HOLTEC PRESENTATION TO NRC

TECHNICAL ISSUES MEETING

January 9, 2003

AGENDA

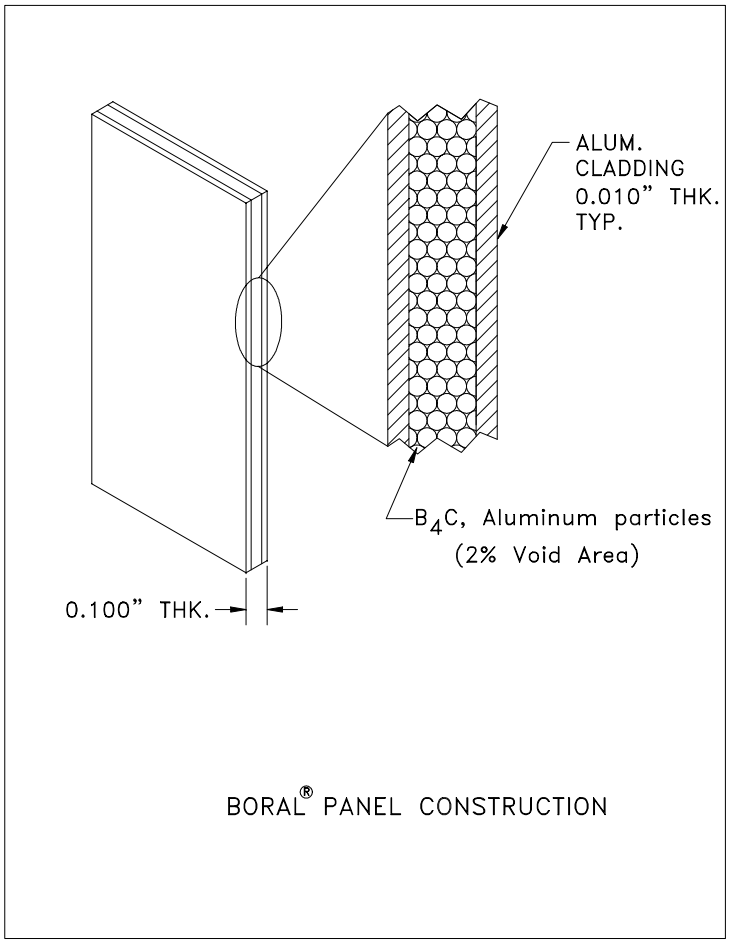
- Introductions
- Opening Remarks (NRC/Holtec)
- Meeting Overview (B. Gutherman)
- BORAL®/Water Compatibility Issue (B. Gutherman)
- MPC Lid Material Issue (B. Gilligan)
- Material NDE Issue (B. Gilligan)
- QA Perspective (M. Soler)

Meeting Overview

- 2 of 3 issues occurred at plants in preparation for, or during dry cask storage campaigns
  - BORAL/Water Compatibility Issue - CGS
  - MPC Lid Material Issue - Hatch
- Meeting is vital to ensure technical facts are presented clearly and NRC questions can be answered directly
- Overall, all actions taken and information presented by Holtec are consistent with knowledge at the time, with the highest regard for quality and accuracy

BORAL/Water Compatibility

- BORAL construction
  - Al Cladding
  - B_4C/Al core



BORAL/Water Compatibility (cont'd)

- Aluminum exposed to air will form a thin aluminum oxide layer
- Aluminum in water will form a thicker, more protective oxide layer
- BORAL panels used in wet storage not pre-passivated
  - In-pool hydrogen generation not a concern for wet storage

BORAL/Water Compatibility (cont'd)

- BORAL panels used in dry storage are pre-passivated in shallow water tank for at least 144 hours prior to installation in MPC
  - Aluminum oxide layer forms on the aluminum cladding surfaces and edges of BORAL panels
  - Knowledge at the time was that the aluminum oxide layer from pre-passivation would reduce additional aluminum-water interaction to essentially zero
    - Original FSAR language (i.e., "no" hydrogen generation) was believed to be accurate

BORAL/Water Compatibility (cont'd)

- No problem during normal storage (dry helium environment)
- During preparation for fuel loading at CGS, bubbles were observed emanating from the submerged cask in the SFP
  - 65-75% hydrogen, balance air
- No reliable information as to the hydrogen evolution rate

BORAL/Water Compatibility (cont'd)

- Holtec evaluated the reaction of BORAL with spent fuel pool water (DS-248, Revision 2)
- Calculation shows over 24 days after lid is installed before hydrogen ignition limit is reached (well beyond actual time needed for this evolution)
- Holtec technical evaluation was reviewed by two separate third parties for EN and conclusions found to be reasonable

BORAL/Water Compatibility (cont'd)

