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REPORT
of
REVIEW of REPLIES to AEC QUESTIONS by CONSOLIDATED EDISON COMPANY on INDIAN POINT UNIT -2 SAFETY and RELIEF VALVE INSTALLATION REANALYSIS

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NOTICE

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REVIEW OF REPLIES TO AEC QUESTIONS
BY CONSOLIDATED EDISON COMPANY ON
INDIAN POINT UNIT -2 SAFETY AND RELIEF
VALVE INSTALLATION REANALYSIS

References:

1. Letter of February 9, 1973, Re: Indian Point, Unit -2, AEC Docket No. JO-247, W. J. Cahill, Consolidated Edison Co. of New York to R. C. Young, Assistance Director for Pressurized Water Reactors, Directorate of Licensing, USAEC, and Attachment: 34 pages entitled "Additional Information Concerning the Re-Analysis of Safety and Relief Valve Installations for ASME Class -1 and Class -2 Systems in Indian Point, Unit No. 2", dated Feb. 9, 1973.

2. Criteria and Guidelines for the Design of Safety and Relief Valve Installations on Westinghouse Pressurized Water Reactor Plants, October 1972, Westinhouse Electric Corporation, Nuclear Energy Systems, PWR Division (Received by PARAMETER in connection with Assignment No. DC-103 on Surry -1.)

As a result of our review of Reference -1 on the above subject, we have the following comments: (Item numbers refer to Question numbers in the reference.)

1. We concur in the use of Dynamic Load Factor (DLF) of 2.0 in calculation of the equivalent static loads applied to piping systems by open discharge safety valve thrusts. For the single degree of freedom system, 2.0 is the upper limit of dynamic load application for an instantaneously applied force. This is shown graphically in Figure 7-2, page 7.7 of Ref. -1 for a rise time (t_r) equal to zero.

   We further agree in the classification of all local stresses at the valve (branch) to pipe (header) intersection due to discharge thrust as primary stresses. (It is assumed, of course, that stresses due to the discharge thrust only are appropriately combined with stresses due to internal pressure, dead weight and seismic effects as applicable in

1. (continued)
making the stress evaluation in this classification). The word "conservatively" (last line) requires some modification. Because the safety valve thrust has mechanical follow-up characteristics, stresses are not self relieving, and both membrane and bending stresses can be classified as primary. Therefore, it is not evident that a substantial degree of conservatism results from the primary stress classification per se.

2. The Welding Research Council Bulletin No. 107 is the presentation of the "Bijlaard Method" in general use.

   (Note: The 3rd Revised Printing, April, 1972 is more recent than Rev. 2, July, 1970 referenced and contains some corrections, but no fundamental changes.)

   This method of analysis of local stresses at intersections of cylindrical bodies cue to forces and moments can be applied by hand calculations or adapted to computer programs as has been done by any number of users. While we are not familiar with the CYLNOZ program specifically, there is no reason to doubt that it correctly interprets and executes the Bijlaard curves and methods of WRC-107.

   Evaluation of the stresses calculated by the CYLNOZ program as primary stresses and comparison with ANSI B31.1.0 Code allowables is reasonable and in agreement with the recommendations of Ref. -2. Using the lower allowable stresses of B31.1.0, which was evidently used for construction of the Indian Point Unit -2 systems, recognizes that the quality requirements which warrant use of higher stresses in ASME-Section III or B31.7 systems were not in force at the time

2. (continued)
of construction. The writers feel that some desirable conservatism results from this approach.

3. Assuming the correct application of strain gages and interpretation of data, the experimental stress analysis test described appears to provide an excellent verification of theoretically obtained force, moment and frequency values.

Verification of a DLF of less than 1.25 is of particular interest and agrees with that which might be obtained from Fig. 7-2, Page 7-7 by comparing valve opening time versus the period of natural vibration of the valve:

Nat. Frequency = 22.7 Hz. (Ref. -1)
Period: $\underline{T}$ = 1/22.7 = 0.044 sec.

Note that the period of natural vibration is close to the valve opening and closing times of 0.060-0.080 sec.

