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September 7, 1984
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Office of Nuclear Reactor Regulation
Attn: J. F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Three Mile Island Nuclear Station Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
EFW System Seismic Interaction

In response to your letter dated August 8, 1984, the additional information requested concerning the auxiliary steam line seismic resistance is provided in Enclosure 1. The results of this enclosed evaluation concludes that the design of the auxiliary steam line provides for its structural integrity during and after an SSE.

Furthermore, by letter dated July 16, 1984, GPUN discussed the walkdown performed in the Intermediate Building in May 1984. As a followup to this walkdown, GPUN also reviewed the EFW piping in Containment and reported the following information in Item 18 of attachment 1 to the July 16, 1984 letter:

ITEM	QUESTION	RESOLUTION
18. EFW pipe supported from stairs in containment	Will the stairwell inside the Reactor Bldg. remain intact (and thus the EFW line supported) under SSE conditions?	Analysis performed in response to IEB's 79-02 & 14 show that EFW piping remains intact during an SSE. Some questions have arisen about the stairs which are being pursued.

GPUN, based on some preliminary hand calculations, determined that the stairway might be overstressed and contracted the Architect Engineer to reassess this particular support. The results of this assessment are

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summarized in Enclosure 2. Based on these results, GPUN plans to remove the support (EF-111) from the stairway and modify an existing support (EF-16). This work is expected to be completed in November 1984, but in any event, prior to criticality. Analysis performed on the EFW piping with the decoupled support demonstrates that the pipe satisfies Code (B31.1) requirement and the stairway will not interact with the pipe so as to cause damage to the pipe. Based on the information provided above and in previous letters pertaining to this subject, GPUN considers this issue resolved.

Sincerely,

H. D. Hukill
Director, TMI-1

HDH:LWH:MRK:lr:0088A

cc: R. Conte
J. Van Vliet

Seismic Resistance of Auxiliary Steam Line

Item

Provide additional information to clarify and justify the calculated Auxiliary Steam Line natural frequencies (for both horizontal and vertical directions) stated in Reference 1 are the bounding conditions for the as-built Auxiliary Steam Line whose failure could produce a harsh environment in which the EFW system must operate. Expand your response to include the evaluation of the pipe supports and their attachments to the building for an SSE condition, specifically, the compression loads applied to the supports during an SSE seismic event.

Reference 1: Letter from H. D. Hukill to J. F. Stolz dated July 30, 1984

Response

The first approach taken in this calculation is to determine if the building is capable of exciting the piping during an SSE seismic event in the weakest system directions (i.e. horizontal directions). The auxiliary steam line upstream of valve AS-V4 is classified as a Seismic Category III line which requires only deadweight supports. The typical configuration of these supports is a long threaded rod with pinned ends. With this type of support, it can be assumed that the pipe will act as a pendulum when it responds to an earthquake in the horizontal direction. Therefore, each support's natural frequency was calculated using the equation,

(Reference b, page 5.70, Table 1)

$$Fn = \frac{1}{2\pi} \sqrt{g/\ell}$$

where: g = acceleration due to gravity. in/sec^2
ℓ = length of pendulum, in.

This equation shows that the natural frequency of a pendulum is independent of its mass and the only parameter is the length of the threaded rod, which varies from 7 to 10 ft approximately. The results of this analysis indicate that the maximum and minimum pendulum frequency for the system is 0.3613 Hz and 0.2794 Hz respectively. In addition to calculating the pendulum frequency for the system, the building's first natural frequency of 13.15 Hz was obtained from the response curve for the building. The building's natural frequency was compared with the maximum and minimum pendulum frequencies of the system to determine if the three frequencies coincide. Based on this comparison, it is evident that the building will be incapable of exciting the piping during a horizontal seismic event (i.e., the piping would tend to experience a gentle swinging motion).

After obtaining the results for the horizontal seismic event, the analysis considered the effects of a vertical seismic acceleration on the system. The analysis considered a representative and maximum support span of 11.25' and 15.0' respectively. For both cases the pipe was considered a uniformly loaded simply supported beam of length equal to the two above mentioned support spans. The first natural frequencies for these models were then calculated using the equation:

$$f_n = C_n \sqrt{\frac{gEI}{\omega \ell^4}}$$ (Reference b, page 5.74, Equation 31)

Where: C_n = Constant depending on which natural frequency is required and the boundary conditions

g = Acceleration due to gravity, in/sec^2

E = Young's modulus, psi

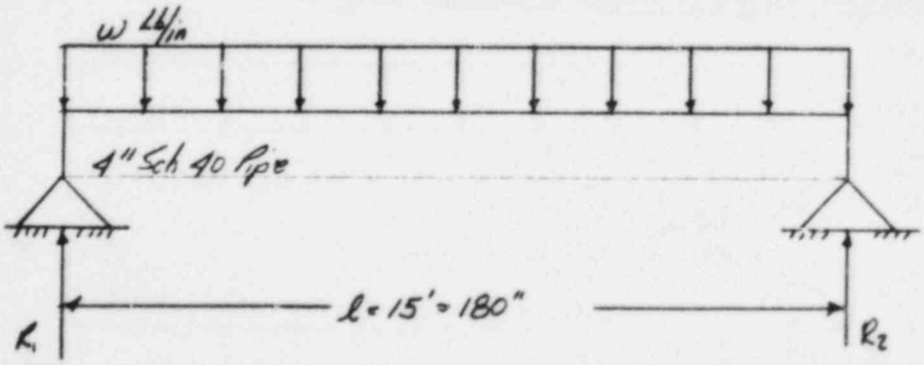
I = Moment of Inertia, in^4

ℓ = Length of beam, inches

ω = Weight per unit length of beam, lb/in

The natural frequencies obtained for the 11.25' and 15.0' spans are 24.17 Hz and 13.598 Hz respectively. These two frequencies were then used to determine the SSE acceleration values from the vertical response spectra for the 355' elevation of the TMI-1 Intermediate Bldg. It should be pointed out that the vertical response curve is assumed to be 2/3 of the horizontal response curve in accordance with the TMI-1 FSAR. This is considered conservative because the building stiffness in the vertical direction is much higher than the horizontal directions. The acceleration values obtained from this response curve were then multiplied by 1.5 to account for multi-modal response based on IEEE STD 344-1975, Paragraph 5.3, Page 13. The resulting vertical SSE accelerations for the 11.25' and 15.0' spans are 1.2g and 2.8g respectively.

