in applying enveloped spectra over the entire length of piping. For the above time, one spectrum is used at the junction of the auxiliary time with the reactor coolant loop, and the other spectrum is used at the other end of the auxiliary piping. This analysis is done using the SUPERPIPE computer code, which is discussed in Subsection 3.9.1.2.

The effect of differential seismic movement of components interconnected between floors or buildings is considered statically in the integrated system analysis and in the detailed component analysis. The results of the building analysis are reviewed on a mode-by-mode basis to determine the differential motion in each mode. In accordance with ASME Code requirements, the stress caused by differential seismic motion is clearly secondary for piping (NB-3650) and component supports (NF-3231). For components, the differential motion will be evaluated as a free-end displacement since, according to NB-3213.19, examples of a free-end displacement are motions "that would occur because of relative thermal expansion of piping, equipment, and equipment supports, or because of rotations imposed upon the equipment by sources other than the piping."

The effect of the differential motion is to impose a rotation on the component from the building. This motion, then, being a free-end displacement and being similar to thermal expansion loads, will cause stresses that will be evaluated with ASME Code methods, including the requirements of NB-3227.5 used for stresses originating from restrained free-end displacements.

The results of these two steps, the dynamic inertia analysis and the static differential motion analysis, have been combined absolutely with due consideration for the ASME classification of the stresses.

3.7.3.10 Use of Constant Vertical Static Factors. Sometimes, constant vertical load factors are used as vertical response loads for subsystems, instead of multimass dynamic analyses. The analysis is done for horizontal and vertical directions of excitation, and the combination of three component earthquake responses is made as described in Subsection

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ACTION ITEM 1.7 (From NRC letter dated March 27, 1985)

The time history method for linear system analysis appears to be acceptable (LTS Section 4.2.1.3).

RESPONSE:

SCE agrees with the NRC position. The methodology described in Section 4.2.1.3 of [1] will be applied.

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 1.8 (From NRC letter dated March 27, 1985)

Floor response spectra peak shifting is acceptable for use with the envelope response spectrum method; for the multiple-level response spectra method, detailed analysis procedures should be described and justified (LTS Section 4.2.1).

RESPONSE:

Peak shifting will only be applied to the envelope response spectrum method. It will not be applied to MLRS analyses.

ACTION ITEM 1.9 (From NRC letter dated March 27, 1985)

The damping ratios recommended by PVRC are acceptable for use with the envelope response spectrum method; for the multiple-level response spectra method, detailed analysis procedures should be described and justified (LTS Section 4.2.1).

RESPONSE:

The technical position of the Task Group on Damping Values (which developed the PVRC damping recommendations) is summarized below:

(i) Test data considered in the damping review demonstrates that damping exhibited by piping is a function of the system properties and is not dependent on the method of analysis [1].

(ii) Independent assessments have shown that acceptable overall margins are maintained for the PVRC dampings when used with the response spectrum method of analysis [3].

(iii) The presently recommended PVRC damping values have not fully realized all potential pipe damping increases. New test data from a carefully defined damping program may provide support for increasing damping in the higher frequency range (beyond 20 Hz.) and for SSE levels [1].

To confirm the validity of applying the PVRC dampings to the MLRS approach, all members [2] of the Task Group on Damping Values were consulted. All members agree that the PVRC damping values are applicable for the conservative response spectrum analysis methods, both the envelope response spectra method and the multiple level response spectra method. (Records of Conversation are available for review.)

It is noted that the multiple response spectra method is basically a response spectrum method and as such possesses all the conservatism that is inherent in the response spectrum method. It is generally used in lieu of the enveloped response spectrum method where piping systems extend between two buildings or where attachments are made both to a building and a large independently analyzed piping system such as the RCS.

The floor response spectra from different buildings or systems are generally quite different. Their spectral peaks are located at different frequencies and their amplitudes are quite different. When the supports of a piping system are attached to different buildings with such drastically different floor response spectra, it is important to properly consider the effects of the different levels of floor response spectra on the piping response. The envelope response spectra method does not have the capability of addressing this effect. The multiple level response spectra method is a refined response spectrum method which has the capability of considering different input floor response spectra at different support levels. Therefore, it is more appropriate to use the multiple level response spectra method to analyze piping systems which are attached to different buildings or structures.

ACTION ITEM 1.9 (continued)

By using MLRS techniques the portion of each piping system within each building will be analyzed appropriately for the input motion associated with the building in which it is located. This motion would be idential to the same motion for which this system would be analyzed using enveloped response spectrum techniques if it were totally located within one building or the other. To arbitrarily analyze the portion of the piping system in one building for the motion of another building, or to arbitrarily reduce damping because a system experiences different motions in different portions of the system, in unnecessarily conservative. A lengthy piping system is not capable of transferring input motion from one anchor point throughout the system and should be analyzed for effects of adjacent motions only at the interface between these two buildings and/or systems. The MLRS techniques proposed for SONGS 1 correctly consider both motions at the interface.

REFERENCES:

1. Welding Research Bulletin 300, December, 1984.

2. a) J. L. Bitner, Westinghouse Electric Corporation, Chairman
   b) W. F. Anderson, U.S. Nuclear Regulatory Committee
   c) S. H. Hou, U.S. Nuclear Regulatory Committee
   d) W. J. Kagay, Tennessee Valley Authority

3. Chuang, T.Y. et. al., "Impact of Changes in Damping and Spectrum Peak Broadening on the Seismic Response of Piping System," NUREG/CR-3526, Lawrence Livermore National Laboratory, December 1983.

ACTION ITEM 1.10 (From NRC letter dated March 27, 1985)

The procedure for considering seismic anchor motion appears to be acceptable (LTS Section 4.2.1).

RESPONSE:

SCE agrees with the NRC position. The procedure described in Section 4.2.1 of [1] will be applied.

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 2.1 (From NRC Letter dated March 27, 1985)

A stress criterion of 2.0 Sy for large-bore piping is reasonable when the stress indices values (B1 & B2) in the ASME Code are used; any other values for the stress indices must be justified in detail (LTS Section 3.1).

RESPONSE:

A detailed discussion of the development of the 2.0 Sy elastic limit is provided in the following references:

1. NRC Submittal: SONGS-1 - Technical Basis for Piping Strain Limits and Development of Linear, Elastic Analysis Methodology - Long Term Service Seismic Program; May 31, 1985 (Attached to this status report).

2. Impell Report No. 04-0310-0063, "SONGS-1 Functionality Criteria for Piping Systems in Response to the DBE Event," Revision 2, December 1983.

