December 9, 1997

LICENSEE: COMMONWEALTH EDISON COMPANY

FACILITIES: QUAD CITIES NUCLEAR POWER STATION, UNITS 1 AND 2
DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3

SUBJECT: SUMMARY OF MEETING CONCERNING THE QUAD CITIES AND DRESDEN ECCS SUCTION STRAINERS (NRC BULLETIN 96-03)

On November 13, 1997, the NRC staff met with Commonwealth Edison Company (ComEd) to discuss the hydrodynamic load methodology of the Emergency Core Cooling System (ECCS) suction strainer replacement project for Dresden and Quad Cities. This ComEd project is in response to NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors." All Boiling Water Reactor (BWR) licensees were requested to implement appropriate measures to ensure the capability of the ECCS to perform its safety function following a loss of coolant accident (LOCA). A list of attendees is provided as Attachment 1.

The objective of the meeting was for ComEd to discuss their hydrodynamic load methodology for the design of the ECCS strainers. Quad Cities, Unit 2, and Dresden, Unit 3, have had new ECCS strainers installed; however, they had requested and received, a deferral in showing compliance to Bulletin 96-03 until December 1998 so that the staff and the industry can finalize the BWR Owners Group Utility Resolution Guidance (URG) report; upon which the design of the strainers is based. A copy of the licensee's presentation is included as Attachment 2.

The licensee discussed their philosophy of continuing the maintenance of the Mark I Containment Program and to make the design of the strainers consistent with the licensing basis and this program. Testing has been performed with the conclusions that ComEd would use 1.2 as the velocity drag coefficient and 1.5 as the hydrodynamic mass coefficient in the design of the strainers.

Based on the meeting, the licensee will address (by letter within 30 days) future potential testing of strainers of the same size and configuration as those used at Quad Cities and Dresden and the "certainty" of the 1.5 used as the hydrodynamic mass coefficient.

Orig. signed by
Robert M. Pulsifer, Project Manager
Project Directorate III-2
Division of Reactor Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-254, 50-265,
50-237, 50-249

Attachments: 1. List of Attendees
2. Licensee's Presentation

cc w/atts: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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Robert M. Pulsifer, Project Manager
Project Directorate III-2
Division of Reactor Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-254, 50-265,
50-237, 50-249

Attachments: 1. List of Attendees
2. Licensee's Presentation

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NOVEMBER 13, 1997, MEETING BETWEEN
COMMONWEALTH EDISON COMPANY AND NRC
QUAD CITIES/DRESDEN ECCS SUCTION STRAINERS

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John Stang	NRC/DRPW	301/415-1345
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Greg Ashley	Duke Engineering	630/778-4218
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Linda Weir	ComEd/Dresden	815/942-2920 x3379
Tim Loch	ComEd/Dresden	815/942-2920 x3246
Ton D'Angelo	NRC/DSSA	301/415-2857
Jack Kudrick	NRC/DSSA	301/415-2871

ATTACHMENT 1

ComEd

Quad Cities and Dresden Stations ECCS Suction Strainer Replacement Project

Presentation
to the
Nuclear Regulatory Commission
November 13, 1997

ATTACHMENT 2

QUAD CITIES and DRESDEN STATIONS

ECCS STRAINER REPLACEMENT PROJECT

Agenda

- Objective
- Hydrodynamic Loads Development Overview
- Hydrodynamic Inertial Mass Testing
- Structural Modifications Overview

Objective

To Clearly Communicate the Mark I Hydrodynamic Load Methodology for the ECCS Suction Strainer Replacement.