- Amount of gas generated and released varies based on:
  - Size of B_4C particles in the BORAL core
    - Smaller particles = smaller void space and thicker protective aluminum oxide layer on panel edges
  - Elevated hydrostatic pressure (time and depth)
    - Aluminum oxide on panel edges may not prevent relatively high pressure water from entering the BORAL core
    - Under pressure, air in the BORAL core capillaries is compressed, exposing previously unexposed internal aluminum material to water
  - Presence of trace impurities in B_4C and SFP water can affect the rate of generation

BORAL/Water Compatibility (cont'd)

- Galvanic reaction of Al and SS evaluated and not considered significant; confirmed by test
  - BORAL outer surface oxide layer acts as an insulator to current
    - Low water flow and neutral or slightly acidic water maintains oxide layer
  - High resistance in path between SS and inner BORAL cladding surface
  - Experience with SS-framed BORAL test coupons in SFP water shows insignificant corrosion

BORAL/Water Compatibility (cont'd)

- Lessons Learned/Corrective Actions
  - FSAR text was based on knowledge at the time that pre-passivation would essentially eliminate further aluminum-water interaction
  - Additional gas generation due to elevated hydrostatic pressure in the spent fuel pool was unexpected
  - FSAR modified under 10 CFR 72.48
    - Clarify language to recognize potential for additional gas generation
    - Require combustible gas monitoring
    - Recommend purging or exhausting space beneath lid

MPC Lid Material

- MPC Lid-to-Shell Weld Description
  - 3/4” thick groove weld between MPC lid (SA-336 F304) and MPC shell (SA-240 Type 304) to form confinement boundary
  - Weld subjected to visual examination and liquid penetrant examination at root and final layer and each 3/8” of weld depth
  - Weld subjected to hydrotest at 125% of design pressure and subjected to helium leakage testing

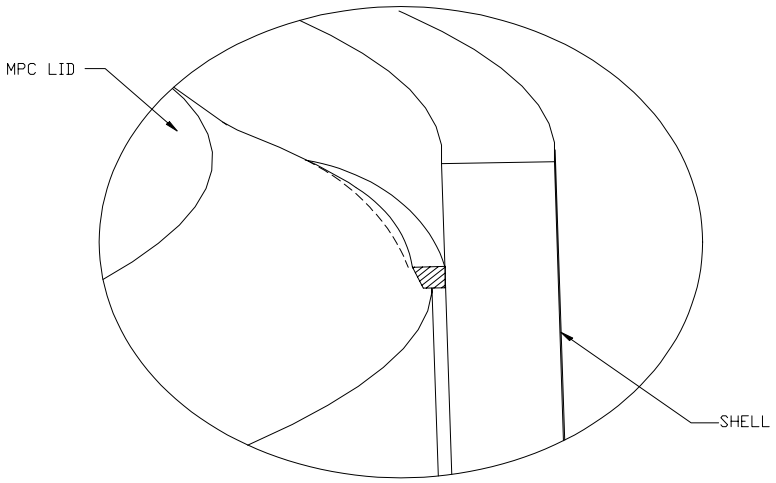
MPC Lid Material (cont'd)

- MPC Lid Forging Pedigree
  - ASME Code Section III, Subsection NB, Class 1 Material
  - Important to Safety Category A
  - SA-336 F304
  - 100% UT Examination (NB-2542)
  - 100% PT Examination (NB-2546)

MPC Lid Material (cont'd)

- Summary of Hatch Welding Difficulties
  - Rejectable indications found in MPC lid base metal during liquid penetrant examination of root pass
  - Indications distributed along entire circumference having the appearance of porosity
  - Code weld repairs attempted by grinding and re-welding - similar indications found
  - Changes in welding processes (GTAW, FCAW, SMAW) and welding parameters also unsuccessful

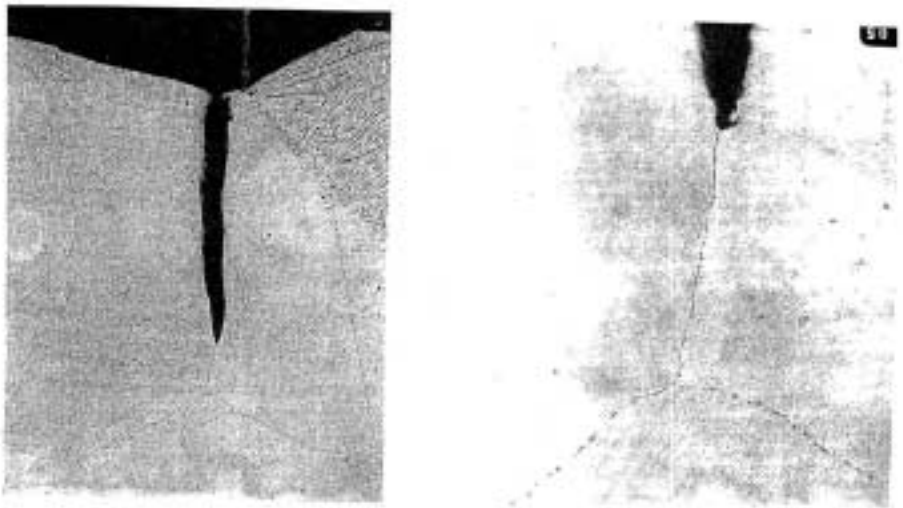
MPC Lid Material (cont'd)