ACTION ITEM 2.2 (From NRC Letter dated March 27, 1985)

The branch-line decoupling criteria for large-bore piping are reasonable provided that: (a) the moment of inertia ratio is greater than or equal to 25 for a pipe diameter ratio greater than or equal to 3; (b) decoupling would not be allowed if there is an anchor or another branch-line in close proximity; and (c) decoupling would not be allowed if the pipe segment includes a termination which defines a reaction load. The latter two exclusions were addressed in the staff's February 8, 1984 RTS evaluation (LTS Section 3.1).

RESPONSE:

SCE agrees with the NRC's position. The decoupling criteria above will be applied.

ACTION ITEM 2.3 (From NRC Letter dated March 27, 1985)

A one percent strain criterion for carbon steel is acceptable. The staff is currently reviewing the proposed justification for a two percent strain criterion for stainless steel; it is not clear at this time whether that justification is soundly based (LTS Section 3.1).

RESPONSE:

The one percent strain limit for carbon steel has been accepted by the NRC. The two percent strain limit for stainless steel is selected to ensure structural integrity of the piping system and to ensure no significant loss of flow carrying capability. The proposed strain limit is based on the following backup data:

- ASME Code Appendix F
- ASME Code Case N47
- Component testing data
- Elbow testing data

The detailed basis for using the two percent strain limit is provided in the following document:

NRC Submittal: "Songs 1 - Technical Basis for Piping Strain Limits and Development of Linear, Elastic Analysis Methodology - Long Term Service Seismic Program," May 28, 1985 (Attached to this status report).

ACTION ITEM 2.4 (From NRC Letter dated March 27, 1985)

The use of the manufacturer's "catalog" criteria for new pipe supports appears to be reasonable.

However, the use of a factor-of-safety (FOS) greater than or equal to two, for existing pipe supports, would only be appropriate when the analysis method or test data, used to establish the FOS, are justified in detail. It would be useful to explain the analysis methods and test data to be applied as part of the criteria (LTS Section 3.3.3).

RESPONSE:

Catalog safety factors will be reduced only on a case-by-case basis for existing supports. When analyses and/or test data are used to establish allowable loads, the analysis methods and test results will be identified and justified.

ACTION ITEM 2.5 (From NRC Letter dated March 27, 1985)

The use of Level "D" stress criteria (ASME Section III, 1980 Winter Addenda) for pipe support welds appears to be reasonable; we may need to audit a range of fabrication, material testing, and non-destructive examination design specifications to support this stress criteria. The material strength may have to be based on the lesser value between the weld and the base-metal, unless the licensee can determine that the welding procedures applied would assure that the weld strength is always greater than or equal to the base-metal (LTS Section 3.3.4).

RESPONSE:

A verification of welding quality level inherent in "Industry Standards" existing at the time of SONGS-1 construction and documentation of compliance with these standards will be provided to the NRC at a later date.

ACTION ITEM 2.6 (From NRC Letter dated March 27, 1985)

The criteria and methods proposed for "secondary steel structures" are reasonable provided that (a) whenever the ductility criterion is applied, a system response evaluation is presented to justify the inelastic behavior; (b) whenever the 1/2 uniform strain criterion is applied, the member response is correlated to a ductility ratio (we would prefer that the ductility criterion be used instead); and (c) appropriate criteria for geometric buckling is applied (the Level "D" stress only addresses the material strength) (LTS Sections 3.4 and 3.3.1).

RESPONSE:

The ductility criterion ($\leq$ 3.0) will be used in place of the 1/2 ultimate uniform strain criterion.

As stated in Section 4.5 of the LTS Criteria Document [1], all secondary steel members will be evaluated for secondary failure modes (or geometric buckling). This includes a check for local buckling and lateral torsional buckling. The criteria for this evaluation will be the rules specified in the AISC Code [2].

The SEP guidelines [3] specify that the criteria of the ASME Code Subsection NF be used to evaluate support structures. However the guidelines do not give specific criteria for geometric buckling. The criteria for geometric buckling as specified in the ASME Code are identical to those in the ASIC Code.

REFERENCE:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

2. AISC, Manual for Steel Construction, 8th Edition, 1980.

3. Letter from W. Paulson (NRC) to R. Dietch (SCE) dated September 20, 1982, "SEP Topic III-6, Seismic Design Considerations, Staff Guidelines for Seismic Evaluation Criteria for the SEP Group II Plants, Revision 1."

ACTION ITEM 2.7 (From NRC Letter dated March 27, 1985)

The methods and criteria for valves appear reasonable, provided that the Level "C" stress criteria for active valves are used in conjunction with the elastic limit (LTS Sections 3.6 and 4.7).

RESPONSE:

SCE agrees with the NRC position. The criteria of Section 3.6 of [1] will be used in conjunction with the materials elastic limit.

REFERENCES:

1. SCE Report No. 01-0310-1368, "San Onofre Nuclear Generating Station Unit 1, Seismic Program for Long Term Service," submitted to NRC on March 8, 1985.

ACTION ITEM 2.8 (From NRC Letter dated March 27, 1985)

The staff is currently reviewing the details of the criteria and methods for electrical raceways; at this point, they appear to be reasonable (LTS Sections 3.9 and 4.10).

RESPONSE:

If the NRC has comments regarding the raceway criteria, SCE will review the NRC's comments and provide a submittal.

ACTION ITEM 2.9 (From NRC Letter dated March 27, 1985)

The envelope response spectrum methods for large-bore piping related to (a) mode/direction combinations (CQC), (b) coupled pipe-structure analysis, and (c) mode/direction combination for multiple levels are currently under review and appear to be reasonable; however, the coupled pipe-structure method does not appear at this time to be soundly based (LTS Sections 4.2.1 and 4.5).

RESPONSE:

SCE agrees with the NRC position on CQC method for enveloped response spectra analysis and mode/direction combination for Multiple Level Response Spectra (MLRS) analysis. However, the NRC has expressed concern regarding the use of MLRS method with the CQC mode combination method. CQC will not be used with MLRS analysis.

The second issue (coupled pipe-structure method) concerns the 1/8" deflection criteria used for a structural rigidity check. This issue is addressed in detail in the April 15, 1985 submittal, "Response to Action Items Resulting From the 4/02/85 and 4/03/85 Meetings with the NRC," Item I.6.

ACTION ITEM 2.10 (From NRC Letter dated March 27, 1985)

The penetration analysis methods would rely on (a) idealized textbook techniques, (b) Bijlaard techniques, and (c) axisymmetric finite-element techniques. While these methods may be appropriate, modelling and procedural details should be submitted for the staff's review (LTS Section 4.9).