RODYNAMIC LOADS DEVELOPMENT OVERVIEW

General Philosophy

- Maintain the Mark I design consistent with licensing basis as established during the Mark I Containment Program

- ComEd has completed significant Mark I evaluations/modifications since completion of the original Mark I Program

DRESDEN AND QUAD CITIES MAJOR MARK I ANALYSIS SINCE COMPLETION OF THE MARK I CONTAINMENT PROGRAM

1983	Dresden/Quad Cities: DW/WW and SRVDL Vacuum Breakers.
1987	Dresden/Quad Cities: As-built Configuration Verification Program. Systematic as-built verification of torus attached piping. Complete reanalysis of several piping systems.
1988	Dresden/Quad Cities: Small Bore Program. Systematic verification and reevaluation of small bore piping supports.
1990	Quad Cities: ACAD/CAM Requalification/Redesign Project.

DRESDEN AND QUAD CITIES MAJOR MARK I ANALYSIS SINCE COMPLETION OF THE MARK I CONTAINMENT PROGRAM

1990	Quad Cities: Torus Water Level Project. Normal high water level lowered by 6 inches. Partial torus reevaluation for dynamic loads.
1991	Quad Cities: HPCI Turbine Exhaust Sparger Replacement. Replacement of torus sparger and addition of internal/external 4 inch bypass line. Added new penetration.
1991	Dresden/Quad Cities: GL 89-10 MOV Program. Change outs of valves and motor/air operators. Complete reanalysis of LPCI/RHR and Vacuum Relief Systems.

DRESDEN AND QUAD CITIES MAJOR MARK I ANALYSIS SINCE COMPLETION OF THE MARK I CONTAINMENT PROGRAM

1995	Dresden/Quad Cities: Torus Temperature increase during Post LOCA.
1997	Dresden/Quad Cities: ECCS Suction Strainer Modification.

Philosophy for ECCS Strainer Modification

- Maintain Consistency With Licensing Basis
  - Use same loads generation methodology
    - Use same software tools.
    - Design input parameters same except for strainer geometry and hydrodynamic mass and acceleration drag coefficient.
    - Develop hydrodynamic mass coefficients by test that more appropriately represent the strainer hardware.
    - Reference documents: NUREG-0661, LDR, PUAAG, "Application Guides", PUAR.
    - Rigorous development of all hydrodynamic loads for strainer hardware and associated piping/components versus factorization of existing loads.

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

Mark I Containment and Hydrodynamic Loads Considered

DESCRIPTION	REFERENCE
• LOCA Bubble Drag	APP GUIDE 1, LOCAFOR
• LOCA Jet (Bounded by LOCA Bubble Drag)	
• Chugging/CO Drag	APP GUIDE 2, CONDFOR
• SRV Bubble Drag	APP GUIDE 5, TQFOREX
• SRV Jet (Bounded by SRV Bubble Drag)	APP GUIDE 6, MANUAL
• Pool Fallback (Not Applicable)	APP GUIDE 1 & 10, MANUAL
• Fluid Structure Interaction (FSI)	APP GUIDE 2, MANUAL
• Torus Shell Inertial Loads	LDR, PUAR

> Strainer inertial & submerged structure loads have considered the perforated nature of the strainer, as supported by testing (DE&S Report Nos. TR-ECCS-GEN-01 and TR-ECCS-GEN-05).

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

- LOCAFOR

Developed under BWROG Mark I Containment Program to calculate *LOCA BUBBLE DRAG LOADS* on submerged structures due to DBA LOCA air discharge.

- STRAINER
  - *LOCAFOR* input parameters consistent with existing licensing basis:
    - Geometry of target structure revised to reflect strainer geometry and location.
    - Acceleration drag volumes for strainers reduced by 25% compared to equivalent solid cylinders.
- STRAINER ATTACHMENT (Penetration Nozzle & Flanges)
  - *LOCAFOR* input parameters consistent with existing licensing basis.

RODYNAMIC LOADS DEVELOPMENT OVERVIEW

- CONDFOR

Developed under BWROG Mark I Containment Program to calculate drag forces caused by *CONDENSATION OSCILLATION* and *CHUGGING* on submerged structures.