Checking the t_r/T relationship of Fig. 7.7, the following DLF values may be obtained for opening times (t_r) of .060, .070 and .080 sec:

t_r/T = 0.060/.044 = 1.36 DLF = 1.21

t_r/T = 0.070/.044 = 1.59 DLF = 1.19

t_r/T = 0.080/.044 = 1.82 DLF = 1.12

These values are close to and less than the 1.25 DLF stated.

3. (continued)
Note is taken of the fact that high speed movies verified that the actual angle of discharge of exit steam from the exhaust stack did not vary more than 2° from the 33° angle. This should provide confidence in the assumed line of thrust for systems where the turning elbow and extension pipe are effective. While the length of extension pipe used on this test is not given, it was no doubt long enough to be effective for the 33° turning angle. (Ref. -2 recommends that "A straight length of at least one pipe diameter should be provided on the end of the elbow to assure that the velocity is fully developed at the desired angle.")

There is a discrepancy with the steam exit angle defined by the test and that shown for the modified installation of the main steam safety valves for Indian Point, Unit -2 on Figure 8a, Page 8-2. The test description under Question -3 defines 0° exit as horizontal discharge, 90° exit as vertical discharge and 33° exit, presumably as 33° above the horizontal. However, Figure 8a shows the installation as having the nozzle exits 33° from the vertical (or equal to a "test" angle of 57°). If the test results as reported are for the smaller angle, as it appears, they should be reviewed for applicability and reconciled with the installed angle. Similarily, a review of the analysis for header stresses should also be made to make sure that the correct angle for application of the thrust force was used.

4. The piping flexibility and stress analysis computer programs ADLPIPE and MEL-40 have been in use for a long time, are well accepted and non-proprietary in the sense that they are available commercially from various computer services organizations. Their description by the licensee requires no further comment unless detailed technical questions would arise.

   Refer to observations on CYLNOZ program contained comments on Question -2 above.

   The writers cannot comment from direct knowledge on the Westinghouse FLASH-IV program.

5. a. The licensee states that "thrust loading effects on piping systems were evaluated using equivalent static loads". We feel that they must have applied a dynamic load factor in arriving at the "equivalent" static loads. As the MEL-40 program does not in itself have dynamic capability, it seems reasonable to assume that the DLF values were applied in this fashion. This appears to be in agreement with the analytical rationale described further in response to Question -7 following.

   b. (1) The calculational method presented for obtaining the reaction force (or input forcing function) for open systems has not been evaluated by the writers. It is taken directly from the Westinghouse Criteria, - Ref. -1.

5. b. (1) (continued)
In that document, it is given as a method of verifying by independent analysis the manufacturer's published reaction force data. Thus, the designer has two sources available to him and a built-in check in arriving at the values to be applied in the analysis of a given system.

5. b. (2) Transient hydraulic forces at various points in safety and relief valve discharge piping are the input forcing functions for closed systems. The licensee's presentation does not contain the extensive technical information which would be necessary to evaluate the applicability or accuracy of the FLASH-IV program in computing these forces.

The authors concur in the explanation that the following stated assumptions are conservative:

1. "Valve Opens Full in 40 Milliseconds" - This is obviously more severe than opening to 70% flow as specified by valve manufacturer.

2. "Loop Seal Water is Pushed Ahead of Steam" - This assumption implies that the slug of water stays intact and from this one can conclude it will exert the maximum inertia effect at each elbow. Break-up of the water slug would reduce its average acceleration and extend the time interval, and reduce the force of impingement at each turn.

5. b. (2) (continued)

3. "Two-Phase Flow in the Downstream Piping is Homogeneous." - Some water will flash to steam and separate which would tend to cushion the effect of the water slug. By conservatively assuming a homogeneous mass, this effect is not taken into account.

4. "No Credit is Taken for Power Operated Relief Valves"

The above assumptions were taken directly from Ref. -2. That document also explains that the analytical model used for obtaining hydraulic transient forces is considered to be conservative. An experimental program was being carried out (in late 1972) involving the test of a safety valve with a water seal, the results of which are to be compared with the values obtained from the analytical methods specified for use to date.