RESPONSE:

The methods in WRC Bulletin 107 [1] will be used for the evaluation of the local stresses in the SONGS-1 containment sphere at penetration locations. Stresses are found from the charts of WRC 107 based on three dimensionless parameters which describe the geometry of the spherical shell and the penetration (or nozzle). The application of the WRC bulletin is limited by the values of the dimensionless parameters and the range of the curves in the bulletin. The values of the parameters and the range of the curves are described for the SONGS-1 containment sphere in the following paragraphs:

The SONGS-1 containment sphere has a wall thickness of approximately 1.0 inch and a radius of approximately 840. inches (70. ft.). A comparison of these dimensions and the range of the applicable shell parameter (0.0 U 2.2) and the thickness parameter (.25 p 10.0) in the WRC bulletin, results in the following conclusions:

1. The radius of the penetrations which can be evaluated ranges from 0. inches to 64. inches.

2. The thickness of the penetrations which can be evaluated ranges from 0.25 inches to 10.0 inches.

Based on these ranges, it is expected that all of the penetrations requiring evaluation will be within the limitations of the bulletin.

For simple penetration structures which are being evaluated using hand calculations, parts of the structures may be evaluated using handbook formulations such as those in [2]. Whenever methods such as these are applied, the limitations of the methods, such as geometric limitations and ranges of physical parameters, will be considered to ensure that the methods are applicable. Discussion of limitations of the hand method will also be documented in the calculation files.

As noted in SCE's previous submittals to the NRC, if any penetrations fall outside the limits of [1] or are sufficiently complex such that hand calculations become impractical, the evaluations can be performed using axisymmetric finite element evaluations.

ACTION ITEM 2.10 (continued)

REFERENCES:

1. Wichman, Hopper, and Mershon, "Local Stresses in Spherical and Cylindrical Shells Due to External Loadings." Welding Research Council Bulletin 107, March 1979 Revision of WRC Bulletin 107.

2. Roark and Young, "Formulas for Stress and Strain," 5th Edition, McGraw-Hill Book Company, New York, 1975.

ACTION ITEM 3.1: (From NRC Letter dated March 27, 1985)

The alternative for structural steel strength (yield stress) assumes an 18% increase for actual material properties and a 10% increase for strain-rate effects. We believe that the combination will overestimate the actual material strength: (a) it does not appear that the material test data are applicable to San Onofre 1 and a sample of material tests from San Onofre suggests that this value may be less than 10%; and (b) the strain-rate data do not appear to be representative for seismic loading conditions. Lacking more appropriate justification, the structural steel strength will have to be evaluated on a case-by-case basis (LTS Sections 3.3.1 and 3.4).

RESPONSE:

Two action items related to the 30 percent increase on the Code-specified yield strength for structural steel, resulting from numerous discussions with the NRC in April and early May, 1985, are:

A. Provide justification that for multi-directional loads, ductility is less than 3.0, when using 30 percent increase on the Code-specified yield strength for structural steel.

B. Provide a procedure to be used in applying the 30 percent increase on the Code-specified yield strength for structural steel.

The responses are as follows:

A. In performing pipe support analyses, the nominal values for material yield strength obtained from the Code will be increased by 30 percent to represent average material overstrength and strain rate effects. It should be emphasized that this increase accounts for the normal manufacturing practice in overshooting the Code-specified yield strength and is not a redefinition of the Level D Code allowable.

Although the 30 percent overstrength factor represents an actual yield strength, it is possible that some plant members may have a yield strength closer to the nominal value. In such a case, it is necessary to ensure that absolute ductility criteria for the LTS evaluation are not exceeded.

By postulating a case where a supporting steel member has a nominal yield value as specified by the Code, the upper bound ductility value will be evaluated and compared to a ductility value of 3.0.

The ductility, μ, as defined by SONGS-1, Return to Service Criteria for the evaluation of secondary steel members subjected to biaxial bending [1] is:

$$\mu = 1/2\ [P/P_y + M_x/M_{px} + M_z/M_{pz}]^2 + 1/2$$

where P = elastically calculated axial load
M_x, M_z = elastically calculated bending moments
P_y = yield load
M_{px}, M_{pz} = plastic moment capacity

Based on this definition of ductility, a maximum ductility of 1.7 (see Attachment 1) is determined for a 30 percent increase in the Code Level D allowable stresses for structural steel. This determination has been made both for uniaxial and biaxial bending cases which are the cases expected to be encountered in the analysis. Therefore, allowing an increase of 30 percent in material yield strength is within the ductility limit of 3.0 as accepted by the NRC for LTS application (Action Item 2.6).

B. In general, the LTS approach for the evaluation of existing structural steel members supporting piping will use ASME Level D stress allowables based on the Code-specified nominal material yield strength. On a case-by-case basis, a more realistic material yield strength will be used to determine the allowable stress. A 30 percent increase in material yield strength will be used to account for inherent material overstrength and strain rate effects. Whenever increases in material strength are used, it will be explicitly stated in the calculation file. The increase in yield strength will only be applied to mild steel numbers.

If the structural steel does not qualify with the increased allowables, a ductility evaluation will be performed.

REFERENCE:

1. Bechtel Power Corporation Project Design Criteria, Subjob 430-471, Revision 2.

Attachment 1 to ACTION ITEM 3.1

Consider ductility as defined by SONGS-1 Return-to-Service Criteria:

$$\mu = 1/2\ [P/P_y + M_x/M_{px} + M_z/M_{pz}]^2 + 1/2 \quad [1]$$

Level D stress allowable for tension and bending, $F_a = \min(1.2\ F_y,\ 0.7\ S_u)$

Considering a 30 percent increase in material yield strength for the limiting value of 1.2 F_y,

$$F_a = 1.2 \times (1.3F_y)$$
$$= 1.56F_y$$

Therefore, the elastic stress,

$P/A + M_x/S_x + M_z/S_z$ is limited to $1.56F_y$

where A = cross-sectional area
S_x, S_z = elastic section modulus

So, given that

- $P/A + M_x/S_x + M_z/S_z = 1.56F_y$
- tensile load at yield, $P_y = F_y \times A$
- bending moment at yield, $M_{px} = F_y \times Z_x$ and $M_{pz} = F_y \times Z_z$, where Z_x, Z_z = plastic section modulus

Then,

$$P = (1.56F_y - M_x/S_x - M_z/S_z) \times A$$

and $$P/P_y + M_x/M_{px} + M_z/M_{pz} = \frac{(1.56F_y - M_x/S_x - M_z/S_z)}{F_y} + \frac{M_x}{F_y \times Z_x} + \frac{M_z}{F_y \times Z_z}$$

$$= 1.56 - M_x/(F_yS_x) - M_z/(F_yS_x) + M_x/(F_yZ_x) + M_z/(F_yZ_z)$$

Conservatively, consider that the shape factor, $f = Z/S = 1$, then $Z_x = S_x$ and $Z_z = S_z$

$$P/P_y + M_x/M_{px} + M_z/M_{pz} = 1.56$$

Therefore,

$$\mu_{max} = 1/2\ [P/Py + M_x/M_{px} + M_z/M_{pz}]^2 + 1/2$$
$$= 1/2\ [1.56]^2 + 1/2$$
$$= \underline{1.7} < 3.0$$

CONCLUSION: A 30 percent increase in material yield strength allows a ductility less than the limit of 3.0.

