Consumers
Power
Company

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July 20, 1976

Director of Nuclear Reactor Regulation
Att: Mr Albert Schwencer
Operating Reactor Branch No 1
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-255, LICENSE DPR-20
PALISADES PLANT, MAIN STEAM ISOLATION VALVES

In your letter dated May 6, 1975, you requested additional information regarding the design of the Palisades main steam isolation valves. Specifically, you requested a summary of the analyses employed to confirm the integrity of the main steam isolation valves under the dynamic loads associated with the postulated steam line breaks.

We previously reported preliminary results of our analyses of a main steam isolation valve for these conditions in our letters to you dated October 29, 1975 and June 9, 1976. These preliminary results indicated that the valve would perform satisfactorily under these conditions. The purpose of this letter is to submit the final results of our analyses to you as you requested.

These analyses and their results are described in Attachments 1 and 2.

- Attachment 1 summarizes the detailed fluid-dynamic and valve closing transient analysis which was performed to obtain the dynamic loading conditions on the valve disc during the transient. The results of the analysis are included therein.

- Attachment 2 summarizes the structural analyses which were performed of the critical structural elements for the dynamic loading conditions prior to, during, and after impact of the disc on the valve seat. The results of the analyses are compared to the acceptance criteria.

The results of these analyses confirm that a main steam isolation valve would perform satisfactorily under the postulated steam line break conditions. It was found that the shaft, arm, and disc post can properly support the disc throughout the transient and the disc can absorb the closing impact energy through plastic deformation well within the capability of the material.

Although the valve will perform satisfactorily under the postulated steam line break conditions, we have concluded that a change in valve internal parts (disc

7467

and disc arm) would improve its performance under operating and accident conditions. These parts have been ordered and are scheduled for installation during the next refueling outage. The valve, as modified with the new parts, will meet the same criteria specified in the Joseph M. Farley Nuclear Plant Final Safety Analysis Report, Appendix 10A, Amendment No 45, dated February 21, 1975.

David A. Bixel
Assistant Nuclear Licensing Administrator

ANALYSIS OF DISC IMPACT VELOCITY FOR PALISADES MAIN STEAM ISOLATION VALVE AS A RESULT OF A MAIN STEAM LINE RUPTURE

I. INTRODUCTION

In the event of a postulated main steam line rupture, the main steam isolation valve at the Palisades Nuclear Power Plant would undergo a severe transient due to impact of the valve disc onto the valve seat as the valve closes to isolate its associated steam generator. An analysis was performed to determine the steam pressure and the angular velocity attained by the disc at impact as a result of the postulated accident. The results of this analysis are described herein. A complete report of the analysis including computer printouts is contained in Reference 1. The pressure and impact velocity obtained from this analysis will be used in the structural analysis of the disc and valve body to determine if the valve can perform its function properly under the dynamic loads associated with a postulated steam line break.

The method of analysis uses a control volume approach to solve the mass, energy, and momentum equations throughout the appropriate region of the main steam piping. The valve internals are modeled with sufficient detail to allow a good representation of the torque on the valve disc using the solution from the mass, energy, and momentum conservation equations. Effects of the changing disc position on the flow areas and volumes

in the valve are considered in the analysis.

A description of the transient considered and the corresponding results of the analysis are provided in Section II below. A short description of the computer program used in the analysis including the model used for the valve and the associated steam line piping is described in Section III.

II. TRANSIENT ANALYZED AND RESULTS

A schematic of the main steam line piping is provided in Figure 1. This figure shows the two main steam isolation valves and their relation to the two steam generators and the two main steam lines. The cross connect between the steam lines is also shown in the figure.

The function of the main steam isolation valve in the event of a postulated steam line break is to close promptly and prevent the blowdown of its associated steam generator. Since the safety analyses for the Palisades Plant assume that one steam generator cannot be isolated from the break and consequently blows down through the break, the valve which is analyzed for its ability to isolate its associated steam generator is the one in the steam line not experiencing the assumed break. The most severe closing transient for this valve would occur if the break location is near the cross connect between the two steam lines. This break location, therefore, is taken as the design basis break for the valve analysis.

