ENCLOSURE 1

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Vice President

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February 18, 1997
Re: Indian Point Unit No.2
Docket No.50-247

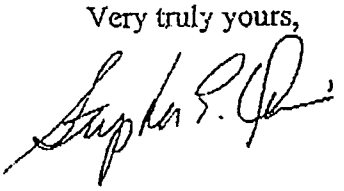
Document Control Desk
US Nuclear Regulatory Commission
Mail Stop P1-137
Washington, DC 20555

SUBJECT: Response to Request for Information Concerning Confirmatory Action Letter 1-97-002 Topical Event.

This letter is to confirm, as stated in your January 31,1997 letter, that members of licensee's management and technical staff will meet with your Region I staff prior to restart of Indian Point Unit 2 to review the items set forth in your letter. In advance of that meeting we provide in the attachment to this letter additional information regarding our January 26, 1997 shutdown, including current information on our root cause evaluation, and the status of corrective measures.

Should you have any questions regarding this matter, please contact Mr. Charles W. Jackson, Manager, Nuclear Safety and Licensing.

Very truly yours,



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ATTACHMENT

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT UNIT NO. 2
DOCKET NO.50-247
FEBRUARY, 1997

RESPONSE TO REQUEST FOR INFORMATION

On January 26, 1997, Indian Point Unit 2 was shut down when it was determined that three of the four main feedwater regulating valves would not adequately respond to a closure demand. After the shutdown, it was also determined that one of the low flow feedwater regulating valves was also not responding to closure demand. Subsequent investigation of the internals of these valves found scoring of the valve plugs and cages. Our investigation indicates that foreign material, determined to be an abrasive grit of the type used to clean the inner surface of the high pressure turbine during the 1995 Refueling Outage (RFO), is the cause of the scoring and the failure of the valves to close upon demand.

Con Edison management promptly recognized the implications of this failure of multiple main feedwater regulating valves. A diverse, multi-disciplined team was immediately assembled to assess the scope of foreign material intrusion to the feedwater regulating valves and balance of plant systems and components, and to aggressively pursue its removal. The team's purpose was to apply a thorough approach to determine the root cause for the main and low flow feedwater regulating valves non-closure. Once the foreign material was discovered in the valve cages and identified as grit, a plan was developed to perform the tasks listed below.

- Survey grit and shot abrasives used during the 1995 RFO
- Review abrasive migration interdiction practices utilized during the 1995 RFO
- Identify systems that could be susceptible to foreign particle intrusion as a result of abrasive usage during the 1995 RFO
- Identify locations for inspections of the susceptible systems
- Perform detailed inspections
- Assess the inspection results
- Document the operability of systems / components deemed susceptible to foreign particle intrusion, including specifically those systems / components which communicate with the feedwater and condensate systems
- Evaluate past similar plant events
- Perform a thorough and comprehensive root cause analysis
- Evaluate the potential implications of the root cause on other plant systems and equipment.
- Recommend corrective actions to prevent recurrence
- Evaluate other potential failure modes, i.e., system dynamics (flow velocities)
- Aggressively pursue the removal of the grit.

To perform a component and system evaluation of this magnitude, and provide a comprehensive root cause analysis, equipment disassembly, inspections, lab analysis, equipment testing or engineering analysis, in various combinations, is required to either prove or disprove validity of various candidate possible cause(s) of this event. To expedite this root cause analysis, and to ensure its thoroughness and depth, the team was assigned on a full time basis. Their areas of expertise include engineering, operations, chemistry, maintenance, metallurgy, failure analysis, and independent safety review.

The team's staff received input from Westinghouse, and Altran personnel, as well as from staff at New York Power Authority's Indian Point 3 Nuclear Power Plant. The services of Conger and Elsea, Inc., have been retained to assist in the root cause analysis for the 1995 event evaluation.

A detailed engineering review was performed to identify all susceptible piping systems. The susceptible systems and components identified are as follows:

- Main Steam
- Condensate
- Main Feedwater
- Auxiliary Feedwater
- Heater Drain
- Main Steam Traps
- Crossunder Piping
- Extraction Steam
- 25 Extraction Steam
- 26 Extraction Steam
- 25 Heater Drains
- 26 Heater Drains
- 25 Extraction Steam Traps
- 26 Extraction Steam Traps
- Moisture Preseparator

The following are the safety-related systems and components that were considered to be potentially impacted:

- Steam Generator Blowdown Containment Isolation Valves (PCV-1214, PCV-1214A, PCV- 1215, PCV-1215A, PCV-1216, PCV-1216A, PCV-1217, PCV-1217A)
- Steam Generator Wide Range Level Transmitters (LT-417D, LT-427D, LT-437D, and LT-447D)
- Auxiliary Feedwater System
- Condensate Storage Tank
- Main and Low flow Feedwater Regulating Valves
- Main Boiler Feedwater Pumps Discharge Valves
- Steam Generator Blowdown Radiation Monitor
- Main Feedwater Flow Instrumentation
- Turbine First Stage Pressure Transmitters
- Steam Generators
- Main Steam

Operability determinations have been performed for the above-listed safety systems and / or

components. These determinations are performed in accordance with our "Equipment Operability Assessment Procedure," SE-SQ-12.317. A separate 10 CFR 50.59 safety evaluation was performed for the effect of grit intrusion in the Steam Generators based on a Westinghouse analysis.

The team selected approximately 200 locations for inspection based on drawing reviews and field walks. Sample locations were established based on a review of field walks, print research or previous sample findings. A record of all locations selected and inspection results was maintained by the team. Inspection results and evaluations will be included in the final Analysis of Station Events and Conditions (SAO-132 A) Report.

Inspections of the identified locations using visual, video, or boroscope techniques in various combinations were aggressively performed. Samples were collected and inspected for the presence of grit and foreign material. Identified locations are being logged, videotaped, or photographed, in various combinations, as appropriate, with information and status on the sample location, Work Order number controlling the inspection activity, inspection results, and disposition of the tracking documentation.

Descriptions of the debris type and quantity removed are being recorded to document the findings at the various identified sample locations. Other grit abrasives utilized for surface preparations during the 1995 RFO were evaluated to contrast their signatures to that of the grit used for the turbine maintenance work. This aided in positive source identification for grit entry and migration paths.

The composition of the debris for the various sample locations is being categorized and quantified (i.e., percentage grit of total sludge at that sample location). Probable source identification of the debris aided in determining the scope and magnitude of the intrusion and the required extent of the investigation.

Third party evaluations are being performed parallel to our evaluations to either corroborate or contrast Con Edison findings. Altran Corp. has been retained to perform a metallurgical and failure analysis. To date, Altran has inspected the main and low flow feedwater regulating valve plug and cage surface conditions. A sample of the debris removed from Heater Drain Tank and several embedded particles removed from the surface of the main feedwater regulating valve plug have been analyzed and are documented in Altran Corp. Letter 97110.1, dated 2-3-97. This letter and its attachments describe preliminary results of their examination of the valve plug and cage, and EDAX scan plots of the removed particles. Comparison of the energy dispersive X-ray analysis (EDS) scans conclude that a sample of debris removed from the heater drain tank pump and the embedded particles removed from valve FCV-447 plug and cage are similar.

Catholic University's Oxide Chemistry Group was requested to analyze the grit. Using optical microscopy technology to ascertain the analyzed materials' physical characteristics, it was substantiated that the type of shot grit present was Amasteel HG-25. In addition, Con Edison's Astoria Chemistry Laboratory and Altran Corporation were also been sent a sample of the grit material for analysis.

The grit appears to have entered the pre-separator devices in the High Pressure Turbine exhaust due to faulty foreign material exclusion controls and final system cleaning that was inadequate

due to lack of recognition of this "hide out" path . The completed inspection results will be documented in the final Analysis of Station Events and Conditions (SAO-132A) Report.