ACTION ITEM 3.2: (From NRC letter dated March 27, 1985)

The criteria proposed for concrete expansion bolts (FOS greater or equal to 2 for two out of four anchors or equivalent) does not appear to allow sufficient margin for observed variations in workmanship and installation practices. While we agree that it may be appropriate to establish the overall integrity of the associated support, such instances may have to be evaluated on a case-by-case basis (LTS Section 3.3.2).

RESPONSE:

In general, the allowable loads for concrete expansion anchor bolts will be obtained by using the manufacturer's reported ultimate capacity with a minimum factor of safety (FS) equal to 4.0 or 5.0 for wedge or shell type anchors, respectively. On a case-by-case basis, a FS less than 4.0 or 5.0 may be used to qualify existing supports. However, a FS less than 4.0 or 5.0 will only be used if:

1. Overall FS = 4.0 or 5.0 (when the factor of safety of individual bolts falls below 4.0 (or 5.0), the overall factor of safety of the support will be evaluated to ensure that it is over 4.0),

2. The adjacent supports, carrying load in the same direction, are qualified elastically, with a FS = 4.0 or 5.0 (if they have expansion anchors), and

3. If there are a minimum of four anchor bolts in the same base-plate for the support in question, not more than 50 percent of the bolts are subjected simultaneously to tensile loads. In no case will an FS less than 2.0 be allowed.

Available test data on concrete expansion anchor bolts [1] indicate that the distribution of data is reasonably close to Gaussian (or normal) distribution with a coefficient of variation of about 0.27. Since an FS less than 4.0 or 5.0 will only be used if the two constraints specified above are met, this will preclude any potential for a "zippering" effect on supports.

It should be noted that for the Return to Service support qualification effort, a factor of safety less than 4.0 or 5.0 was used very sparingly (on less than 5 percent of the supports evaluated).

REFERENCE:

[1] "Realistic Seismic Design Margins of Pumps, Valves and Piping," NUREG/CR-2137, prepared by Battelle Labs/ORNL for the NRC, June 1981.

ACTION ITEM 3.3: (From NRC letter dated March 27, 1985)

The methods proposed for soil-structure interaction and floor response spectra direct generation are currently under review, it is not apparent that appropriate procedures have been established for modelling and parameters sensitivities (LTS Section 4.1.2 and 4.1.3).

RESPONSE:

The proposed methods for generating floor response spectra were soil-structure interaction analysis and direct generation analysis. These two methods will be applied to the SONGS-1 reactor building and turbine building, respectively. To demonstrate the technical validity and correct applications of both methodologies, two test problems were developed by the NRC and performed by SCE. The results of Test Problems I and III were presented in Impell's Report No. 01-0310-1389, dated April 15, 1985 [1].

Test Problem I had the objective of demonstrating soil-structure interaction analysis using the CLASSI computer code for the soil-structure system and the use of the program SASSI for the generation of soil impedances for any foundation shape. After the completion of Test Problem I, the results from Impell's CLASSI/SASSI approach were compared to the CLASSI results generated by Lawrence Livermore National Laboratory and to the constant impedance approach results generated by NTC Engineers.

A comparison of all three approaches produced identical floor response, spectra, both in frequency and in amplitude. The conclusion was that Impell's CLASSI soil-structure interaction approach was technically valid and acceptable.

Test Problem III had the objective of demonstrating direct generation of floor spectra using the FLORA computer code. A fixed-base structural model was analyzed with ground input spectra and various interaction mass values were placed at selected floors. The floor response spectra generated by FLORA were compared to the floor response spectra generated by the time history analysis from the NCT Engineers.

A comparison of both approaches produced very similar results in the floor spectra frequencies and amplitudes for all values of interaction masses. The conclusion of Test Problem III was that Impell's direct generation approach was technically valid and acceptable.

During the generation of floor spectra by the soil-structure interaction analyses, the effects of the Enclosure Building will be explicitly included in the model of the soil-structure system. This will be accomplished by using the same methodology demonstrated in Test Problem I.

REFERENCE:

1. "Methodology Test Problems SONGS-1 Long Term Service Program," Impell Report No. 01-0310-1389, Revision 0, April 15, 1985.

ACTION ITEM 3.4: (From NRC letter dated March 27, 1985)

The similarity analysis method for large-bore piping does not appear to include a requisite procedure to establish complete similarity (LTS Section 4.2.1.4).

RESPONSE:

The Similarity Method for large-bore piping will be used and justified on a case-by-case basis and appropriately documented in the calculation file.

ACTION ITEM 3.5: (From NRC letter dated March 27, 1985)

The non-linear time history analysis method for large-bore piping would rely on a single "artificial" time history. Studies performed in conjunction with Unresolved Safety Issue A-40 suggest that at least seven "real" time histories are necessary to adequately assess the phase relationships and, moreover, the "artificial" time histories should not be used for non-linear analyses (LTS Section 4.2.2.1)

RESPONSE

A report summarizing the technical basis and application of the proposed nonlinear time history analysis method for SONGS-1 large-bore piping will be submitted to the NRC at a later date.

ACTION ITEM 3.6: (From NRC letter dated March 27, 1985)

The energy balance method for large-bore piping should be supported by a confirmatory analysis, as described in the staff's February 8, 1984 RTS evaluation, and should not be applied in system segments containing elbows, tees, or valves (LTS Section 4.2.2.2).

RESPONSE

Two documents on the Energy Balance Method have been submitted to the NRC:

- Report titled "Energy Balance Method for Piping Systems," dated April 15, 1985.

- Calculation No. EB-1, "Energy Balance Method Verification."

During a conference phone call on 05/20/85, the NRC raised additional questions and concerns related to the Energy Balance Method described in the two documents mentioned above. Responses to these questions and concerns will be submitted by 06/10/85.