- STRAINER
  - *CONDFOR* input parameters consistent with existing licensing basis:
    - Geometry of target structure revised to reflect strainer geometry and location.
    - Acceleration drag volumes for strainers reduced by 25% compared to equivalent solid cylinders.
- STRAINER ATTACHMENT (Penetration Nozzle & Flanges)
  - *CONDFOR* input parameters consistent with existing licensing basis.

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

- TQFOREX

Developed under BWROG Mark I Containment Program to calculate drag forces caused by T-Quencher *SRV BUBBLES* on submerged structures.

- STRAINER AND ATTACHED STRUCTURES
  - *TQFOREX* input parameters consistent with existing licensing basis:
    - Geometry of target structure revised to reflect strainer geometry and location.
    - Acceleration drag volumes for strainers reduced by 25% compared to equivalent solid cylinders.
- STRAINER ATTACHMENT (Penetration Nozzle & Flanges)
  - *TQFOREX* input parameters consistent with existing licensing basis.

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

- POOL FALLBACK

Manual calculation developed under BWROG Mark I Containment Program to calculate the drag forces caused by pool fallback striking exposed portions of the strainer above the downcomer exit or engulfed by LOCA Bubble.

- STRAINER
  - *Pool FALLBACK* input parameters consistent with existing licensing basis:
    - Geometry of target structure revised to reflect strainer geometry and location.
    - Strainer structures are below downcomer exits and not engulfed by LOCA bubbles. Pool Fallback not applicable.

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

- FLUID STRUCTURE INTERACTION (FSI)

Manual calculation method developed under BWROG Mark I Containment Program to calculate drag forces caused by torus shell accelerations acting on the fluid.

Continuum Dynamics, Inc. (CDI) FSI software and flow field acceleration data conservatively replaced by bounding FSI load definition developed by DE&S during the Mark I Program.

- Geometry of target structure revised to reflect strainer geometry and location.
- Acceleration drag volumes for strainers reduced by 25% compared to equivalent solid cylinders.
- Methodology previously reviewed by NRC on another Docket.