MPC LID-TO-SHELL WELD INDICATIONS

MPC Lid Material (cont'd)

Gulf Coast Machine & Supply Co.
RJ Lee Group Project No. MAH210298



A. 100x

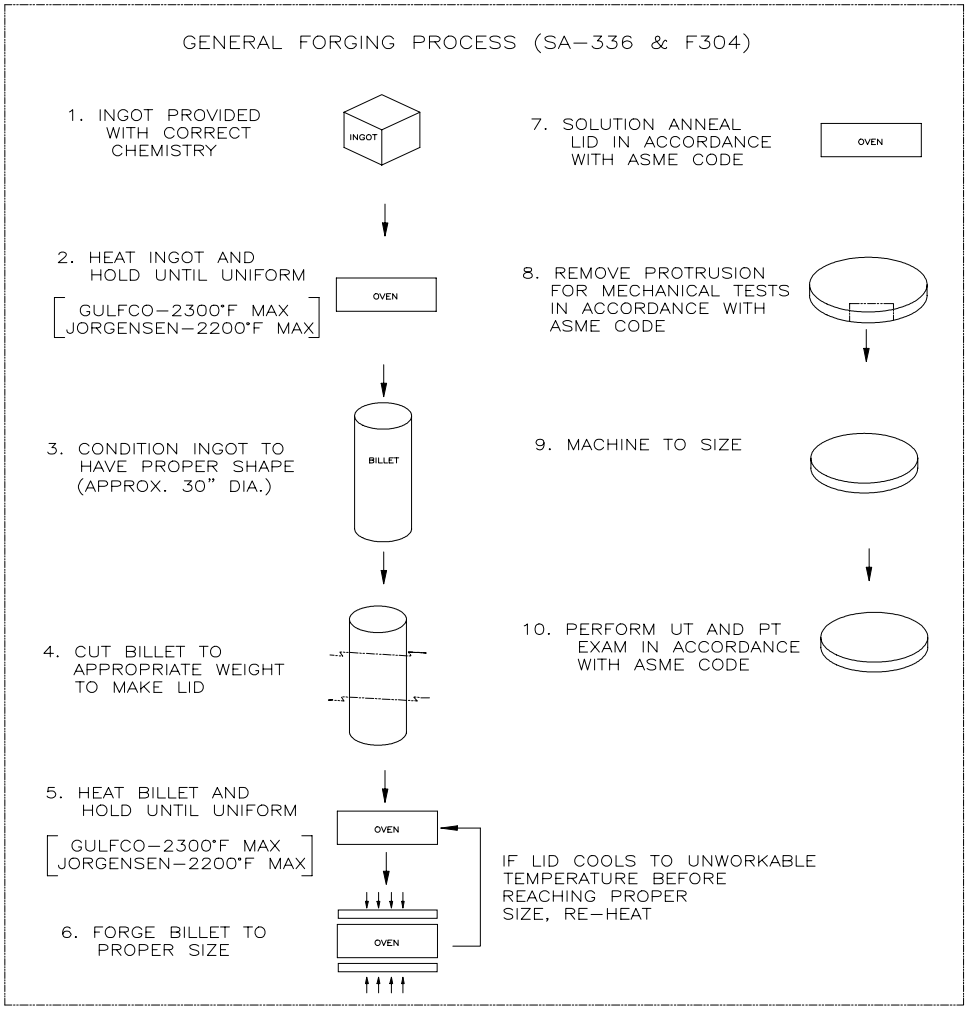
B. 500x

Figure 2. Photomicrographs of cracks in Gulf Coast Sample 2FB1S, etchant: acetic/nitric acid/HCl/glycerol

MPC Lid Material (cont'd)

- Root Cause
  - Large grain size (≥ "00" ASTM E-112)of lid forgings makes the lid susceptible to liquation cracking (grain boundary cracking in the base metal)
  - Subject lids met all ASME requirements for mechanical properties and chemistry
  - Lids already in service are unaffected based on satisfactory weld inspection

MPC Lid Material (cont'd)



MPC Lid Material (cont'd)

- Grain Size Effect on Material Properties
  - Grain size does have measurable effect on most mechanical properties - literature is extensive for low carbon steels
  - Lid mechanical properties measured from protrusion on each lid forging - grain size is fully accounted for in tests

MPC Lid Material (cont'd)

- Liquation Cracking
  - Impurities in metal are concentrated at grain boundary. Metals with large grain size have less grain boundary available, causing local concentrations of impurities
  - Material still meets ASME Code chemistry requirements
  - Impurities reduce the melting point - reducing intergranular cohesion at high temperatures.