Since higher steam pressures cause more severe valve closing transients, the design basis pressure used for the analysis was the hot standby condition of 900 psig.

The Palisades main steam isolation valve is held open by pressure from an air cylinder which applies a torque to the disc. This air pressure is removed by a signal generated when the pressure in the steam generator drops below 500 psig. The analysis described in this report predicts that the restraining torque on the disc will be overpowered by the fluid forces on the disc during the early part of the transient, leading to a valve closure before a signal to trip the valve is generated. For the sake of conservatism it is assumed that the valve could trip at any time during the transient. To determine the time of trip which would lead to the largest impact velocity a number of computer runs were made, each assuming a different time at which the valve trips. The maximum impact velocity was found to occur when the valve trips at 104 milliseconds after the break occurs. For conservatism, this trip time was assumed as the design basis for the analysis.

The results of the analysis show a maximum disc centerline velocity of 81 ft/sec and an impact energy of 7.8×10^5 in-lbs. The pressure upstream of the disc peaks at 905 psia within 3 milliseconds after impact due to steam hammer. The pressure upstream of the disc at impact is 767 psia.

III. DESCRIPTION AND BASIS OF COMPUTER PROGRAM

The motion of the disc in the main steam isolation valve is determined to a large extent by the fluid pressures and flows which exist inside the valve. These pressures and flows are in turn strongly dependent on disc position. Consequently, a solution for the impact velocity attained by the disc as a result of a postulated main steam line break requires a simultaneous solution of the fluid equations which describe the blowdown of the main steam line and the equation of motion of the disc. The calculational technique used achieves such a solution by utilizing a time step approach in which the fluid conditions and disc position are determined alternately during each time step using the mass, energy, and momentum conservation equations for the fluid behavior and the equation of motion for the disc. The basic approach is a modified version of the Flash-4 approach described in Reference 2 where the equation of motion of the disc has been added to the solution and is utilized to redefine the geometry inside the valve during each time step.

