Jersey Central Power & Light Company

MADISON AVENUE AT PUNCH BOWL ROAD • MORRISTOWN, N.J. 07960 • 539-6111

August 11, 1972

Mr. A. Giambusso
Deputy Director for Reactor Projects
Directorate of Licensing
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Giambusso:

Subject: Oyster Creek Station
Docket No. 50-219
Safety Valve Seat Bushing Cracks

8/16/72
JR
FN

In accordance with my letter to you, subject as above, dated May 1, 1972, I am attaching a report of our investigation and repair of the Oyster Creek main steam safety valves.

We are enclosing forty copies of this letter with attached report.

Very truly yours,

Ivan R. Finfrock Jr.

Ivan R. Finfrock, Jr.
Manager, Nuclear Generating Stations

IRF/pk

Attachments

cc: Mr. J. P. O'Reilly, Director
Regulatory Operations

50-219
Original

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# OYSTER CREEK NUCLEAR GENERATING STATION

## Report on

## Safety Valve Seat Bushing Cracks

### Introduction

A liquid penetrant inspection of the pressure containing parts from twenty-one safety valves that have been in service at the Oyster Creek Plant disclosed cracks in nine seat bushings. No cracks were observed in the valve discs.

### Summary

One of the cracked seat bushings was destructively examined. The metallographic examination disclosed the cracks to be low temperature transgranular chloride stress corrosion. The cracks were located radially across the seat and longitudinally and circumferentially on the outside of the seat bushing. The maximum crack depth was 150 mils. Material tests confirmed that the seat bushing was 304 stainless steel in the fully annealed condition.

The valves with the cracked seat bushings were in the three or four valve positions located closest to the reactor on each steam line. These valves had been leaking in service as determined by radiation measurements and scale deposits on the seat bushings.

The environment at the cracked seat bushing was steam and water, free oxygen and chloride contamination. The source of the chlorides is not known. During plant operation, the seat bushing was under stress from the reactor pressure of 1020 psig. Under these conditions, 304 stainless steel is known to be susceptible to chloride stress corrosion cracking.

To minimize the possibility of cracking in the future, a) all cracked seat bushings were replaced with new 304 stainless steel bushings; b) all valve parts and the outlet piping were washed with demineralized water to remove chloride; c) a drain hole was added just above the inlet flange of each valve to prevent water from standing in the valve base; and d) the valves were reassembled using lubricants free of chlorides.

### Background Information

The Oyster Creek Nuclear Power Plant has a total of sixteen spring-loaded safety valves on the main steam lines between the reactor vessel and the isolation valves. The valves are attached to the steam line by flanged connections. The steam line and the inlet valve flanges are insulated. The valve bodies above the inlet flange are not insulated. A drawing of the safety valve identifying the primary parts is shown on Figure 1. As shown in Figure 1, the seat bushing and the disc are the reactor coolant pressure boundary. The seat bushing is machined from 304 stainless steel. The disc is machined from 422 stainless steel. Both the seat bushing and the disc were ultrasonic and liquid penetrant inspected at the time of manufacture.

The Technical Specifications for the Oyster Creek Plant requires ~ minimum of five of the valves shall be bench checked or replaced with a bench checked valve each refueling outage such that all valves are checked in three successive refueling outages to insure setpoints are as follows:

| Number of Valves | Set Point (psig) |
|---|---|
| 4 | 1212 ± 12 |
| 4 | 1221 ± 12 |
| 4 | 1230 ± 12 |
| 4 | 1239 ± 12 |

The popping point of the safety valves at the Oyster Creek Plant was set at the valve factory on steam.

During the Poison Curtain Removal Outage in October 1971, five valves were removed from a steam line and replaced with spares. In April 1972, these valves were being disassembled and decontaminated for return to the factory for setpoint checks when the cracks were found. The cracks were detected by liquid penetrant examination.

The location of the valves on the steam lines from plant startup in 1969 to the curtain outage in October 1971 is shown on Figure 2. The location of the valves on the plant from October 1971 to the refueling outage in May 1972 is shown on Figure 3.

## Examination Results

The seat bushings and discs of the five valves removed from service in October 1971 were liquid penetrant inspected. Two seat bushings were found cracked. No cracks were observed in the discs.

The seat bushing from valve serial number BK-6247 had radial cracks at the valve seat and circumferential cracks at the fillet radius above the lower threads. The radial cracks started at the outside surface and extended part way across the seat face. The circumferential cracks were located around a major portion of the circumference. The maximum depth of the circumferential cracks was 120 mils as determined by grinding out the cracks. There were no crack indications on the inside diameter of the seat bushing.