Based on the above-described inspections, the removal of the foreign material from the identified systems and components, and the repair of and evaluation of the effect of the foreign material on the feedwater regulating valves and other components, we are confident that the plant can be returned to service and that the corrective actions described will prevent recurrence.

To ensure operability of the various systems and / or components the following work was performed:

- Steam Generator Blowdown (SGBD) Containment Isolation Valves -

  Inboard SGBD valves were disassembled and inspected for foreign material and /or damage caused by foreign material intrusion. Visual Inspection Technologies Inc. (VIT) performed a visual inspection of the outboard SGBD valves. Type C local leak rate testing was performed on all eight SGBD valves and passed. No damage from grit was evident. All valves passed an as-found leak tightness test.

- Steam Generator Wide Range Level Transmitters -

  Steam Generator Wide Range Level Transmitters low side (bottom tap) impulse lines were blown down into sock filters. Small quantities of sludge were obtained from each transmitter. Samples of this sludge were analyzed and found to contain no grit material. Based on the very small quantity of sludge removed from the impulse lines, it has been determined that the accuracy of the transmitters was unaffected.

  These instruments (LT-417D, -427D, -437D, -447D, -5001, -5002) will have their low side (bottom tap) impulse lines blown down when steam pressure is present. This will ensure that the potential for grit or sludge accumulation subsequent to sludge lancing operations is eliminated.

- Auxiliary Feedwater System -

  The Auxiliary Feedwater System low point drains were opened and sampled, and Flow Control Valves FCV-405A through D, and FCV-406A through D were disassembled and inspected for the presence of foreign material (i.e., grit). The drains and valves were found to be free of grit. Some damage to valve internals was observed. The analysis of the damage indicated it was the result of misalignment between the plug and the cage caused by a gasket design problem. The valves were repaired and a new gasket design installed.

- Condensate Storage Tank (CST) -

  The CST was opened and inspected using underwater video inspection techniques. This underwater video inspection was conducted by VIT on February 5, 1997. The visual inspection revealed a thin oxide layer, at or near the center, on the tank bottom. The oxide

layer appeared to be a normal oxide layer and a sample was taken for analysis. The sample composition results for this oxide follow:

Fe	49.9 %	Cu	5.5 %
Cr	1.3 %	Si	3.4 %
Ni	3.1 %		

The inspection and sample results have been reviewed and the results are acceptable. No grit was indicated in the CST.

- Main and Low Flow Feedwater Regulating Valves -

  Analysis of Main Feedwater Regulating valve internals was performed and confirmed via energy dispersive X-ray analysis and visual examination that foreign material (grit) intrusion caused the damage and subsequent failure of the valves to stroke. These findings are documented in Altran Report Number 97110.1, "Feedwater Regulating Valves," and other reports. The Main and Low Flow Feedwater Regulating Valves were rebuilt with replacement trim sets installed. The valves were stroked open and closed through their full range of travel as a post-maintenance functional test (PT-V24).

- Main Boiler Feedwater Pump Discharge Isolation Valves -

  Valves BFD-2-21 and BFD-2-22 were boroscopically inspected, found clean, and stroke time tested using procedure number PT-V24.

- Steam Generator Blowdown Radiation Monitor (R-49) -

  The liner for R-49's shield removal and inspection for foreign material intrusion has been completed. No grit was found.

- Main Feedwater Flow Transmitters -

  These transmitters (FT-418 A/B, -428 A/B, -438 A/B, -448 A/B) will have their high and low side impulse lines blown down under system pressure.

- Turbine First Stage Pressure Transmitters -

  These transmitters (PT-412 A and B) will have their impulse lines blown down during start up when steam is available.

Steam Generators / Main Steam

The secondary side of all four Steam Generators (S/G's) were opened for inspection and cleaning. Sludge lancing and Foreign Object Search And Retrieval (FOSAR) has been completed. Sludge volume was as expected with a small amount of grit indicated in samples of the sludge taken.

Westinghouse was retained to analyze the safety significance of this event for Loss of Coolant Accident (LOCA) and Non-LOCA accident and transient analyses described in the Updated Final Safety Analysis Report (UFSAR). The evaluation concluded that the most limiting single failure assumed in each of the current licensing basis analyses bound an accident which assumes the common mode failure of the four main feedwater regulating valves and the four bypass feedwater regulating valves. A report, entitled "Indian Point Unit 2 Justification of Past Operation For Common Mode Failure of All Feedwater Control Valves," has been prepared, and provides Justification for Past Operation (JPO) for the common mode failure of all feedwater regulating control valves at Indian Point Unit 2.

Failure of Foreign Material Exclusion (FME) barriers during the 1995 RFO resulted in the eventual foreign material intrusion into mainfeed regulator valves, low flow feedwater regulating valves, and a heater drain tank pump and other secondary plant components. The material has been identified, via physical analysis, as Amasteel HG-25 grit (surface preparation blasting abrasive).

Precursors to this event were the June,1995 Heater Drain Tank Pump failure, 1995 main feedwater regulating valve incident, and December 1996 and January 1997 Steam Generator Level excursions. These precursor events were diagnosed as acceptable, based on the information available at the time of their occurrence. Subsequent operations suggested that the conditions causing these events had been rectified.

The remedial actions resulting from the 1995 heater drain tank pump failure have been secondary sampling, main feedwater regulating valve stroke testing, heater drain pump replacement, and continued observation of heater drain tank pumps and feedwater regulating valves. Additional mechanisms of foreign material exclusion practices were implemented subsequent to the 1995 Heater drain tank pump failure. These included the revision of SAO-251, "Conduct of Maintenance," which addresses the FME requirements when work requires grit blasting. The SAO was revised to require a grit blasting permit, FME required training, and a QC closeout of systems and/or components which are grit blasted.

Summary responses to the numbered items set forth in Confirmatory Action Letter 1-97-002 for discussion are as follows:

1) "the scope of your efforts to determine the root causes of the FRV failures, and subsequent observed damage to other balance of plant components;"

As described above, equipment disassembly, inspections, lab analysis, equipment testing and engineering analysis was performed to prove the validity of the root cause of this event. To expedite this root cause analysis a multi-disciplined team was assembled to ensure its

thoroughness and depth.

2) "the basis for your confidence that the identified root causes completely encompass the failure mechanisms and the physical damage observed in the failed components;"

System and component inspections, foreign material removal when encountered, coupled with fluid circulation and blowdown increase our confidence that the root cause for FRV failure has been completely encompassed. Positive identification of the grit as Amasteel HG-25 is indicative of its singular use during the 1995 RFO. This material was used for surface preparation of the high pressure turbine.

3) "the scope of your corrective actions to ensure that you have identified all affected equipment and the safety impact on that equipment; and that you have identified the location of all foreign material, and have appropriately removed it. Should you not have confidence that all material has been removed, provide your basis for restart of the plant in recognition of this condition;"

Our corrective actions included aggressive removal of foreign material from various balance of plant systems, performance of operability determinations for the potentially impacted systems and /or components, and equipment testing. Subsequent fluid circulation and blowdown, when system pressures are available, will be performed to further enhance the effectiveness of the foreign material removal efforts.

4) "the safety significance of this event"

Westinghouse was retained to evaluate this event and has provided Indian Point Unit 2 with a Justification for Past Operation (JPO) which documents that common mode failure of the four main and four low flow feedwater regulating valves is bounded by the results of the current licensing basis UFSAR analyses.

5) "the root causes of your failure to more broadly evaluate the extent of condition of the foreign material intrusion during your evaluation and corrective action pursuant to the June 1995 heater drain pump failure. In this discussion, also include information about other indicators that may have previously existed that were additional precursors to this event."