HYDRODYNAMIC LOADS DEVELOPMENT OVERVIEW

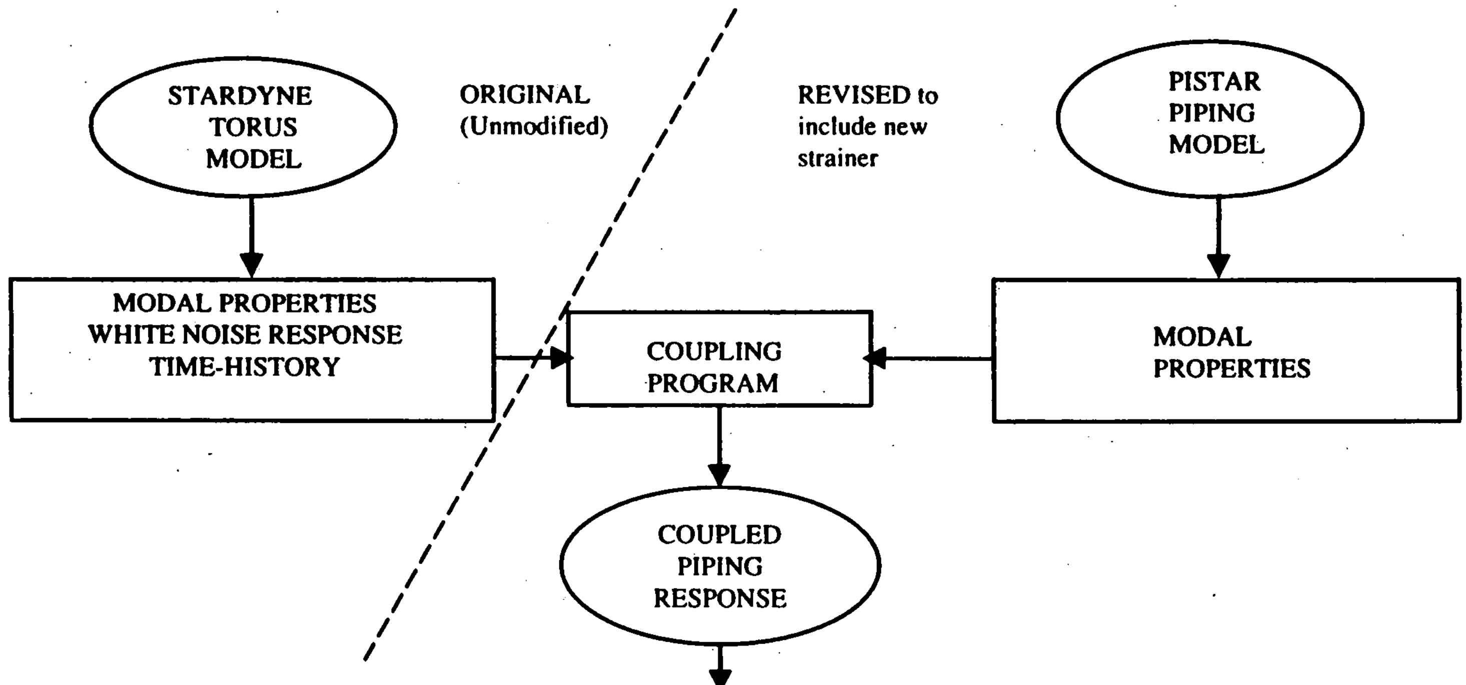
- TORUS SHELL INERTIAL LOAD

Torus to piping coupling methodology developed under BWROG Mark I Containment Program to calculate piping response caused by torus shell vibratory motions.

- DE&S software is same as used during Mark I Program.
- External/Internal piping completely reanalyzed for all loads.

RODYNAMIC LOADS DEVELOPMENT OVERVIEW

Torus Shell Inertial Loads



- TRANSFER RESPONSE TO FREQUENCY DOMAIN
- COMPUTE TRANSFER FUNCTION
- DETERMINE CRITICAL PIPING RESPONSE FREQUENCIES
- COMPUTE PIPING RESPONSES AT CRITICAL LOAD FREQUENCIES USING TRANSFER FUNCTIONS
- EVALUATE PIPE STRESS AND SUPPORT LOADS TO DESIGN BASIS ALLOWABLES

HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS

Background

- Tests undertaken by DE&S in October 1996
  - Strainers are large submerged structures in the pool.
  - Appropriate values of hydrodynamic mass and acceleration drag volume are not readily determined using available geometric forms (Application Guides).

- Objective of the tests was to investigate the response of typical stacked disk strainers when subjected to free vibrations in submerged condition

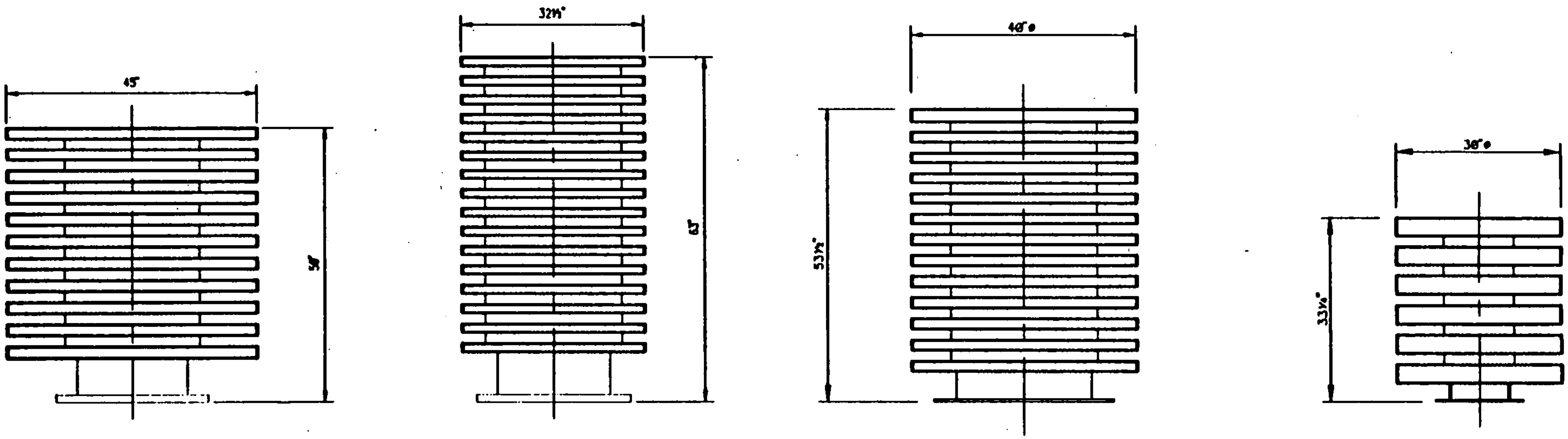
HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS

Background (Cont'd)

- Test specimens were full scale designs very similar to the Quad and Dresden strainers
  - Same hole pattern
  - Same hole size (1/8")
  - Same percent open area (40%)
  - Similar diameters and lengths
  - Similar disk and gap widths

- All tests were performed in accordance with the DE&S 10CFR50 Appendix B Quality Assurance Program

HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS



QUAD CITIES

DRESDEN

PROTOTYPE 1

PROTOTYPE 2

HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS

Testing consistent with the Methodology of the Mark I Program

- The focus of the program was the measurement of the hydrodynamic mass ("virtual mass") first suggested by J.R. Morison
  - Morison's (and later, Moody's) work formed the basis for estimation of drag forces and inertial loads on submerged structures, as described by the Mark I LDR
  - Morison and Moody considered hydrodynamic force to consist of a velocity drag component and an inertial component

- Free vibration tests are accepted as a means to determine hydrodynamic mass. This method was used as part of the Mark I 1/4 scale tests (NEDE-23545)

HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS

Description of Tests

- The tests performed were of two types
  - Drag tests
  - Free vibration

- To study the effects of strainer geometry and holes, two reference strainer configurations were tested
  - Solid cylinder
  - Strainer geometries less holes

HYDRODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION STRAINERS

Interpretation of Test Results

- Hydrodynamic mass coefficients (C_m) could be measured directly from the drag tests - However, these tests were later abandoned due to limitations of the test facility towing rig.

- C_m was determined from the free vibration tests by conservatively assuming $C_m = 2.0$ for the reference cylinder.

- C_m for design was ultimately determined from the free vibration tests (not the drag tests).

RODYNAMIC INERTIAL MASS TESTING OF ECCS SUCTION RAINERS

Principal Conclusions

- As expected, the strainers exhibited significantly higher velocity drag coefficients than the smooth reference cylinder (1.1 vs 0.6). ComEd used 1.2 for design. Typically, 1.2 was used during original Mark I Program.

- Also as expected, the strainers exhibited significantly lower hydrodynamic mass coefficients than the smooth reference cylinder (less than 1.25 vs assumed 2.0). ComEd used 1.5 for design.
  - This factor is utilized to determine total hydrodynamic mass and acceleration drag volume.

CTURAL MODIFICATIONS OVERVIEW

General Philosophy

- Maintain consistency with current licensing basis.

- Rigorous analysis of replacement strainer assembly for all design basis loads including hydrodynamic loads consistent with original Mark I methodology.

- Modify torus penetration reinforcement to maintain stresses within design basis allowable.

STRUCTURAL MODIFICATIONS OVERVIEW

Strainer Modification Affects Only Torus Penetration and Attached Piping

- Torus Attached Piping
  - Piping/supports only minimally affected. Controlling pipe stress magnitudes remained essentially unchanged, high stress locations have changed. Some spring can and snubber settings needed reverification.
  - No additional modification necessary.