The seat bushing from valve serial number BK-6268 had approximately fifteen radial cracks across the seat, numerous longitudinal cracks on the outer diameter and circumferential cracks at the fillet radius above the lower threads. No crack indications were found on the inside diameter. This seat bushing was shipped to Vallecitos Nuclear Center for destructive examination. The metallography examination disclosed that the cracks were transgranular chloride stress corrosion cracking. A fracture surface of a crack was examined by microprobe in two areas. Chloride, sulphur and potassium were detected in both areas. The material was tested and found to meet the requirements of ASTM A-182, 304 stainless steel. No evidence of carbide precipitation was found.

When the plant was shut down for refueling in May 1972, the sixteen valves in service were removed, disassembled and inspected. A dye penetrant inspection of the seat bushings and discs from the valves disclosed that seven of the seat bushings were cracked. On three of the seat bushings there were cracks across the seat and on the outside surfaces. Two of the seat bushings had cracks only across the seat, and two of the seat bushings had cracks only on the outside surfaces. The location and appearance of the cracks were the same as previously described for valves BK-6247 and BK-6268. A summary of the inspection results on the sixteen valves is given in Table 1.

Prior to disassembling the valves, the discharge area of the valves was examined. All valves had scale or rust deposits on the outside of the seat bushings. There was a water level ring even with the low point in the outlet discharge pipe indicating that all valves had leaked. Valves were conducted at a pressure of 1020 psi after maintenance on the reactor coolant systems.

On the cracked seat bushings, there was a hard scale about 1/32-inch thick that had flaked off in places. The scale was light tan in color and was located below the water level mark on the base. The contact gamma radiation dose rate at the thick scale was 200 to 2000 mr/hr. Three of the valves with the heavy hard scale (BK-6312, BK-6314 and BK-6323) were on the plant a short time from November 1971 to May 1972.

With the exception of the cracks across the seating surfaces, the longitudinal and circumferential cracks on the outside of the seat bushings were located below the water level mark.

As indicated in Table 1, four of the seat bushings had damaged threads at the seat bushing to valve base connection. Metallurgical examination of two of these seat bushings indicated that the thread damage was mechanical in nature and probably occurred either during valve assembly or disassembly.

## Discussion

The high gamma dose rates and the hard scale deposits indicate the valves with the cracked seat bushings were leaking steam in service. The scale deposits are believed to have been deposited by a condensing and boiling cycle inside the valve body. There is evidence that steam was condensing on the inside of the uninsulated valve body and the resulting water was running down in the area between the valve base and the seat bushing. The water was boiling at the side of the seat bushing depositing the scale on the hot surface. The seat bushing would be heated by the reactor steam.

The valves with the cracked seat bushings were the valves located closest to the reactor as shown in Figures 2 and 3. Since these valves were not randomly located on the steam line, the steam leakage is believed to be a significant factor in causing the cracking.

The microprobe examination of fracture surfaces and the analysis of a crud sample taken from inside a valve base indicated chloride contamination was present on the surfaces of the valve parts exposed to the drywell ambient. Possible sources of chlorides include chloride contamination of the valve parts and outlet piping during fabrication and installation and concentration of chlorides in the reactor water by boiling. The chloride concentration in the reactor water is normally less than 0.1 ppm with an operating limit of 1.0 ppm. Some free oxygen is present at the outside of the seat bushings from the nominal two percent oxygen in the drywell during plant operation.

In summary, the environment at the seat bushing during plant operation was hot steam and water, free oxygen, chloride contamination and stress in the seat bushing from the reactor pressure of 1020 psi. Under these conditions, stress corrosion cracking of 304 stainless steel could occur.

The valve manufacturer has indicated that cracking of seat bushings has previously occurred in only three or four instances out of thousands of similar valves in service. According to the valve manufacturer, in each of the previous cases, the cracking was attributed to chloride contamination of the valve. In no instances had a seat bushing failed catastrophically. In previous cases, the corrective measure was to replace the defective parts and to control further exposure of the valves to sources of chloride contamination.

## Conclusions and Corrective Measures

Based on the above information and the experience at other plants, the cracks in the seat bushings at the Oyster Creek Nuclear Plant are the result of chloride contamination.

To eliminate the possibility of water standing in the lower part of the valves where cracking occurred, a drain hole was added just above the inlet flange.

All cracked seat bushings were replaced with new Type [illegible] stainless steel bushings of the same design as originally provided.