It is important to briefly review the actions taken and processes in place during the time #21 heater drain tank pump failed.

The 1995 failure of #21 heater drain tank pump resulted in a Priority 2 Significant Occurrence Report. Upon disassembly of the pump, a grit-like substance was noted in the bottom of the pump barrel and within the lower stages of the pump. This was entered into our corrective action system via an Open Item Report. The material was collected and sent to the Company's lab at Astoria and also to an independent lab. The results indicated that the material was Amasteel HG-25 grit. This material was used during surface preparation of the H.P. turbine shell during the 1995 RFO.

The determination was that the grit had flowed from the H.P. turbine through the heater drain pump to the steam generators. Inspection of the heater drain tank following the pump failure

indicated minor levels of grit material. The impact of the grit material on the steam generators was evaluated and found acceptable by the OEM (Westinghouse). There were some discussions with the main and low flow feed regulator valve OEMs concerning dimensional clearances within the valves. The clearances were determined to be adequate to allow grit to pass through the valves. This assessment concerning valve clearances was not documented. There were no discussions on grit material specific properties. The valves were stroke tested satisfactorily to demonstrate operability. A program was established to continually monitor and filter the presence of grit within the following systems:

- Condensate
- Heater Drain
- Main feed pump
- Steam Generator blowdown flow stream

Samples were recovered weekly immediately following the unit startup. The filters did not indicate the presence of grit at any time.

The evaluation in 1995 was deficient for the following reasons:

- The OIR process for documenting operability was not standardized. The acceptance of the operability justification was made by a single organization.
- The priority of this event and the resources applied to determine the root cause and corrective actions was less than adequate.
- The root cause methodology utilized during the investigation in 1995 was not rigorous.
- There was a less than adequate review of the results of this investigation.

Contributing factors were:

- The hideout potential within the system piping configuration system of the heater drain tank was not fully understood.
- The physical properties of the grit and its potential impact to specific plant components was not fully understood.

The preliminary results of a third-party review conducted in 1997 of the 1995 event indicate similar conclusions to those listed above.

Enclosure 2 - NRC REVIEW OF THE CON EDISON RESPONSE TO THE ISSUES DETAILED IN CAL 1-97-002

On January 31, 1997, the NRC issued Confirmatory Action Letter 1-97-002 to document Con Edison's commitment to meet with the NRC Region I staff prior to the restart of Indian Point 2 from the shutdown which began on January 26, 1997. The plant was shutdown when three of the four main feedwater regulating valves would not close upon demand. Subsequent investigation of the internals of these valves found extensive scoring of the valve plugs and cages as well as a buildup of a predominately iron-based foreign material that prevented closure of these valves. Con Edison's subsequent investigation of this matter indicated that this foreign material, an abrasive grit used to prepare the inner surface of the high pressure turbine during the early 1995 outage, was the cause of the failure of the valves to close upon demand. Furthermore, this abrasive material was found in other areas of the feedwater system and also caused the failure of a heater drain tank (HDT) pump in June 1995 as well as damage to another heater drain pump in late January.

CAL 1-97-002 detailed five specific issues that Con Edison was requested to respond to at the meeting. These issues, Con Edison's response and the NRC review and conclusions are detailed below:

1. **"The scope of your efforts to determine the root causes of the FRV failures and subsequent observed damage to other balance of plant components."**

   Con Edison disassembled the main feedwater regulating valves and bypass valves and performed a series of laboratory and engineering analyses and equipment testing to prove the validity of the root cause of this event. Other equipment that was adversely affected, or could have been adversely effected, was also inspected and/or disassembled. To expedite their root cause analysis, Con Edison assembled a multi-disciplined team to perform an extensive root cause analysis of this event and coordinate the inspection of potentially affected systems. The team was subdivided into three investigation teams: 1) a system/flow team, 2) an analysis team, and 3) a design/historical review team.

   NRC resident inspectors and a materials specialist inspector reviewed the scope of Con Edison's efforts to determine the root causes of the FRV failures and found them to be thorough and comprehensive. Over 200 locations in the balance of plant as well as the steam generators and the steam generator blowdown lines were opened and inspected via boroscope, robot or direct visual examination. The information presented at the February 19th meeting with the NRC reflected the broad scope and thoroughness of Con Edison's efforts to determine the root causes of the FRV failures.

2. **"The basis for your confidence that the identified root causes completely encompass the failure mechanisms and the physical damage observed in the failed components."**

   Con Edison performed over 200 system and component inspections, removing foreign material when encountered and evaluating the possible flow path of the

material based on the geometry of the piping configuration and the locations in which foreign material was found. Con Edison positively identified that the foreign material was an Amasteel HG-25 blasting grit which was singularly used for surface preparation on the high pressure turbine casing during the 1995 refueling outage. Examination of the inner surfaces of the FRV cages and plugs confirmed that they were damaged by the buildup and scoring of the surfaces by the Amasteel grit, which was significantly harder than the valve material.

The NRC's review of Con Edison's actions in this matter, including examination of laboratory analysis reports, indicated that Con Edison developed a credible and supportable explanation for the failure of the FRVs which encompasses the failure mechanisms and physical damage observed. The damage observed in the HDT pumps was also caused by the grit which damaged the FRVs and also supports Con Ed's conclusions in this matter.

3. **"The scope of your corrective actions to ensure that you have identified all affected equipment and the safety impact on that equipment; and that you have identified the location of all foreign material and have appropriately removed it. Should you not have confidence that all material has been removed, provide your basis for restart in recognition of this condition."**

Con Edison's corrective actions included numerous inspections of the secondary plant and the steam generators to remove foreign material, performance of operability determinations for potentially impacted systems and/or components and equipment testing. Based on the location of the foreign material identified, the quantities collected and the large number of sample points, Con Edison is confident that virtually all of the material was removed. Measures are also being put in-place to monitor the secondary plant via slip stream flow and augmented FRV and steam generator blowdown valve testing to ensure that trace quantities of any foreign material in the system do not impact on plant equipment operability. In addition, when system pressures are available after plant startup, component blowdowns will be performed to further enhance the effectiveness of the foreign material removal efforts.

The NRC inspected Con Edison's efforts to search the plant for the location of foreign material and considers their investigation to be thorough. The magnitude of system and component inspections, coupled with the amount and quantity of material found, indicate that Con Edison's identification efforts were comprehensive. While the NRC acknowledges that there was no definitive way for Con Edison to quantify the amount of grit that entered the secondary plant such that they could evaluate whether they retrieved all of the material, their system inspections bounded the possible pathways of the grit and give confidence that no significant quantities of grit remain. The multiple operability determinations performed provide a measure of confidence that the plant is safe to restart; NRC review of Con Edison's operability determinations is currently ongoing.

4. **"The safety significance of this event."**

Con Edison retained Westinghouse to evaluate this event and provided a Justification for Past Operation (JPO) which documented that the common mode failure of the four main and four low flow FRVs is bounded by the results of the current licensing basis UFSAR analyses. The critical analysis is the main steam line break with continued feedwater addition and with offsite power available.

The NRC reviewed the JPO and noted that Con Edison found the safety impact of having all four main and low flow FRVs stuck open to be essentially the same as the failure of just the FRVs on a faulted steam generator due to the dynamics and flow resistance characteristics of the feedwater system and S/Gs. Also, since no other safety-related equipment was found to be adversely affected by this grit intrusion event, the safety significance of this event was small.