ACTION ITEM 3.7: (From NRC Letter dated March 27, 1985)

The secant stiffness method has not been presented in sufficient detail for the staff to review. (LTS Section 4.2.2.3)

RESPONSE:

A report summarizing the secant stiffness method as will be applied for SONGS-1 LTS was submitted to the NRC on April 15, 1985. At the May 1, 1985 meeting, the NRC requested additional information to describe the situations in which the secant stiffness method will be used for LTS, particularly the distinction between the secant stiffness application and the Energy Balance Method application. The following is a response to these questions:

The analysis of large bore piping for the Long Term Service effort will be performed using rigorous computer analysis methods. Generic support stiffness will be used to model pipe supports. These values reflect the lower bound support stiffnesses used for typical pipe support design and are consistent with current industry practice. The support loads generated from the piping analysis will be used to evaluate the supports and all associated secondary steel members.

Ductility limits will be used to measure the capability of inelastic structural elements to maintain their design function. When this inelastic behavior occurs, or when the supporting structure is not rigid, the generic support stiffness assumed in the piping analysis may not be representative of the actual stiffness at the pipe support location. As a result of this discrepancy, the predicted pipe support loads may no longer be appropriate. Depending on the magnitude of inelastic behavior, the pipe support will be considered to either remain functional or, if major inelasticity is experienced, it will be ignored. In the later case, a full re-evaluation of the effect of this loss of support must be performed to ensure acceptable piping performance. Where only one span is affected, it is proposed to use the Energy Balance Method, which is an energy based analysis method, to analyze this local impact, as opposed to a full non-linear time history analysis.

For minor excursions beyond yield, it is appropriate to retain the use of linear techniques, but to modify the generic support stiffness to ensure accurate representation in the model. To obtain a more representative pipe support load, a more appropriate stiffness at the pipe support location should be used in the piping analyses.

The secant stiffness method is an iteratively applied linear elastic analysis approach to determine support stiffnesses which are more representative of the pipe-structure interaction. This approach will provide a more accurate support load distribution for the piping system.

ACTION ITEM 3.7: (From NRC Letter dated March 27, 1985)

The iterative procedure for the secant stiffness method is outlined in the flow chart shown in Figure 1. To explain this procedure, the analysis steps will be illustrated through a simple example problem. Figure 2 shows a straight span beam which represents a piping system. The system is supported by three supporting elements.

The initial analysis of this system (iteration 1) is performed with generic support stiffness values as shown in Table 1. The support loads (P_{11}, P_{21}, P_{31}) obtained from this analysis are then applied to the supporting structure (which is comprised of the pipe support and the secondary steel member). In this example, support numbers 1 and 3 remain elastic (ductility less than one), whereas support number 2 exhibits inelastic behavior (ductility of 2.0). This ductility value is now used to estimate the revised stiffness:

$$K_{22} = K_{21}/\mu$$

It is noted that the use of ductility to evaluate revised stiffness is a means to arrive at a converged set of loads which correctly represents the pipe-structure interaction. The ductility definition as used for the SONGS-1 secondary steel members evaluation (Reference 1) is a convenient parameter which aids in accelerating the convergence process.

This revised stiffness of the inelastic support (K_{22}) is now used in iteration 2 of the piping analysis to develop revised loads (P_{12}, P_{22}, P_{32},). The support loads and stiffness for iteration 1 and 2 are compared and are seen to be significantly different. This indicates that convergence of results is not yet achieved. The revised loads are used to evaluate revised ductilities and, subsequently, revised stiffness for the inelastic support (K_{23}).

Iteration 3 is performed with the revised stiffness K_{23}. The loads and stiffnesses are then compared for iteration 2 and 3. The support loads for iteration 3 remain basically unchanged (difference from previous iteration less than 10 percent on the average), demonstrating that support loads have converged to the iteration 3 stiffness values. Thus, pipe-structure interaction is accurately represented.

The previous discussion of the Energy Balance Method describes its use when the performance of a support was sufficiently degraded that no credit can be taken for its function in system analysis. It should be noted that this method is also applicable to evaluate pipe functionality when the strain limits (one percent and two percent for carbon steel stainless steel) are used instead of the Code Class 2/3 stress based screening limit of 2.0 Sy. The Method is a hand evaluation procedure which compares the earthquake kinetic energy input to the piping system with the strain energy capacity of the pipe. The effect of the non-linear behavior of the piping system is considered in the strain energy calculation.

ACTION ITEM 3.7: (From NRC Letter dated March 27, 1985)

A document related to the Energy Balance Method application will be submitted to the NRC by 06/10/85 (See Action Item 3.6). Also a document, titled "Summary Report for the Evaluation of Interaction of Pipe and Structure, SONGS-1 RTS," May 1985, which further describes the secant stiffness method application is included in this submittal.

Reference

(1) Bechtel Power Corporation Projects Design Criteria, Subjob 430-471, Revision 2, "Impact of Pipe Support Loads on Structures."

TABLE 1

ITERATIONS FOR THE SECANT STIFFNESS METHOD

	Analysis Stiffnesses (k/in)		Predicted Loads (k)	Ductility
Iteration 1	$K_{11} = 100$	Generic Values	$P_{11} = 20$	1.0
	$K_{21} = 100$		$P_{21} = 40$	2.0
	$K_{31} = 200$		$P_{31} = 30$	1.0
Iteration 2	$K_{12} = 100$		$P_{12} = 22$	1.0
	$K_{22} = 50$		$P_{22} = 30$	2.2
	$K_{32} = 200$		$P_{32} = 33$	1.0
Iteration 3	$K_{13} = 100$		$P_{13} = 23$	1.0
	$K_{23} = 45$		$P_{23} = 29$	2.2
	$K_{33} = 200$		$P_{33} = 34$	1.0

NOTE

1. K_{ij} refers to stiffness of support i assumed in iteration j of the analysis.
2. P_{ij} refers to the load on support i obtained from iteration j of the analysis.