Based on the method of supporting the auxiliary steam line, the system will have vertical accelerations and motions transferred to it by the building. Therefore, to account for the maximum vertical SSE and deadweight stress the 15' span was analyzed for stress as a simply supported, uniformly loaded beam in which the uniform load consists of the weight of the pipe and 1 1/2 inches of insulation. This pipe model is shown below.



Where R_1 = Support AS-69, R_2 = Support AS-70

The deadweight moments and stresses were calculated using the following formulas:

Max Moment = $M_{DW} = 1/8 \omega \ell^4$ (Reference C, page 106, Case 13)

$\sigma_{DW} = M_{DW}/Z$ where $Z = I/C$ is the Section Modulus of the pipe (inches)^3

The SSE seismic moments and stresses were calculated using the following formulas:

Max Moment = $M_{SSE} = (g_{SSE})(M_{DW})$

$\sigma_{SSE} = M_{SSE}/Z$

To determine the magnitude of occasional stress defined in the ANSI B31.1 Code Paragraph 104.8 Equation 12, the above two stresses were combined to arrive at a maximum deadweight plus SSE stress of 5737 psi which is well below the allowable of 18,000 psi (1.2Sh) for A-106-Grade B piping material. It should be emphasized that even if internal pressure acts concurrently with deadload and SSE, the combined stress will still be below the allowable value mentioned above. In addition to determining the maximum stress in the pipe during an SSE event, the supports were also evaluated to determine their dynamic load capacity in both tension and compression.

The pipe supports including the anchor bolts, were analyzed for a maximum tensile load defined by

$T_{SSE} + T_{DW} = (g_{SSE} + g_{DW})$(Support Design Load)

where:

g_{SSE} = Seismic acceleration multiplier
g_{DW} = Deadload acceleration multiplier = 1.0
Support Design Load is defined on the pipe support detailed drawings.

Also, the above load was multiplied by a dynamic load factor to account for impact on the various support components. The results of this analysis indicates that the anchor bolts have a factor of safety greater than 5 and the supports remain intact during and after an SSE event.

The rod was also evaluated for dynamic stability during compression by the method of paragraph 2.22, page 158 of Reference (a) and found to be stable during an SSE seismic event. Also, it is known that deflection during a seismic event is limited to the amount of travel which can be attained during the cyclic period over which a specific acceleration is acting during this event. Therefore, the rod deflection was calculated assuming the rod supplied no resistance to the pipe movement. This movement was calculated using the equation for distance traveled,

$$S = S_o + \frac{a}{2} t^2$$

where: S_o = initial movement = 0

$a = (g_{SSE} - g_{DW})(g)$

g = Acceleration of gravity in./sec.^{2}

t = time which is 1/2 the pipe period, sec.

The total displacement calculated using this equation was .4696 inches. To determine the axial displacement of the rod, support clearance were subtracted from this value which resulted in a total axial rod displacement of .282 inches. This axial displacement was used to determine the maximum bending stress in the rod due to lateral deflection during compression loading. The results of this conservative analysis indicates the stresses will not exceed the yield stress of the material.

In conclusion, since the deadweight plus SSE seismic stress is low and the supports remain intact during compression and tension loadings of an SSE event, the design for the auxiliary steam line will ensure its structural integrity during and after SSE.

References:

(a) Theory of Elastic Stability, Second Edition, S. P. Timoshenko and J. M. Gere, McGraw-Hill Book Company, New York, 1961.

(b) Marks Handbook for Mechanical Engineers, 8th Edition.

(c) R. J. Roark, Formulas for Stress and Strain, 4th Ed., McGraw-Hill, 1965.

Enclosure 2

EFW Pipe Supported From Stairs Inside Containment

An analysis of Emergency Feedwater Line Support EF-111 has been initiated to investigate the interaction of the piping with the stair framing to which it is attached. The analysis, as performed by Gilbert Associates, has concluded that isolated members of the stair system may be stressed beyond allowable limits during an SSE event.

Two separate options have been explored to remedy the situation. The first option involves reinforcing the affected stair members so that all stress levels will be within prescribed limits. The second option is the removal of support EF-111. In support of option two, an analysis of the piping system and all remaining supports has concluded that all piping stresses remain within allowable limits with the exception of support EF-16. The results of the evaluation performed in response to IE Bulletins 79-02 and 14 are unaffected for the remaining supports. Support EF-16 is a threaded rod approximatley twelve feet long and under the option two configuration would be subject to compressive loads during an SSE event. This support must be revised to a suitable compression strut. No adverse interaction of the piping and stair system due to seismically induced lateral deflections is expected.

For ease of implementation, GPUN intends to remove EF-111 and revise support EF-16 as option two provides the most expeditious resolution. The engineering for this work is now being initiated and it is anticipated that construction can be completed by the end of November, 1984.