5. **"The root causes of your failure to more broadly evaluate the extent of condition of the foreign material intrusion during your evaluation and corrective action pursuant to the June 1995 heater drain pump failure. In this discussion, also include information about other indicators that may have previously existed that were additional precursors to this event."**

Con Edison detailed in their 2/18/97 submittal the events and follow-on corrective actions after the June 1995 heater drain pump failure. They determined that their evaluation of the June 1995 event was deficient for the following reasons: 1) The OIR process for documenting operability was not standardized, 2) the priority of the event and the resources applied to determine the root cause and corrective actions was less than adequate, 3) the root cause methodology utilized during the investigation in 1995 was not rigorous and 4) there was a less than adequate review of the results of this investigation. There were no other precursors to this event between June 1995 and the week before the 1/25 FRV failures when Con Edison's investigation of FRV control problems was begun.

NRC inspection of Con Edison's current root cause investigation of this event indicated that it was thorough and comprehensive. However, the NRC agrees that significant deficiencies existed with the extent of condition review following the June 1995 failure of a heater drain pump due to Amasteel HG-25 grit intrusion.

Based on the information provided by Con Edison and the NRC's independent review of this matter, the NRC concluded that Con Edison satisfied the terms of CAL 1-97-002 and had no concerns with the restart of Indian Point 2. This decision is based upon Con Edison completing the remaining actions for startup (e.g. equipment blowdowns at operating pressure) that were detailed in the February 19th meeting. This NRC decision was verbally communicated between Mr. Cowgill of the NRC and Mr. Quinn of Con Edison on the afternoon of February 19th. We note that Con Edison has longer term corrective actions in progress as well (e.g. implementation of a single corrective action system) which will not be completed prior to restart. The NRC staff will monitor progress in implementing these corrective actions.

ENCLOSURE 3

Management Meeting

Indian Point 2

February 19, 1997

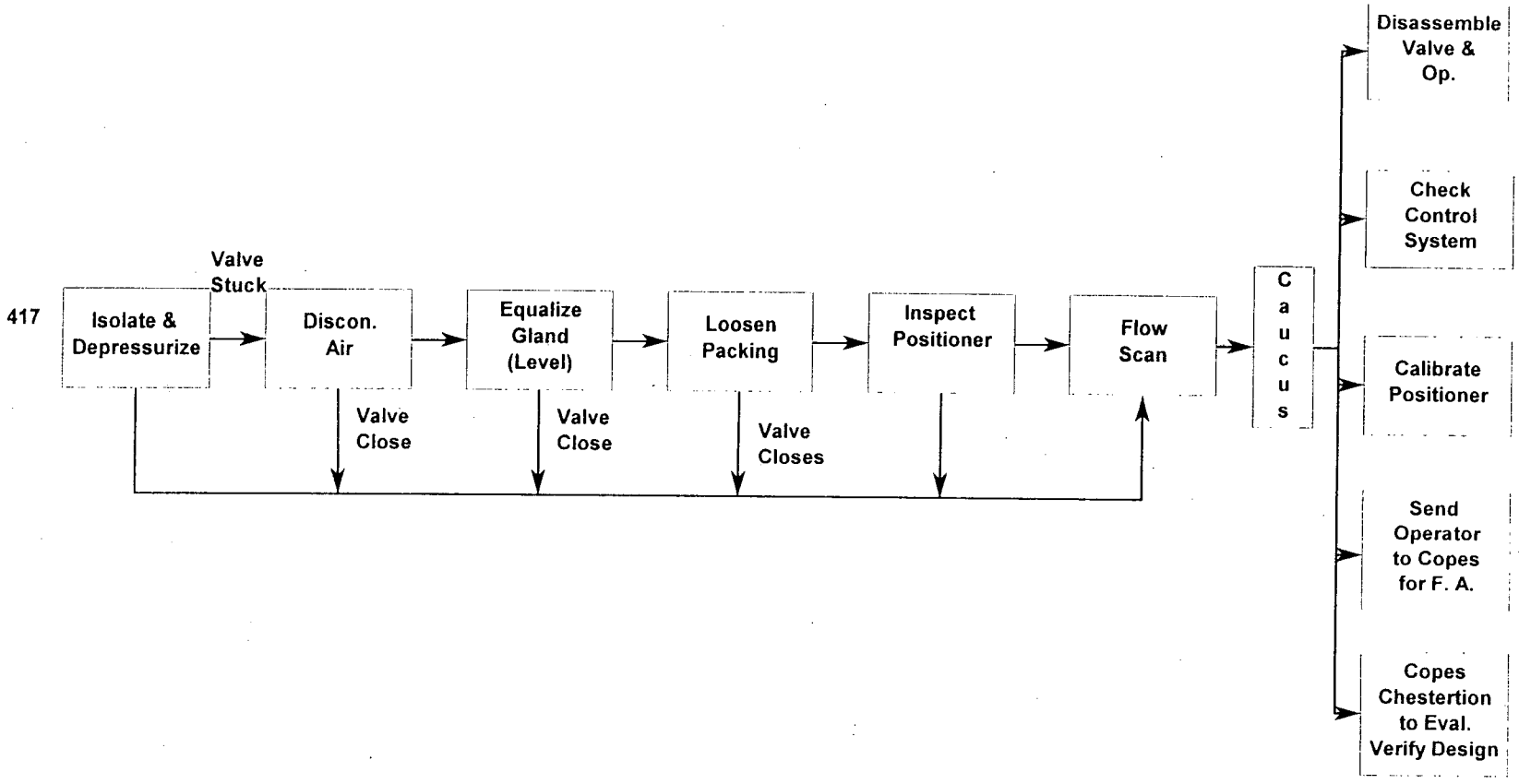
Agenda

- Introduction
- Description of Event
- Root Cause Investigation
  - Team Makeup/Charter
  - Potential Failure Modes
  - Failure Mechanism
  - Inspection Results
  - Transport of Material
- Prior Events/Precursors
- Safety Analysis
- Corrective Actions
  - Plant Inspection and Restoration
  - Work Practices
  - Corrective Action Process
- Conclusions for Unit Restart

Main Feed Regulating Valve Failures

- FCV-417 Appeared Stuck on 1/25/97
- Related Problems Noted Earlier in the Week
  - Initially Thought to be a Control Problem
- Earlier Indications of Problem Identified
  - Valve Stems Lubricated
  - Plans to Add Additional Diagnostic Instruments
- Problem of 1/25/97 Indicated Problem was with the Valve
  - Conferred with Management and Shutdown to 30% Begun
  - As Power and Flow Reduced, Two Additional Valves Bound
  - Shutdown Controlled Until Approximately 15% Power
  - Opening of Recirculation Valve Affected Level Control
  - In Accordance with Plan, Turbine Tripped
  - Rx Subsequently Tripped Automatically
- Equipment "Quarantined" for Detailed Evaluation

Initial Decision Process
Re: FCVs 1/26/97



Root Cause Analysis

- Team Makeup/Charter
  - Makeup
    - Chemistry, Operations, Metallurgist, Failure Analysts, System Engineering, Independent Safety Engineer, Mechanical/Design Engineer, Maintenance Engineer
  - Charter
    - Root Cause
      - Thorough and Systematic Determination of Root Cause
      - Determine Corrective Activities Necessary to Return to Operability
      - Provide Corrective Actions Recommendations to Prevent Recurrence

Root Cause Approach

- Identified Potential Failure Modes
  - Foreign Material (i.e. steel grit, flame spray)
  - Maintenance Activities (i.e. packing, misalignment)
  - Chemistry Changes (i.e. Ethanolamine-ETA)
  - Design Issues (i.e. spring rate, stem bushing)
  - Manufacturer Defect (i.e. material hardness, dimensional irregularities)
  - Support Systems (i.e. instruments, controls, pneumatics)
  - Environmental Effects (i.e. ambient temperature)
  - System Dynamics (i.e. flow, pressure, temperature, vibration, transients)