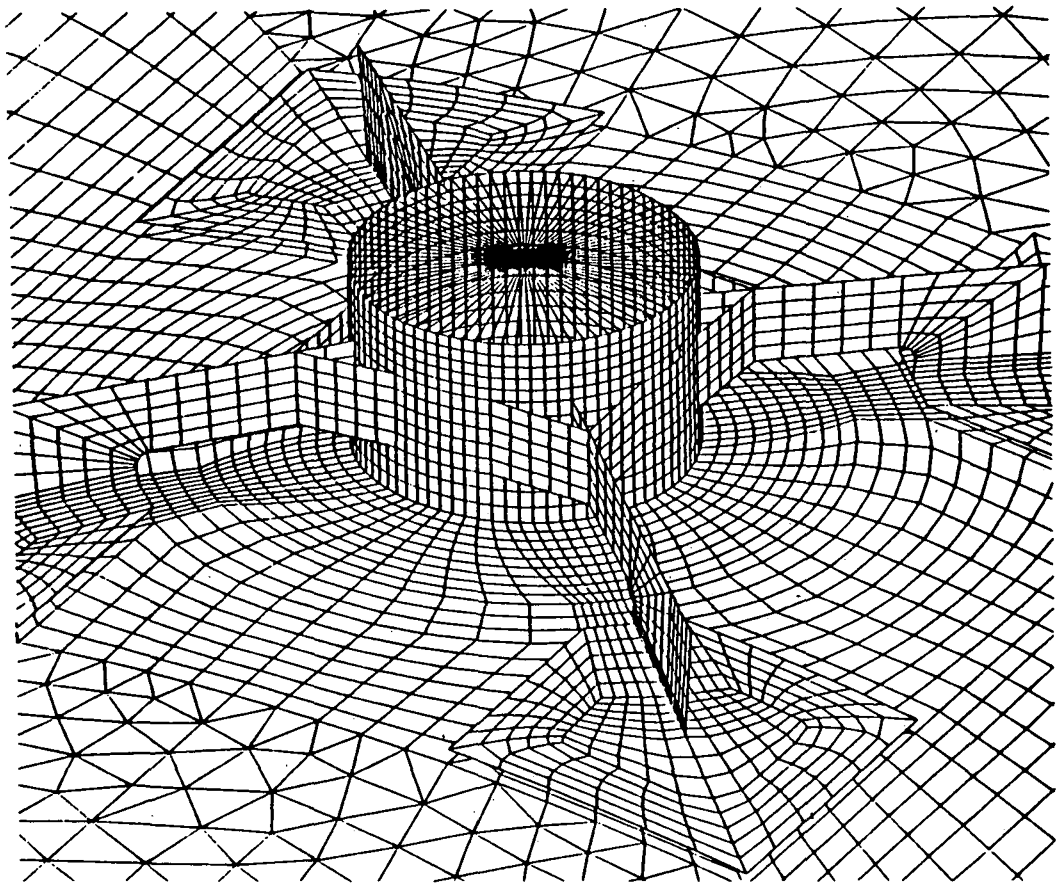
STRUCTURAL MODIFICATIONS OVERVIEW

Strainer Modification Affects Only Torus Penetration and Attached Piping (Cont'd)

- Torus Penetrations
  - Rigorous Finite Element evaluation
  - Increased loads necessitates additional reinforcement
  - Modified all ECCS torus penetrations. Added reinforcement to penetration external support arms to better distribute the additional load.