5. c. The licensee's answer to the question asking for a summary of stresses for open and closed systems at high changes of flexibility notes that points of maximum stress occur at elbows, tees and support points as would be expected. The stresses are reported generally to be well within allowable limits. No further comment is needed here. The "Summary Report of Safety and Relief Valve Installation and Re-Analysis for ASME Class -1 and Class -2 System in Indian Point Unit -2", July 13, 1972, referenced in this paragraph was not available for this review.

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6. The question asks for the licensee's justification for using 0.15g horizontal and 0.10g vertical Design Basis Earthquake (DBE) inputs in lieu of results from a multi-degree-of-freedom system. It would seem to stem from the questioner's understanding that those values were used as shock factors in a static type analysis. The licensee's response indicates that a dynamic analysis was indeed performed incorporating multi-degree-of-freedom mathematical models and response spectra appropriate to the piping systems. As discussed earlier, these dynamic forces must be handled as "equivalent static forces" when using the MEL-40 program with shock factors.

7. A valid question is posed in asking for justification for the use of a (dynamic) load factor of 2 for closed systems. In his response, the licensee first explains that the maximum DLF for a single-degree-of-freedom system and a single, one sided pulse, is 2.0. He goes on to explain that, theoretically, for a two sided pulse, the maximum DLF can be greater than 2.0. (Examples are given in Fig. 7-4). Therefore, the use of 2.0 as a basis for design must be validated for the systems in question.

   The narrative response provides an accounting of dynamic time-history analyses that were performed with Westinghouse computer programs on <u>typical</u> systems. Actual DLF's were determined as the ratio of the maximum stress from the time-history analysis to the maximum stress from a static load analysis.

7. (continued)

DLF's on the order of 1.20 to 1.64 are reported in Table 7-1 on page 7.5. The results of the described analytical work are reported to substantiate the use of a DLF of 2.0 for closed steam systems. No doubt this is a safe conclusion for the systems analyzed or very similar systems. The writers consider, however, that the last sentence of the response goes too far in stating more or less generically that "Since these systems include those with relatively low maximum stresses and those with relatively high maximum stresses, a design dynamic load factor of two for closed steam systems is sufficiently conservative to be consistent with current design practices." (underlining added) We feel that, because it has already been indicated that the DLF on a hypothetical system could be greater than 2.0 for certain loading conditions, it is incumbent on the designer to show that 2.0 is adequate for any system in question. No further justification appears to be necessary for Indian Point - Unit -2 systems but the generalization is to be avoided. In other words, it appears to be quite possible to design a system wherein hydraulic transients could result in DLF greater than 2.0.

8. The question asks for sketches of the required modifications used for all typical systems (on Indian Point,Unit -2) which are provided in Figures 8a, 8b, 8c and 8d on which we have the following observations:

8. (continued)

Fig. 8a "Main Steam Safety Relief Valve Arrangements"

The angle of inclination of the safety valve discharge pipes being 33° from the vertical, is not as described in the valve test program. (See comments under Question No. 3 above.) Because in the modified arrangement, the safety valve discharge flow now impinges on the stack wall, attention to securing the stack and assuring that discharge flow is not restricted is important. Ref. -2 recommends that "---- stacks should be designed so that back pressure does not affect the blowing valve reaction force."

Fig. 8b "Main Steam Safety Valve Nozzle Reinforcement - Weld Buildup - Indian Point, Unit -2"

It is noted that local reinforcement in the form of a weld deposited pad has been provided on the steam header. This integral buildup is the preferred method of providing material to spread the valve thrust loads out to a larger area of the header wall. The Bijlaard Method (or WRC Bulletin No. 107), as discussed in the comments on Question No. 2 above, is directly applicable only for integrally provided reinforcement. (For other designs, such

8. (continued)

Fig. 8b (continued)

as welded-on plate pads, simplifying assumptions and the use of bracketing calculations must be used in applying the WRC-107 rules.)

Fig. 8c "Pressurizer Nozzle"

No specific comment is offered in connection with this "fix" which is not included in the discussion of Ref. -1, except to say that it is assumed that the reinforcement was applied in the form of integral weld deposit employing suitable heat treatment and non-destructive testing procedures. The material is not given. This modification could result in the need to review or revise the fatigue analysis of the nozzle.

Fig. 8d "Restraint Added on A Typical System - at Accumulator Tank No. 24"

No comment is made on this sketch which is not discussed in Ref. -1.