Investigation Teams

- System/Flow Team
- Analysis Team
- Design/Historical Review Team

System/Flow Team

- Identify Systems Sample Locations
- Analyze System Flowpaths
- Identify Sample Methodology. (i.e. components versus low point drains)
- Component Inspection Requirements

Analysis Team

- Analyze, Characterize and Record Sample Results
- Photograph Samples
- Initiate/Coordinate Independent Labs Analysis
- Hardness Readings, Dimensional Checks, Match Marking
- Characterize "As Found" Visual Inspections (i.e. wear patterns, broken piece parts)
- Chemically Test Spring Seal Elastomer

Design/Historical Review Team

- Review OEM Design Data
- Review Valve Maintenance History
- Review and Analyze Component and System Precursors
- Review Industry Data
- Review "As Found" Flow Scan Traces
- Consult with Others for Lessons Learned and Corrective Actions
- Evaluate/Consider FAC Impact

Failure Mechanism

Plan

- Identify All Susceptible Systems and Components
- Identify Locations for Inspections and/or Tests of Susceptible Systems and Components
- Establish Criteria for Sample Population
- Perform Inspections and/or Tests. Flow Path Description
- Assess the Inspection and/or Test Results

Susceptible Systems

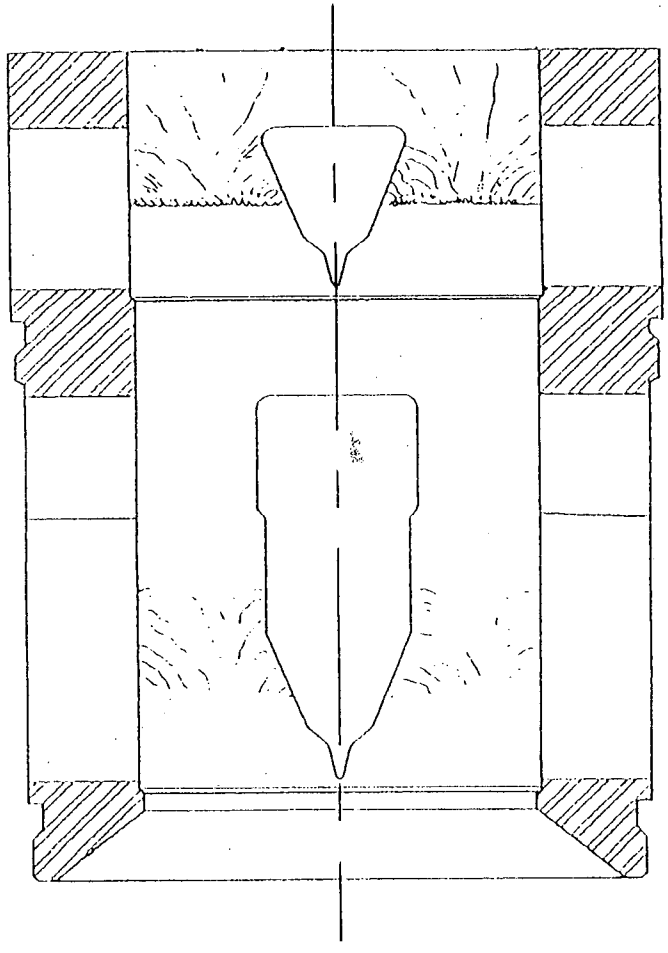
- Main Feedwater
- Heater Drains
- Extraction Steam
- Steam Generators and Blowdown System
- Main Condensers and Condensate
- Moisture Preseparators
- Condensate Storage Tank
- Auxiliary Feedwater System
- Main steam
- Turbine

Feedwater Regulating Valves Damage Assessment

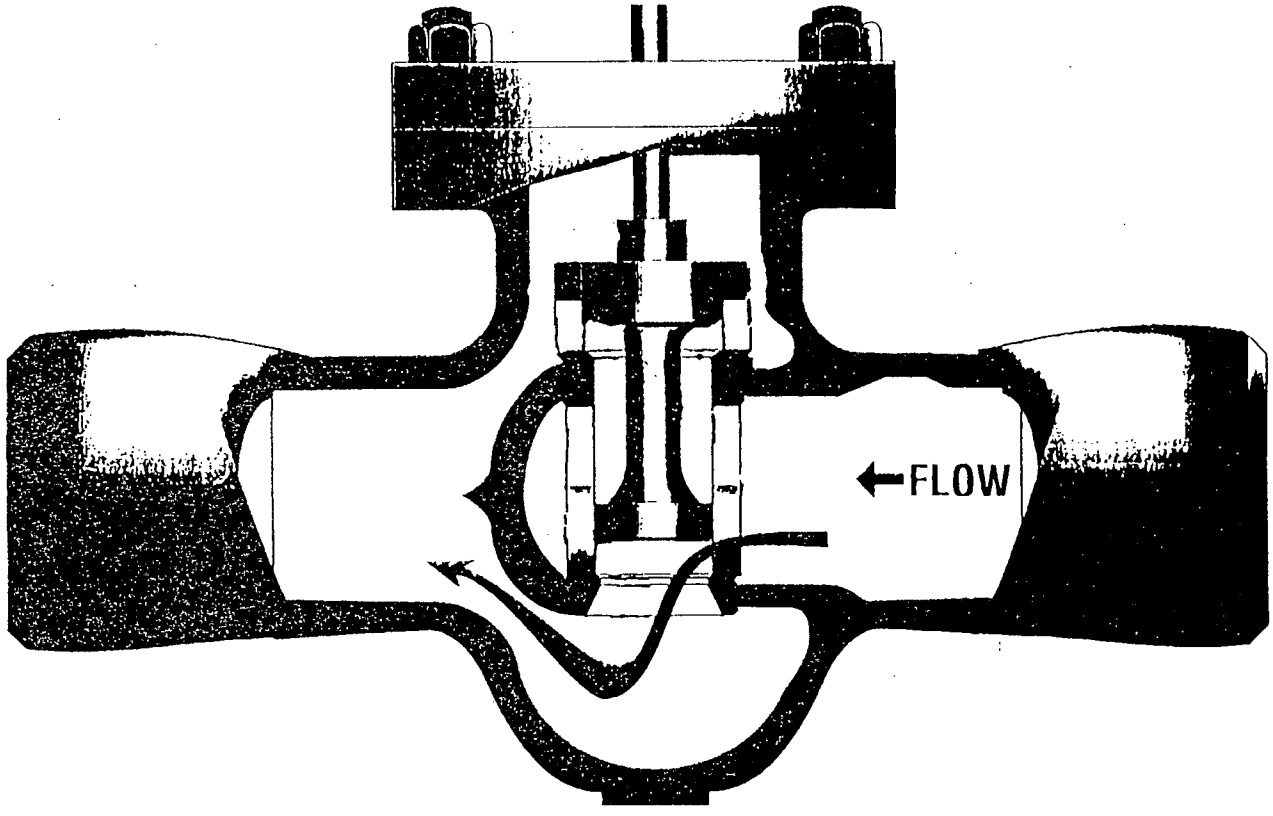
- Main Feedwater Regulating Valves
  FCV 417, 427, 437 and 447

- Low Flow Feedwater Regulating Valves
  FCV 417L, 427L, 437L and 447L

Main Feedwater Reg. Valve



Main Feedwater Reg. Valve



Main Feedwater Reg. Valves

Material - 420 SS/Rc 46

- Upper Plug Region
  - Vertical Score Marks
  - Embedded Particles
- Lower Plug Region
  - Vertical Score Marks
  - Flow Grooves Adjacent to Ports
  - Embedded Particles

Main Feedwater Reg. Valves

Material - 410 SS/Rc 36

- Upper Cage Region
  - Vertical Score Marks/Embedded Particles
  - Vertical Grooving
  - Circumferential Groove at Opened Position
- Lower Cage Region
  - Same Features as Upper Region
  - Flow Grooving Adjacent to Port
  - Embedded Particles in Seat Area