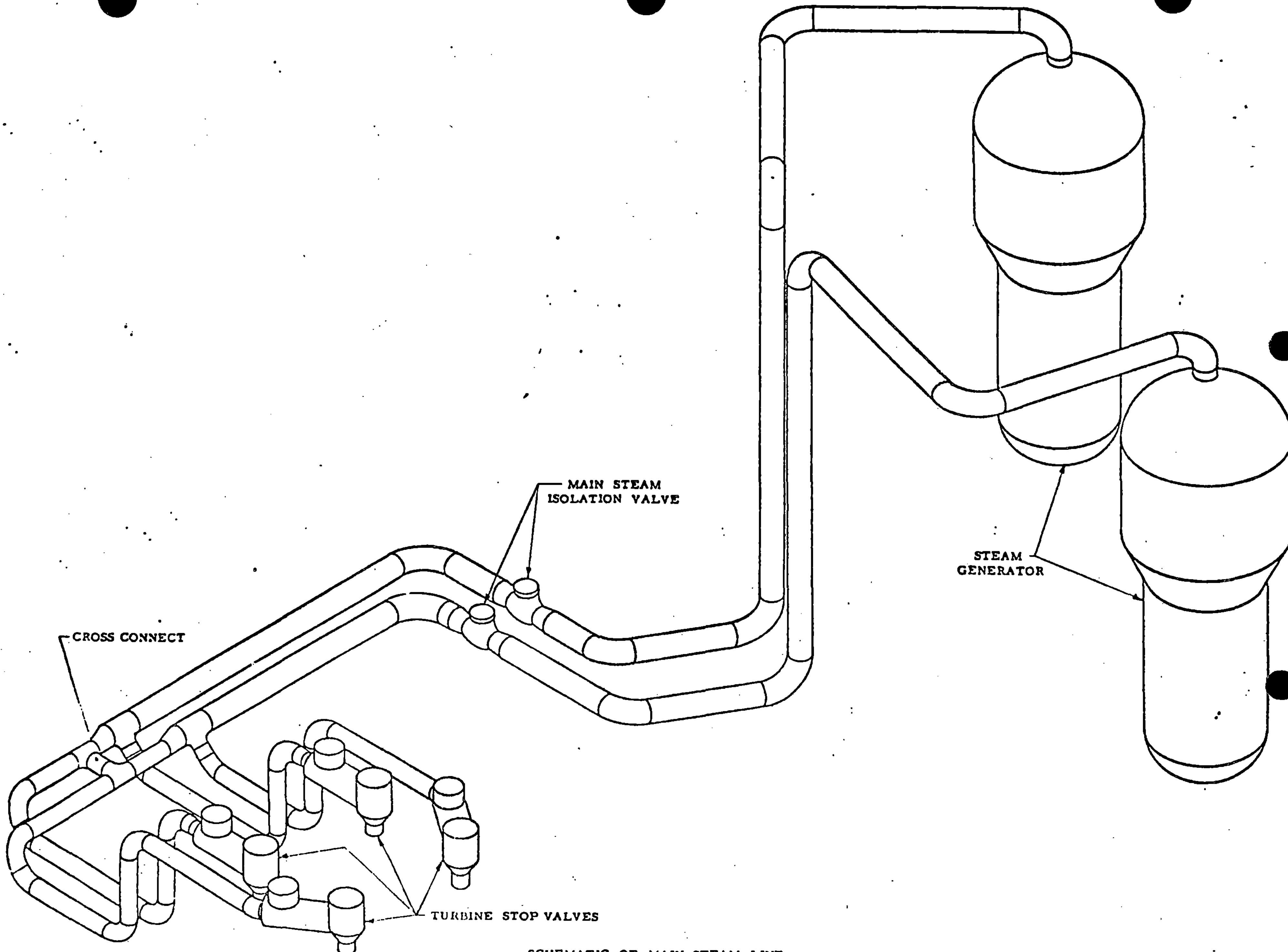
A schematic of the computer model used for the simulation of the steam line break is shown in Figure 2. This schematic shows the division of one of the two main steam lines into a series of connected control volumes beginning at the steam generator and ending at the turbine stop valves. The location of the break in the cross connect between the two steam lines is also shown.

The valve internals are modeled by four separate control volumes and four fluid connectors so as to provide enough detail to allow an adequate determination of the pressure drop across the disc. A detail of the valve showing the control volumes and flow paths as modeled in the program logic is given in Figure 3. As can be seen in the figure, several of the control volumes and flow areas inside the valve are dependent on the angular position of the disc. These volumes and areas, and all parameters dependent on them, are redefined by the computer program at each time step so as to take into account the geometry changes due to disc motion.