After parts were machined and dimensionally checked, the parts were cleaned with alcohol and demineralizer water, and the valves were assembled using graphite and caster oil as a lubricant. All materials were checked for chloride and fluoride contamination.

The inlet and outlet flanges on the valves were covered during shipping, handling and installation. The outlet discharge pipe for each valve, which consists of a flange, a piece of pipe and a pipe tee was washed with demineralized water prior to installation.

To prevent the leakage of water during leak testing of the reactor coolant systems, the safety valves will be gagged above a pressure of 900 psi.

## Future Action

At the next refueling outage, selected valves from locations where seat bushings were previously found cracked will be removed, disassembled and the seat bushings inspected for cracks.

The leakage of safety valves during plant operation will be investigated.

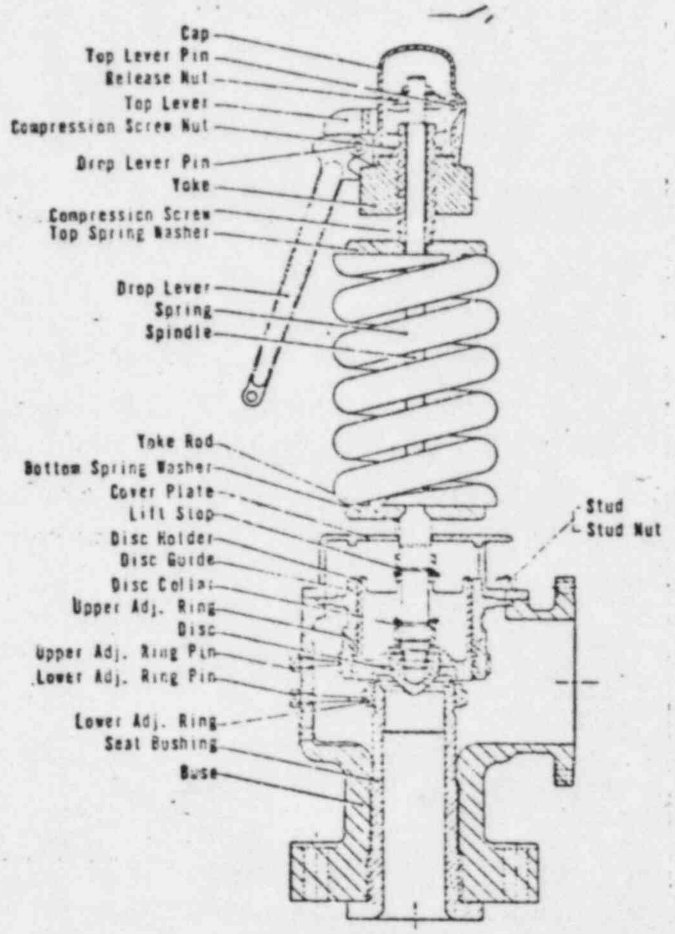
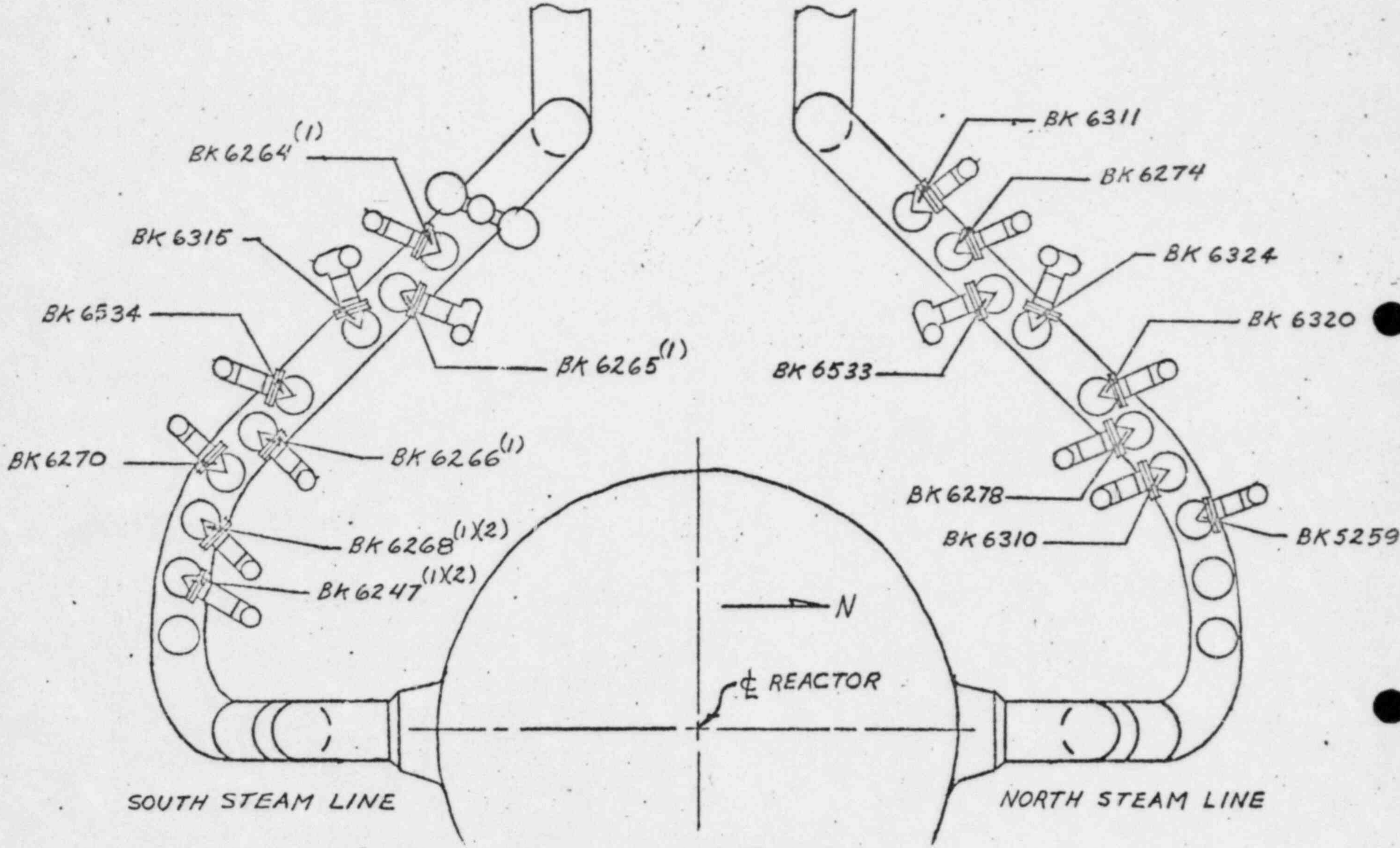