Low Flow Feedwater Reg. Valves

- Scored Cages and Plugs
- FCV 437L
  - Plug Stuck in Cage
  - Seal Damage - Grit Suspected
  - Flow Grooving
- Grit Damage Suspected, Parallel Flow Path to Main Feedwater Reg. Valves

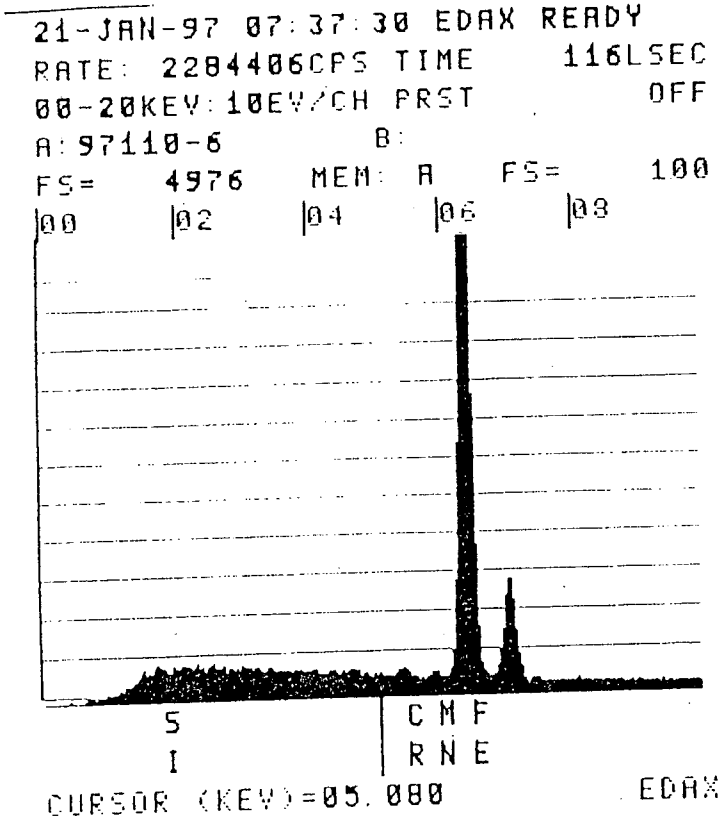
Sampling for Damage Agents

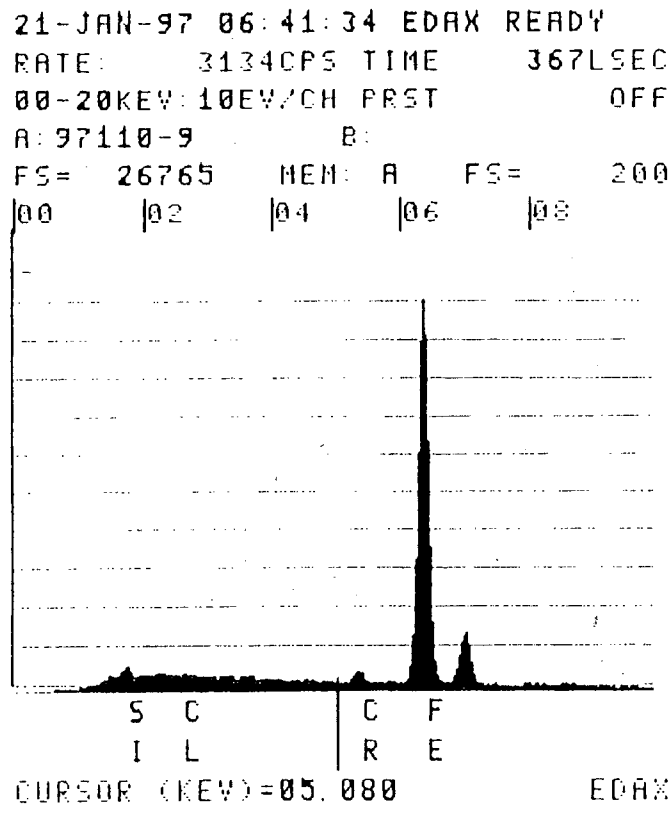
- Main Feedwater Regulating Valve Drains
- Main Feedwater Regulating Valves
- Heater Drain Tank

Materials Investigation

- Optical Examination
- Chemical Analysis
- Metallurgical/Materials Evaluations
- SEM/EDX Analysis
  - Embedded Particles
  - Reference Materials

EDX-HDT Mtrl/MFRV Particle





Abrasive Material Characterization

"Broken Metal Balls"

- Size — Approx. 20-30 Mils
- Hardness — Mohs 7 (quartz - like)
  Knoop 820/Rc 64

Amasteel Grit

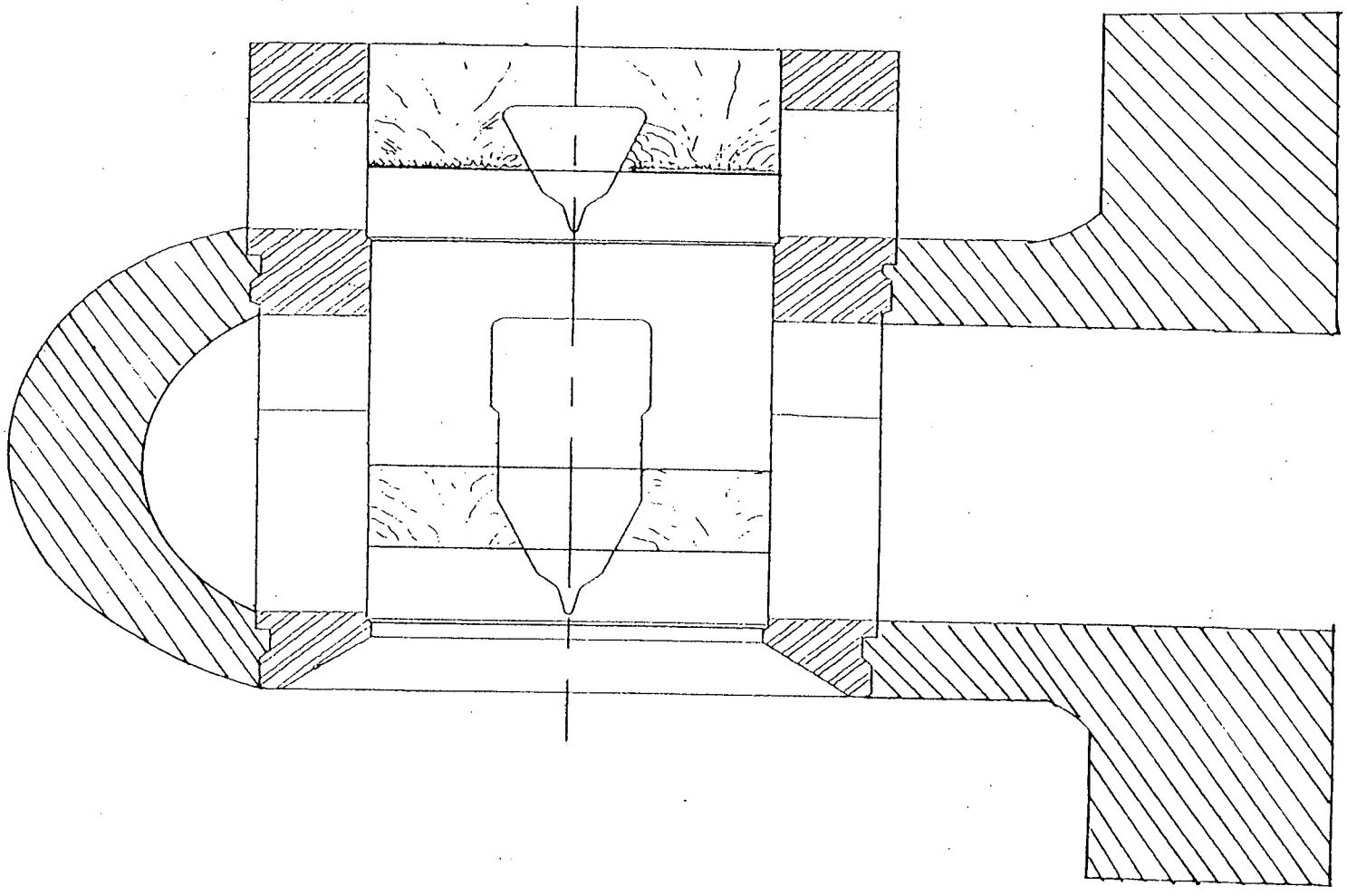
- HG 25 Grit
- Hardness — Rc 60-67 (Avg. Rc 64.8)