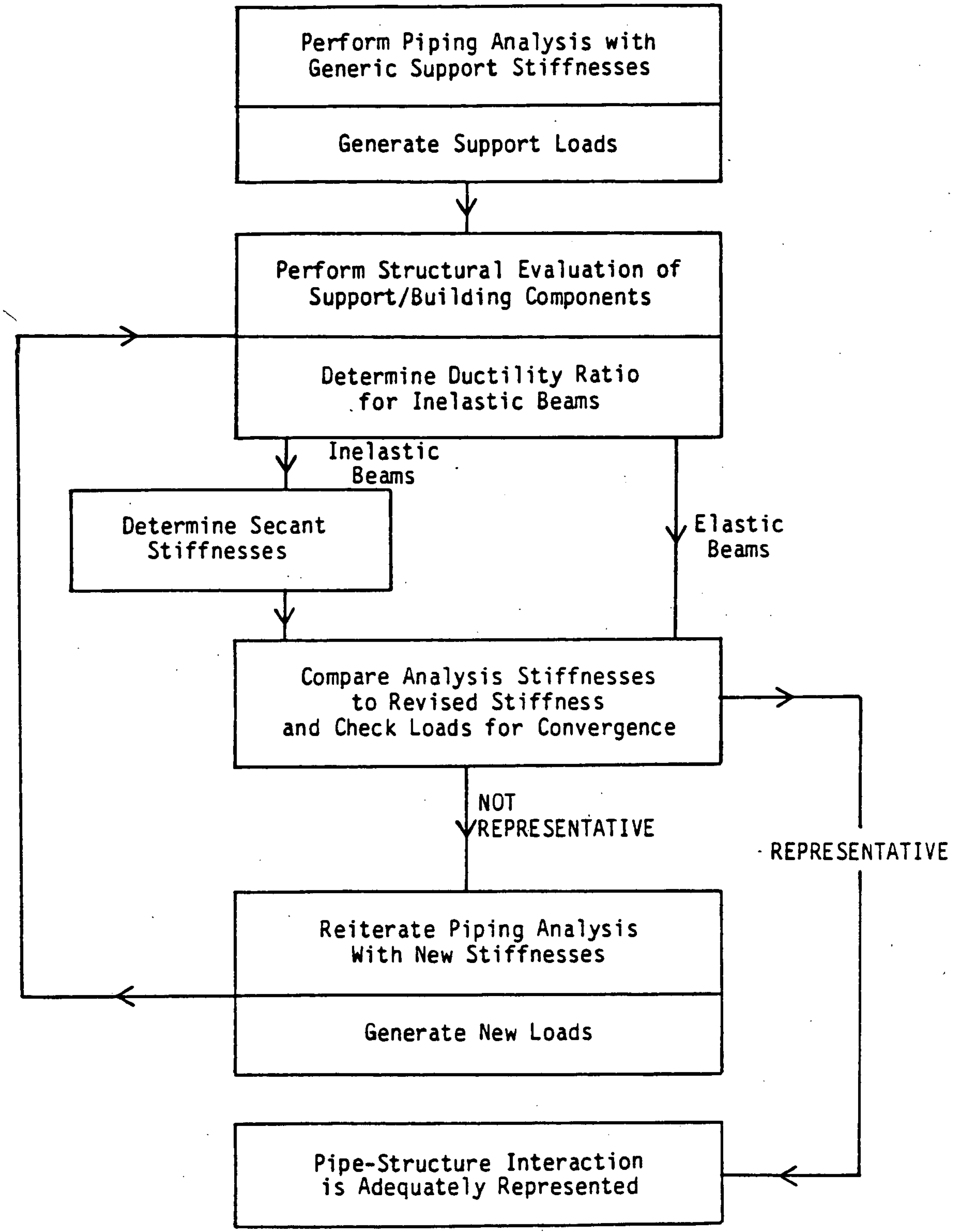

Figure 1: Secant Stiffness Method Flowchart

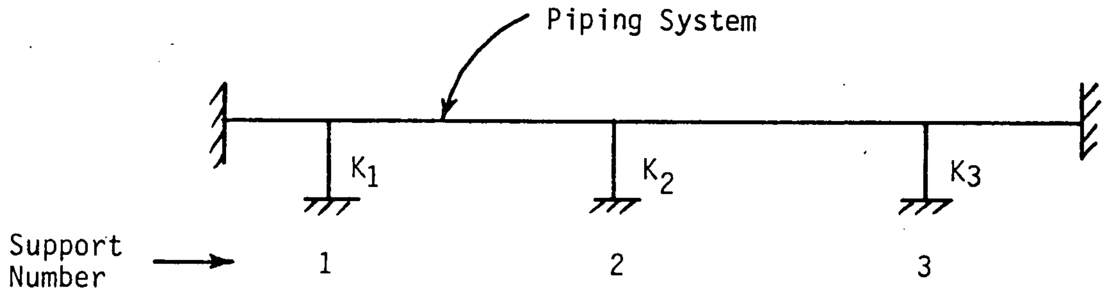

Figure 2: Example Problem for the Secant Stiffness Method

ACTION ITEM 3.8: (From NRC Letter dated March 27, 1985)

For pipe support analyses where a snubber is located in close proximity to a rigid support, the analysis should assume that the snubber fails to lock (LTS Section 4.4).

RESPONSE:

Snubbers are considered inactive if their locations with respect to a rigid support in the same direction are within the following proximity criteria.

i) 3 times the pipe diameter, for pipe sizes with diameters equal to or greater than 8", and

ii) 5 times the pipe diameter, for pipe sizes with diameters less than 8", but greater than 2".

The above criteria were used in the Diablo Canyon project [1].

REFERENCE:

1. NUREG-0675, Supplement No. 25, "Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2," July 1984.

ACTION ITEM 3.9: (From NRC Letter dated March 27, 1985)

The square-root-of-the-sum-of-the-squares (SRSS) load combination technique is proposed for pipe supports bearing multiple pipes (e.g., beams). Independent motion of the pipes has not been demonstrated. Moreover, we would expect such pipe configurations would have dependent motion, such that an absolute sum (ABS) load combination method should be used (LTS Section 4.4).

RESPONSE:

Pipes, supported by the same supports, will experience the same seismic input motion. However, if the dynamic properties (modal frequencies and mode shapes) of these pipes are different, they will respond differently to the same input motion. The example, illustrated in the attached Figure 1, shows that two pipes are supported by the same two supports and are subjected to the same seismic input motion. The fundamental periods of these pipes are 1 sec. and 2 sec., respectively. Due to this difference in fundamental periods, the maximum responses (pipe stresses and support reactions) of the two pipes will occur at different times even though they are set into motion simultaneously.

The total reaction loads at the gang supports are obtained as a combination of all the reaction loads from the individual pipes. During a seismic event, all the pipes will be responding according to their respective dynamic properties. The responses for pipes with similar dynamic properties will be in phase and therefore should be combined absolutely, while those for pipes with different properties will be out-of-phase and may be combined using the SRSS method. This phenomenon is fundamentally analogous to the modal responses of a dynamic system. Responses of modes whose frequencies are closely spaced are expected to be in phase and are combined by absolute sum. Responses of modes whose frequencies are not closely spaced can be combined by the SRSS. The Standard Review Plant Section 3.9.2 specifies that the modal responses of a dynamic system may be combined using the grouping method in Regulatory Guide 1.92. Based on the aforementioned similarity, this method is considered also appropriate for combining the pipe reaction loads at the gang supports.