REFERENCES

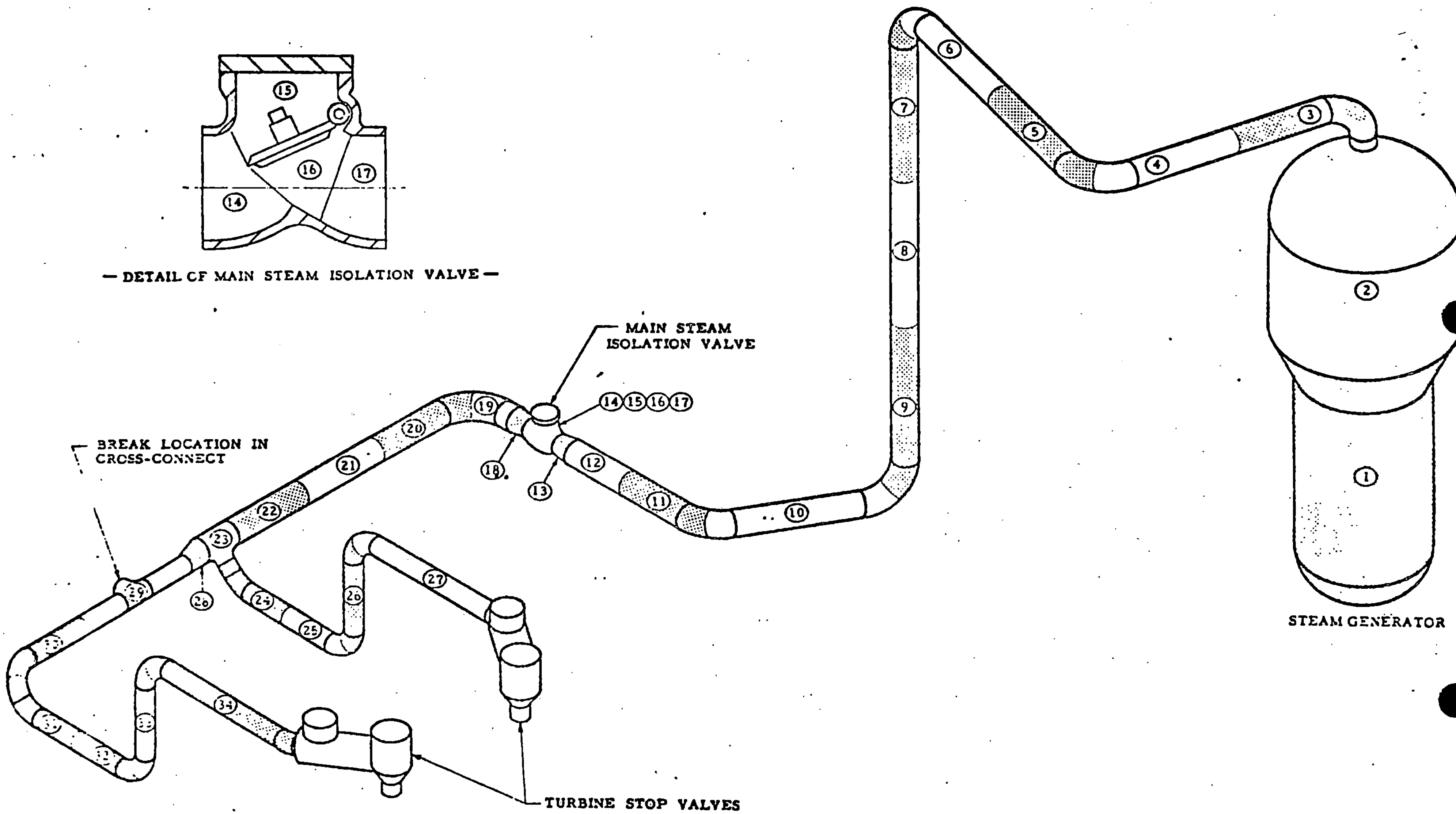
1. MPR Associates Report, MPR-500, "Analysis of Disc Impact Velocity for Palisades Main Steam Isolation Valve as a Result of a Main Steam Line Rupture," dated November 1975.

2. Porsching, T. A., Murphy, J. H., Redfield, J. A., and Davis, V. C., "Flash-4; a Fully Implicit Fortran IV Program for the Digital Simulation of Transients in a Reactor Plant," March 1969, WAPD-TM-840 Bettis Atomic Power Laboratory.