Chemical Analyses

Composition in Weight Percent

Element	Amasteel - Nominal	Amasteel - 1997	HDT - 1997	HDT - 1995
Iron	Balance	96.62	96.7	96.9
Carbon	0.85 - 1.2	0.83	0.91	0.97
Silicon	0.40 - 1.5	1.163	0.97	0.94
Manganese	0.50 - 1.2	1.09	1.06	0.92
Copper	--	0.19	0.17	0.81
Aluminum	--	0.05	0.07	0.12
Sulphur	--	Not Analyzed	0.0048	0.0068
Zinc	--	0.031	0.036	< 0.016
Calcium	--	-	0.006	< 0.016
Lead	--	0.017	0.023	< 0.016

Main Feedwater Reg. Valve



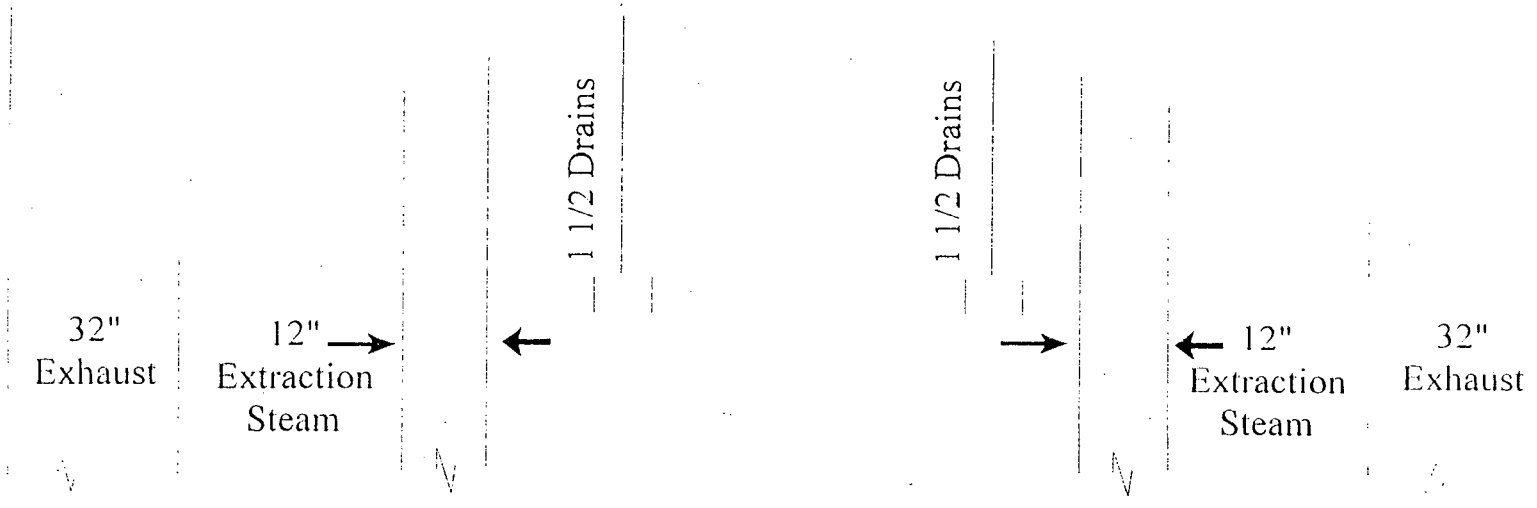
Conclusions

- Material in HDT and Embedded Particles MFRVs are the Same
- Above Materials are Amasteel Grit
- Amasteel is Harder Than Valve Materials
  - Plug Rc46
  - Cage Rc36
  - Amasteel Rc 65
- Damage to MFRV Caused by Amasteel Grit

Root Cause

- Why Focused on H.P. Turbine
  - Limited Use of Amasteel Grit on Site.
  - One Logical Contamination Path Including a "Hideout" Path
  - Time Line of Events Supported by Inspection Findings