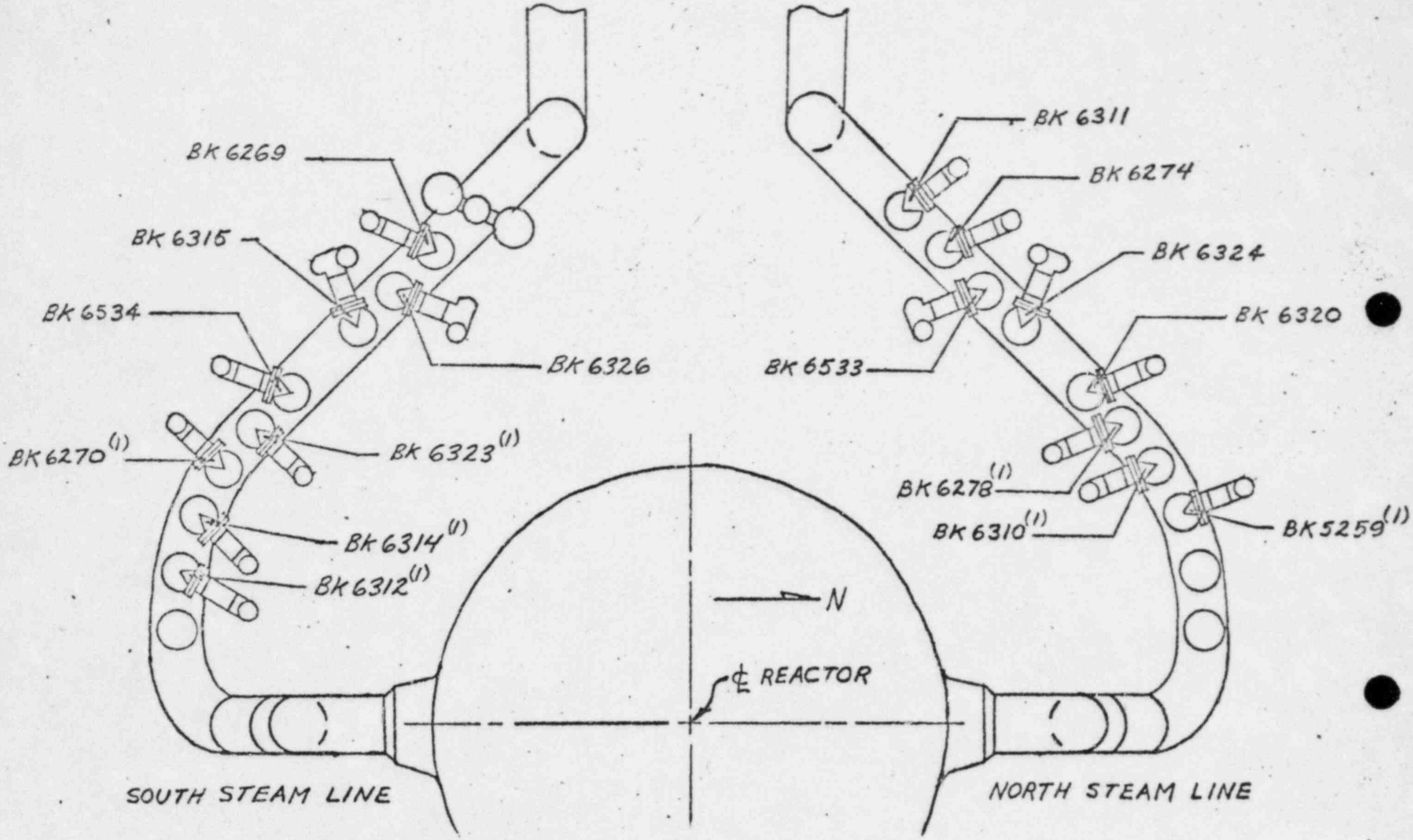

FIGURE I - MAXIFLOW SAFETY VALVE




(1) Valves Removed Oct 1971 and Inspected

(2) Cracked Seat Bushing

Figure 2. Safety Valves in Service from Aug 1969 to Oct 1971




(1) Cracked Seat Bushing
All Valves Removed and Inspected.

Figure 3. Safety Valves in Service at Reactor Shutdown May 1972

TABLE 1

EXAMINATION RESULTS OF SEAT BUSHINGS INSPECTED MAY 1972

| Valve Serial Number* | Set Pressure psig | Liquid Penetrant Inspection | Thread Damage | Scale Deposits | mr/hr Radiation Measurements |
|---|---|---|---|---|---|
| BK 6259 | 1230 | small linear cracks on outside | none | hard scale | 2000 |
| BK 6310 | 1212 | four radial cracks on seat<br>many linear cracks on outside | none | hard scale | 2000 |
| BK 6278 | 1212 | twenty-four radial cracks on seat<br>linear cracks on outside | threads damaged | hard scale | 1000 |
| BK 6320 | 1239 | no cracks | none | medium rust scale | 50 |
| BK 6324 | 1239 | no cracks | none | light rust scale | 50 |
| BK 6533 | 1230 | no cracks | none | light rust scale | 75 |
| BK 6274 | 1221 | no cracks | none | light rust scale | 50 |
| BK 6311 | 1221 | no cracks | threads damaged | light rust scale | 35 |

*Valves from north steam line

| Valve Serial Number* | Set Pressure psig | Liquid Penetrant Inspection | Thread Damage | Scale Deposits | mr/hr Radiation Measurements |
|---|---|---|---|---|---|
| BK 6312 | 1239 | ten radial cracks on seat | none | hard scale | 500 |
| BK 6314 | 1212 | small linear cracks on outside | threads damaged | hard scale | 200 |
| BK 6270 | 1212 | nine radial cracks on seat | none | hard scale | 300 |
| BK 6323 | 1221 | twenty-three radial cracks on seat<br>many linear cracks on outside<br>circumferential cracks above threads | none | hard scale | 500 |
| BK 6534 | 1221 | no cracks | none | light rust scale | 70 |
| BK 6315 | 1230 | no cracks | threads damaged | light rust scale | 40 |

*Valves from south steam line

TABLE 1
EXAMINATION RESULTS OF SEAT BUSHINGS INSPECTED MAY 1972

| Valve Serial Number* | Set Pressure psig | Liquid Penetrant Inspection | Thread Damage | Scale Deposits | mr/hr Radiation Measurements |
|---|---|---|---|---|---|
| BK 6326 | 1230 | no cracks | none | not examined | low |
| BK 6269 | 1239 | no cracks | none | very light rust scale | 75 |

*Valves from south steam line