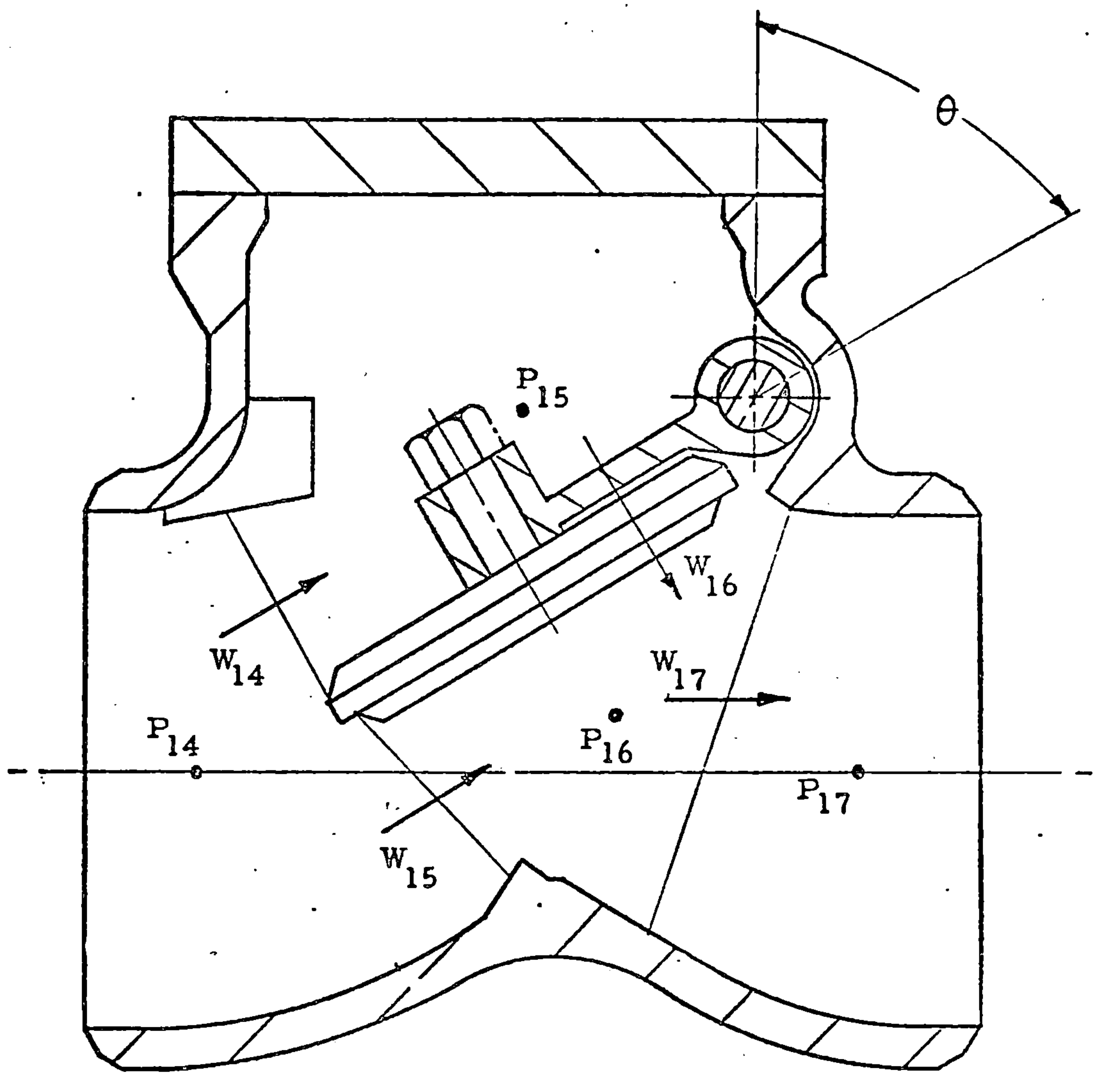
SCHEMATIC OF MAIN STEAM LINE

FIGURE 1



COMPUTER MODEL OF SYSTEM

FIGURE 2



DETAIL OF VALVE INTERNALS

FIGURE 3

Attachment 2

ATWOOD & MORRILL CO., INC.
DESIGNERS AND MANUFACTURERS
Special Valve and Control Equipment
PHONE: 617-744-5690
TELEX: 94-0299
POWER PLANT · OIL INDUSTRY · MARINE AND INDUSTRIAL SERVICE
SALEM, MASSACHUSETTS 01970