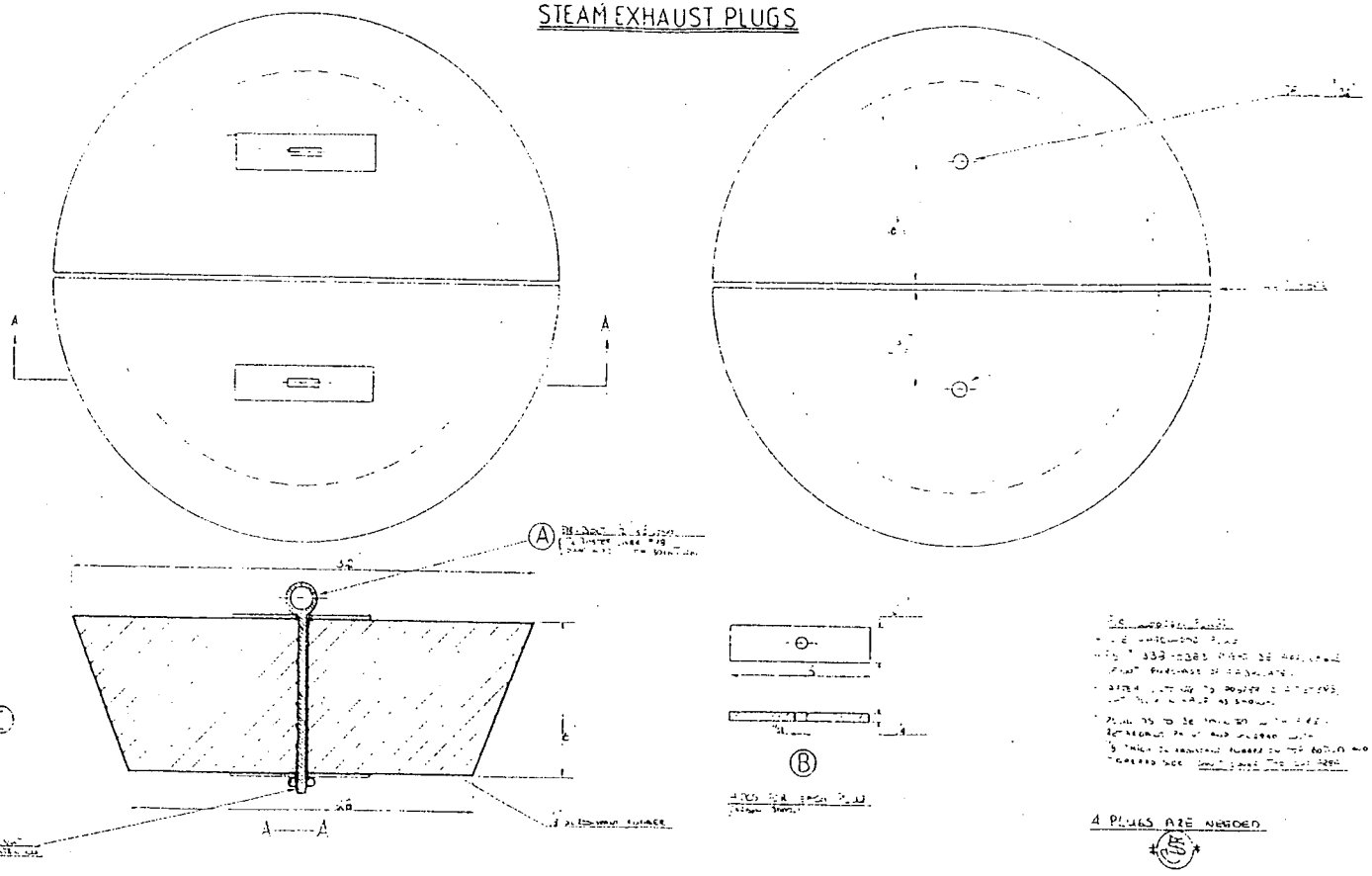
H. P. TURBINE


32"
Exhaust
12"
Extraction
Steam
1 1/2 Drains
1 1/2 Drains
12"
Extraction
Steam
32"
Exhaust

FME Controls

- Best is Prevention with Defense in Depth Followed by Verification FOSAR
- F.M.E. was Singular Barrier in Each Location (Exhaust, Extraction and Drain Lines)
- No Secondary Boundary
- Design of Plugs, was Truncated Cones in Hyperboloid Holes
  - Exhaust Plugs Split Down Center w/o Rubber Seal in Center
  - No Rubber Skirt on Upper Portions
  - No Assurance to Block Moisture Pre-separator Annulus
  - Duct Tape Seal Down Centerline and on Perimeter Known to Come Loose

INDIAN POINT HP TURBINE
STEAM EXHAUST PLUGS



4 PLUGS ARE NEEDED

FME Controls

- Some Plugs Believed to be Removed During Machining
- All Portals Showed Grit, and Machine Turnings Upon Cleaning Video Inspection

Precursor Events

- Regulating Valve Failures - 6/12/95
  - Failed to Close Following Rx Trip
  - Packing Found Overtightened
  - Valve Operated as Expected Afterwards
- 21 Heater Drain Pump - 6/16/95
  - Found "Bound" on Plant Restart
  - Immediate Actions Taken Included:
    - Removal/Replacement of 21 HDP
    - Identification of Grit Material (Amasteel Grit)
    - Opening/Cleaning of HDT
    - Stroke Testing of Main Feed Regulating Valves
    - Observations of Downstream Equipment Operation
    - Evaluation of Impact on Steam Generator
  - Continuing Actions Included:
    - On-Going Sampling in Secondary Systems
    - Temporary Sampling in SGBD
    - Continuing Observations on HDP's, Feed Reg. Valves
    - Endorsing of FME Improvements

Safety Analysis Review and Evaluation

- Review Process
  - In-House Review
  - Independent Consultant
  - Westinghouse
  - Obtain and Review Westinghouse "Calc Notes"

Safety Analysis Review and Evaluation

- Assume Coincident Failure of 4 Main Feedwater Valves and 4 Low Flow Feedwater Valves
- Review of All FSAR LOCA and Non-LOCA Transient and Accident Analysis
  - Steam Line Break With Continued Feedwater Addition Bulletin 80-04
- Westinghouse Evaluation Concluded That Postulated Event Bounded by Prior Analysis

Corrective Actions

- Plant Inspection and Restoration
  - Boroscope Piping Inspections of Affected Systems (> 200 System Inspections Performed)
  - Robotic Inspections
  - Cleaning of Affected Tanks/Heat Exchangers. (i.e. steam generators, main condensers, heater drain tank, separator tanks, cross under piping, moisture separator reheaters, moisture preseparators)
  - Inspections/Repairs of Affected Components (i.e. control valves, CIV's, pumps)
  - QC Closeout of Affected Systems (new practice)
  - Recirculation/Instrument Blowdown Procedures Developed
  - "Flow Scan" Signatures
  - On-Line Monitoring Strainer/Filter
  - Documented Operability of All Safety Related Systems and Components

Operability Determination

- Potentially Degraded SSC
- Safety Function of SSC
- Postulated Failure Mechanism
- Applicable Tech. Specs., FSAR
- Time Constraints
- Source of Potential Problem
- Operability Determination
- Corrective Actions to Restore Design Basis

Typical Operability Basis

- Steam Gen. Blowdown CIV's
  - "As Found" Leakage Testing (PT-R26A)
  - Disassembled/Inspected
  - QC Visual Inspection
  - "As Left" Leakage Testing (PT-Q13)
  - Sludge Lancing and FOSAR of Steam Generators
  - Secondary Side System Cleanliness

Operability Determinations

- SGBD Containment Isolation Valves
- SG Wide Range Level Transmitters
- Auxiliary Feedwater System
- Condensate Storage Tank
- Main and Bypass Feedwater Reg. Valves
- MBFP Discharge Valves
- SGBD Rad Monitor
- Main Feedwater Flow Transmitters
- Turbine First Stage Pressure Transmitters
- Steam Generators
- Main Steam System

FME Program

- Prevention
- Detection
- Correction

Prevention

- Department Continuing Training
- Project Manager Training
- Review of FME Hardware
- Procedures

Detection

- Verification
- Formality
- Detectability

Correction

- Sensitivity
- Open Item Report
- Follow-Up/Tracking

Root Cause

Investigation

There was a less than adequate root cause analysis of this event.

- Did Not Recognize Hide Out Potential for Grit Material
- The Impact of the Grit Material and its Physical Properties on the MFRV was Not Adequately Evaluated for Component Impact
- The Quality of the FME Controls was Inappropriately Viewed as Sufficient to Prevent Failure
- There May Have Been a Willingness to Accept a Favorable Answer Without Appropriate Questioning Attitude

Root Cause

Process Performance

- Operability Review Process existing at the Time of the Event was Not Standardized and Lacked Sufficient Rigor. It Also Relied on Single Review and Approval for Closeout.
- The Priority and Level of Review Determination for this Event was Less Than Adequate.
- The Root Cause Methodology was Not Rigorous.
- There was No Collegial Review of these Events When Completed.

Corrective Actions

- Operability Determination Procedure SE-SQ-12.317 Has Been Implemented
  - Requires Formal Documentation and Reviews and Approvals Similar to NRC Guidance on Operability
  - Station Safety Committee Reviews
- Station Administrative Order (SAO-132) Has Been Revised to Require Peer Reviews and Senior Management Reviews for Priority 1 Events
- "Group Think" Training has been Conducted for Safety Committee Members, Daily management Members and Engineering Support Personnel

Corrective Actions

- A Single Corrective Action System Has Been Selected (CITRS) Implementation is in Progress
- For High Priority Events Multi-Discipline Teams Will Be Utilized
- A Standard Method for Conducting Root Cause Has Been Adopted. Implementation is in Progress
  - Pre-Approved Investigation Plan
  - Investigation Techniques to be Utilized Selected
- Retraining on the Root Cause Process is in Progress. (Including Plant Management)
- A Mechanism for Raising a Priority on an Event After Initial Screening Has Been Developed and Is Being Implemented
- A Third Party Review of These Events and the Indian Point Corrective Action Program is Being Conducted

Basis For Confidence That Plant Is Ready To Be Safely Returned to Service

- Root Cause Identified
- Verification of Grit Removal
- Potentially Affected Safety Related Equipment Analyzed and Determined to Be Operable
- Startup Monitoring Program
  - Temporary Operating Instructions
  - Temporary Modifications
  - Increased Periodic Testing
- Station Nuclear Safety Committee Reviews Completed