PENETRATION EVALUATION

Penetration Finite Element Model (ANSYS 5.3)



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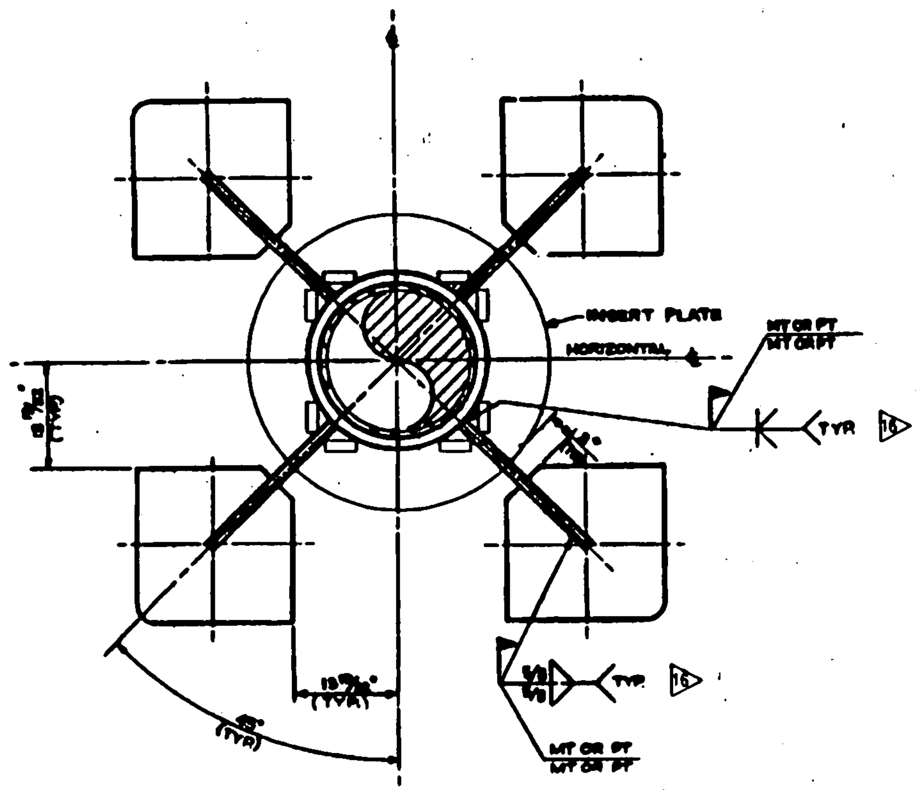
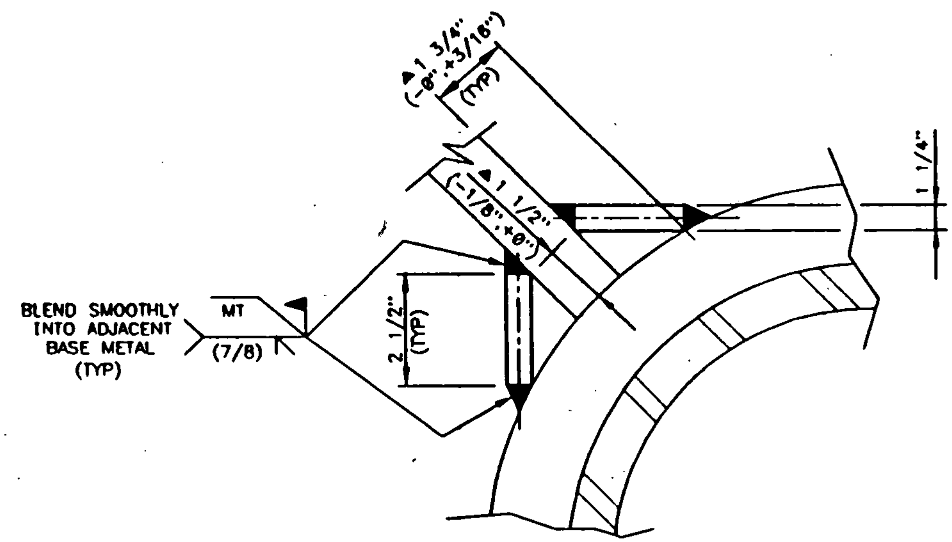
PENETRATION EVALUATION

Penetration Reinforcement Details





PENETRATION EVALUATION

Maximum Penetration Design Interaction
(Max Stress/Allowable Stress)

	Before	After
Dresden	0.95	0.96
Quad Cities	0.99	0.92