July 6, 1976

Consumers Power Company
1945 Parnall Road
Jackson, Michigan 49201

Attention: Mr. John Yope

Subject: Palisades Nuclear Plant
Main Steam Isolation Valves
Consumers Power P.O. No. 72575
A&M S.O. 13938
Valve Closure Analysis

Gentlemen:

A&M is performing an evaluation to confirm the integrity of the main steam isolation valves (MSIV's) at Palisades Nuclear Plant under the dynamic loads associated with the steam line break.

Summary of Results and Conclusions

The preliminary results are summarized below:

1. The kinetic energy at impact is 179000 ft-lb.

2. The maximum equivalent strain in the rim region of the disc is 17%. This is less than the maximum allowance equivalent strain from Reference 1 of 30%.

3. The maximum equivalent strain in the center region of the disc is 10.5%. This is less than the maximum allowable strain from Reference 1 of 18%.

The evaluation was based upon qualifying the Palisades MSIV's by reference to J M Farley Nuclear Plant FSAR Appendix 10A Amendment No. 45 (Reference 1) and correlating the parameters by means of the methods outlined in TMR Report TR2196 (Reference 2).

The same modifications made to the Farley MSIV's will be incorporated in the Palisades MSIV's. In brief, this involves replacing the present discs with discs of Type 304 stainless steel of a slightly modified configuration and replacing the disc arms with the newer design which allows for greater deflection of the disc center.

We therefore conclude that the redesigned discs and disc arms for the Palisades MSIV's meet the criteria specified in Reference 1 and the discs will withstand the impact due to the pipe break.

Methods

1. Design Closing Transient

The design closing transient conditions were calculated by MPR Associates, Inc. That calculation used a computer model of the fluid dynamics and valve mechanics to obtain the transient pressures, flows, accelerations, and velocities resulting from the postulated main steam line break. The predicted closing velocity of the disc centerline at the time of impact on the seat is 120 feet per second. This value is used in the structural evaluation of the disc and seat upon impact.

2. Structural Analysis

The disc centerline velocity was converted to an "Equivalent Translational Velocity" which is the velocity obtained by equating rotational kinetic energy of impact to translational kinetic energy by

$$\frac{I\omega^2}{2g} = \frac{MVeg^2}{2g}$$

where I is the moment of inertia of the disc assembly, ω is the rotational velocity, M is the mass of the disc assembly, g is the gravitational constant and Veg is the equivalent translational velocity.

The kinetic energy of the disc assembly is then solved for by

$$\frac{M_d \; Veq^2}{2} = KE$$

where KE is the maximum kinetic energy of the rotating system, and M_d is the mass of the disc.

The kinetic energy was normalized with respect to disc volume to yield the energy density from

$$e = \frac{KE}{V}$$

where e is the energy density and V is the disc volume.

Because of the geometric similarity between the valves and the Farley valve, the structural evaluation was performed by comparing the impact energies of Palisades with that of Farley. The method is presented in Reference 2. The equivalent strain is found from the Farley analysis by plotting the equivalent strain in critical locations versus the energy absorbed by the Farley valve.

The formal report covering the above is due to be completed in early August. If you have any questions regarding any of the above, please contact me or Paul Syrakos.

Very truly yours,

ATWOOD & MORRILL CO., INC.

Robert a Genier /PAS

Robert A. Genier
Manager, Project Management Dept.

RAG:aa

cc: P. A. Syrakos

References

1. Joseph M. Farley Nuclear Plant Final Safety Analysis Report Appendix 10A Amendment No. 45 dated 2/21/75.

2. Teledyne Materials Research Technical Report, TR-2196, "Further Interpretation of Farley Isolation Valve Closure Analysis" dated November 5, 1975.