The mode shapes of each pipe will be reviewed to identify the most significant mode and the corresponding modal frequency associated with the region of interest and the support direction of interest. This most significant mode is identified as the mode whose mode shape values show the highest participation for the region and the support direction of interest. These modal frequencies will be used to determine the combination method as specified by the grouping method in Regulatory Guide 1.92. Pipe support loads from pipe whose modal frequencies are within 10 percent groupings will be combined with the absolute summation method. These sums will then be combined with the remaining pipe loads using the SRSS method. In combining the pipe support loads, the resultant support reaction load for each pipe, including contribution from all modes considered in the piping analysis, will be used.

As discussed above, only the frequency of the most significant mode for each pipe is used in the 10 percent screening criteria. This is considered adequate because this modal response will typically represent a significat portion of the total response for the pipe. This is due to the fact that for a piping system, there is generally only one significant mode associated with a local region of the piping system for a given direction. The remaining modes correspond to other regions of the piping system and other directions. While it is possible that some mode other than the fundamental mode may contribute to piping response and support loadings at a given support, combination of this response by SRSS techniques is acceptable for the following reasons.

1. Responses of higher modes will be quite random in nature and it is highly unlikely that peak response of such a mode would occur coincidentally with peak response of another pipe at the same support.

2. This mode will constitute a very small percentage of the total response, and its magnitude is already included in the responses combined by SRSS. In the unlikely event its peak response was directly coincident with another pipe response, the variation, due to combining this minor response by SRSS instead of absolute sums, is expected to be insignificant.

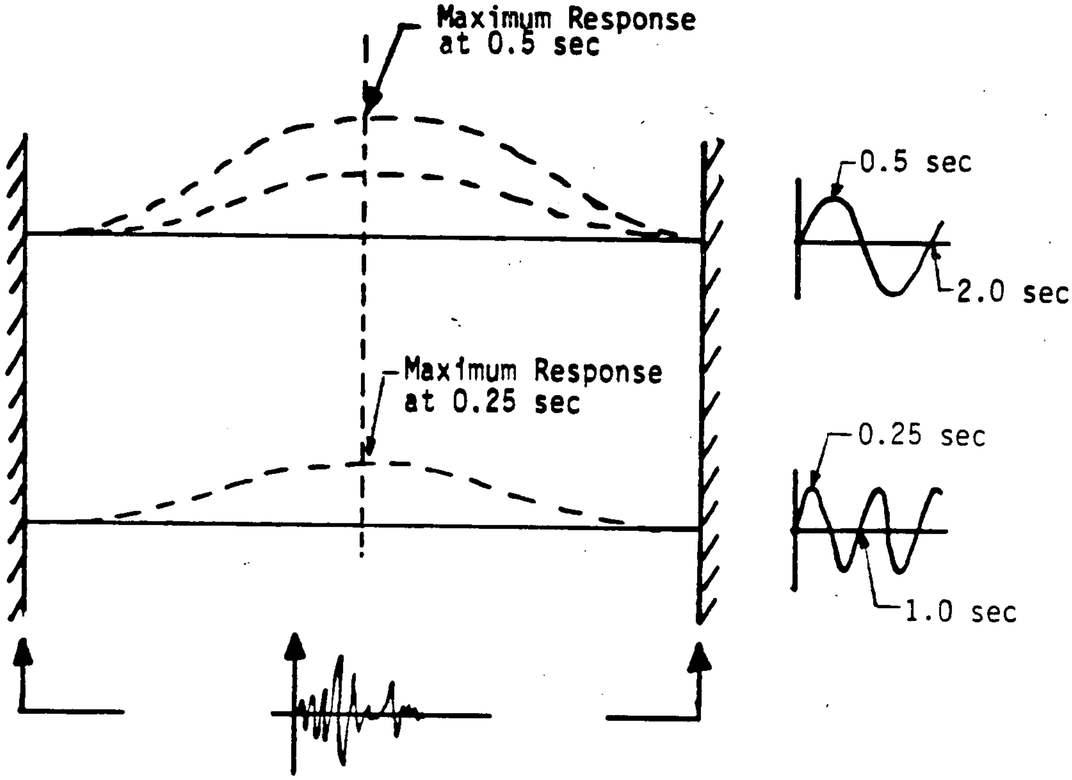

FIGURE 1 : SCHEMATICS FOR MULTIPLE PIPING RESPONSES

CATEGORY (1)	CRITERIA (2)	EXPECTED USAGE(3) (% of the Scope)	METHODOLOGY (2)	EXPECTED USAGE(3) (% of the Scope)
1. Piping Analysis				
° Large Bore	Strain Criterion:			
	1% strain for carbon steel and 2% strain for stainless steel	100		
	Application of Strain Criterion:			
	- ASME Code based screening criterion $\frac{PD}{4t} + 0.75i \frac{M_A + M_B}{Z} \leq 2.0\ Sy$	- 90	- (a) Elastic analysis by computer code SUPERPIPE with Enveloped Response Spectra Method:	-(a) 65
			° Mode combination by complete Quadratic Combination (CQC).	
			° Direction combination by RG 1.92	
			° PVRC damping values (Code Case N 411).	
			° Peak broadening by RG 1.122 or peak shifting by Code Appendix N-1226.3	° 90 (RG 1.122) 10 (N-1226.3)
			(b) Or, elastic analysis by computer code SUPERPIPE with Multiple Level Response Spectra (MLRS) Method:	(b) 15
			° Mode combination by RG 1.92.	
			° Direction combination by RG 1.92.	
			° Support level combination by ASUM, or by SRSS, if correlation coefficient for the input motion is between plus or minus 0.16.	° 90 (ASUM) 10 (SRSS)
			° PVRC damping values (Code Case N 411).	
			(c) Or, elastic analysis by computer code SUPERPIPE with Linear Time - History Analysis Method:	(c) 2
			° Direction combination by RG 1.92.	
			° RG 1.61 damping values.	

CATEGORY (1)	CRITERIA (2)	EXPECTED USAGE (3) (% of the Scope)	METHODOLOGY (2)	EXPECTED USAGE (3) (% of the Scope)
			° Multiple level time-history input. ° Input motions include both acceleration and displacement motions of the supports.	
			(d) Or, interactive elastic analysis by computer code SUPERPIPE with Secant Stiffness Method: To account for nonlinear behavior of the secondary steel beams.	(d) 8
	- Or, use of nonlinear analysis techniques (All pipe stresses are expected to meet 2.0 Sy screening criteria. Nonlinear techniques are used to evaluate local areas where supports fail.)	- 10	- (a) Hand calculation using Energy Balance Method	-(a) 8
			(b) Or, nonlinear time history analysis by computer code ANSYS or other appropriate codes. ° Three directional loadings combined simultaneously. ° Rayleigh type damping. The hysteric behavior due to material yielding will also be factored into the evaluation.	(b) 2
° Small Bore & Tubing	- Walkdown & Chart (a verification report was submitted to the NRC on 05/01/85).	- 95	- Detailed walkdown procedures and checklist.	- 95
	- Or, large bore piping analysis criteria will be used.	- 5	- Or, large bore piping analysis methods will be used.	- 5

CATEGORY (1)	CRITERIA (2)	EXPECTED USAGE(3) (% of the Scope)	METHODOLOGY (2)	EXPECTED USAGE(3) (% of the Scope)
2. Pipe Supports				
° Structural Steel	- Code Level D	- 94	- Pipe Supports will be qualified by hand evaluation methods, or computer codes STRUDL or EDSGAP.	- 95 (Hand) 5 (Computer)
	- Or, Code Level D plus 1.3 factor on Sy (for material overstrength and strain rate effects) for those materials at SONGS-1 for which test results are applicable.	- 5	° If Energy Balance Method is used for piping qualification, supports adjacent to the "failed" or "yielded" support will be reevaluated for revised loads.	
	- Or, Ductility ≤ 3 (1.3 overstrength factor will not be used).	- 1	° Supports with multiple pipe (gang supports) will have the individual loads combined by RG 1.92 Grouping Method (SRSS or ASUM, depending on frequency contents of their respective loadings). ° Seismic inertial loads and SAM loads will be combined by SRSS for support evaluation.	
° Concrete Expansion Anchor Bolts	- Wedge Type Factor of Safety (FS) = 4; Shell Type FS = 5.	- 95		
	- Or, $2 \leq FS < 4$ or 5 for individual bolt may be used on a case-by-case basis with the following restrictions: (a) Overall FS = 4 or 5 (b) Adjacent supports in the same direction are qualified elastically and FS = 4 or 5 on anchor bolts. (c) Minimum of 4 bolts per base plate and no more than half subject to tension simultaneously.	- 5		
° Catalog Items	- Manufacturer's load capacity data for Level D Service Conditions.	- 98		
	- Or, engineering analysis with $2 \leq FS < 4$ or test data with $2 \leq FS < 4$ for existing supports.	- 2		
° Welds	- Code Level D (1.3 overstrength factor will not be used for weld material).	-100		

CATEGORY (1)	CRITERIA (2)	EXPECTED USAGE(3) (% of the Scope)	METHODOLOGY (2)	EXPECTED USAGE(3) (% of the Scope)
3. Secondary Steel Structures	- Code Level D	- 80	- Secondary steel structures will be qualified by hand evaluation methods, or by computer codes STRUDL or EDSGAP.	- 95 (Hand) 5 (Computer)
	- Or, Code Level D plus 1.3 factor on Sy (for material overstrength and strain rate effect) for those materials at SONGS-1 for which test results are applicable.	- 5	° For non-rigid structures (a rigid structure is one that has its first mode frequency over 33 Hz or into the rigid range of the accelera-tion spectrum, or it deflects less than 1/8" under the seismic loadings), a review of the impact of stiffness on piping analysis will be performed.	
	- Or, Ductility ≤ 3 (1.3 overstrength factor will not be used).	- 15	° For yielding (nonlinear) structures, a review of the impact of the coupled piping/structure interaction will be performed. On a case-by-case basis, secant stiffness or coupled pipe and structure analyses may be performed. All yielding members will be evaluated for end connection strength, as well as local buckling effects. Physical configuration verification will also be performed.	
4. Mechanical Equipment				
° Pressure Retaining Parts	- Code Level C for active pumps; Code Level D for inactive pumps, vessels and heat exchangers	-100	- Mechanical equipment will be qualified by hand evaluation methods or by computer code STRUDL or EDSGAP, using equivalent static analysis and dynamic analysis approach. ° Nozzle qualification by Bijlaard analysis (WRC 107).	- 60 (Hand) 40 (Computer)
° Supports	- Criteria for pipe supports will be used.	-100		
5. Valves				
° Pressure Retaining Parts	- Code Level C for active valves; Code Level D for inactive valves	-100	- Valves will be qualified by hand evaluation methods to calculate stresses in critical sections of the valve.	-100
° Non-pressure Retaining Parts	- Code Level C for active valves; Code Level D for inactive valves	-100		

SONGS-1 Long Term Service Evaluatio[illegible].67 Modification Housner Earthquake:
Proposed Criteria and Methodology and Expected Usage
(Continued)

CATEGORY (1)	CRITERIA (2)	EXPECTED USAGE(3) (% of the Scope)	METHODOLOGY (2)	EXPECTED USAGE(3) (% of the Scope)
6. Tanks	- Code and industry standards (an evaluation report for the Refueling Water Storage Tank was submitted to the NRC on 05/01/85).	-100	- For RWST, computer code SASSI was used for the SSI and developing tank seismic loads; tank structure and supports qualified by hand evaluation methods.	-100
7. Penetration				
° Containment	- Code Level D (Subsection NE)	-100	- Penetrations will be qualified by hand evaluation methods including textbook solution and Bijlaard analysis (WRC 107), or by axisymmetric finite element computer analysis using computer code ANSYS.	- 95 (Hand) 5 (Computer)
° Penetration Structure	- Criteria for pipe supports will be used.	-100		
° Piping	- Criteria for piping analysis will be used.	-100		
8. Electrical Raceway Supports	- RTS Design Criteria (BPC RTS Design Criteria for SONGS-1, Design or Raceway Support Modifications. Revision 0, May 9, 1984, Job No. 15691-308).	- 90	- Electrical raceway supports will be qualified by hand evaluation methods or by computer codes STRUDL or EDSGAP.	- 95 (Hand) 5 (Computer)
	- Or, criteria for piping supports will be used, with specific raceway supports displacement limits.	- 10		

NOTES:

(1) A "living scope chart" summarizing the actual criterion and methodology applied to each structure, system and component within the LTS scope will be prepared during the LTS evaluation.

(2) If more than one criterion and methodology are proposed for each category or subcategory, they are presented in order of their preferences (separated by a word "or").

(3) Percentages of usage are projected for the LTS evaluation.