MPC Lid Material (cont'd)

- Liquation Cracking (cont'd)
  - Lack of cohesion between grain boundaries initiates cracks aided by tensile stresses resulting from contraction of weld
  - Cracks were determined to be "micro-fissures" limited in length to 400 microns (roughly the grain size)

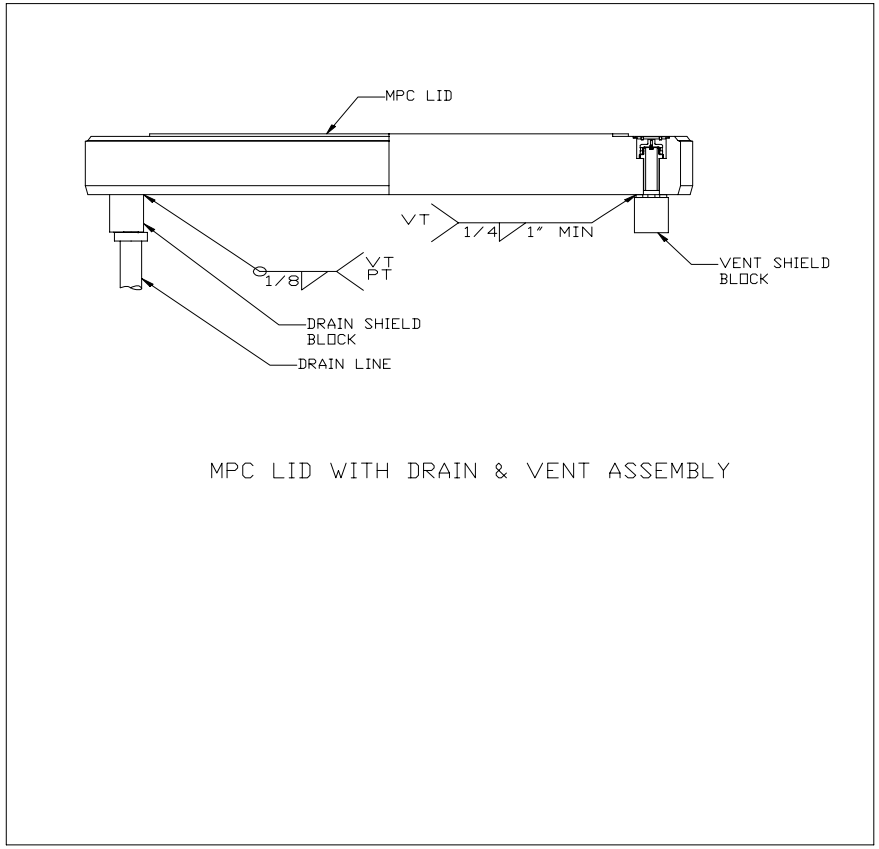
MPC Lid Material (cont'd)

- Delayed Cracking/Hydrogen Cracking
  - Typically observed in carbons steels and martensitic and ferritic stainless steels (e.g., 400 series)
    - Higher diffusibility and lower solubility allows hydrogen ions to move about and join to create hydrogen gas in the structure
    - Hydrogen gas leads to increased internal pressure and ensuing hydrogen cracking
  - All MPC stainless steel is austenitic (300 series)
    - Lower diffusibility and higher solubility do not allow hydrogen ions to move about freely and join together

MPC Lid Material (cont'd)

- Time Line for MPC Lid Welding Difficulties
  - UST&D issues NCRs for 2 unweldable lids - 9/01
  - Holtec orders lids scrapped - 9/01
  - Welding difficulties begin on S/N 40 lid - 9/18/02
  - Holtec notifies licensees via HIB-9 - 9/23/02
  - Holtec issues QPV – 9/23/02
  - Decision to replace S/N 40 lid – 10/16/02
  - 10 CFR 72.242(d) Report to NRC - 11/13/02
  - Root cause report completed - 11/18/02

MPC Lid Material (cont'd)



MPC LID WITH DRAIN & VENT ASSEMBLY

MPC Lid Material (cont'd)

- Corrective Actions
  - S/N 40 & 25 lids replaced at Hatch
  - Holtec recommends to all clients loading at that time to perform weld tests prior to use
  - Lids not in-service tested for grain size. Grain sizes $\geq$ 1.0 receive additional weld tests
  - Revise lid purchase specification to include grain size and weldability requirements

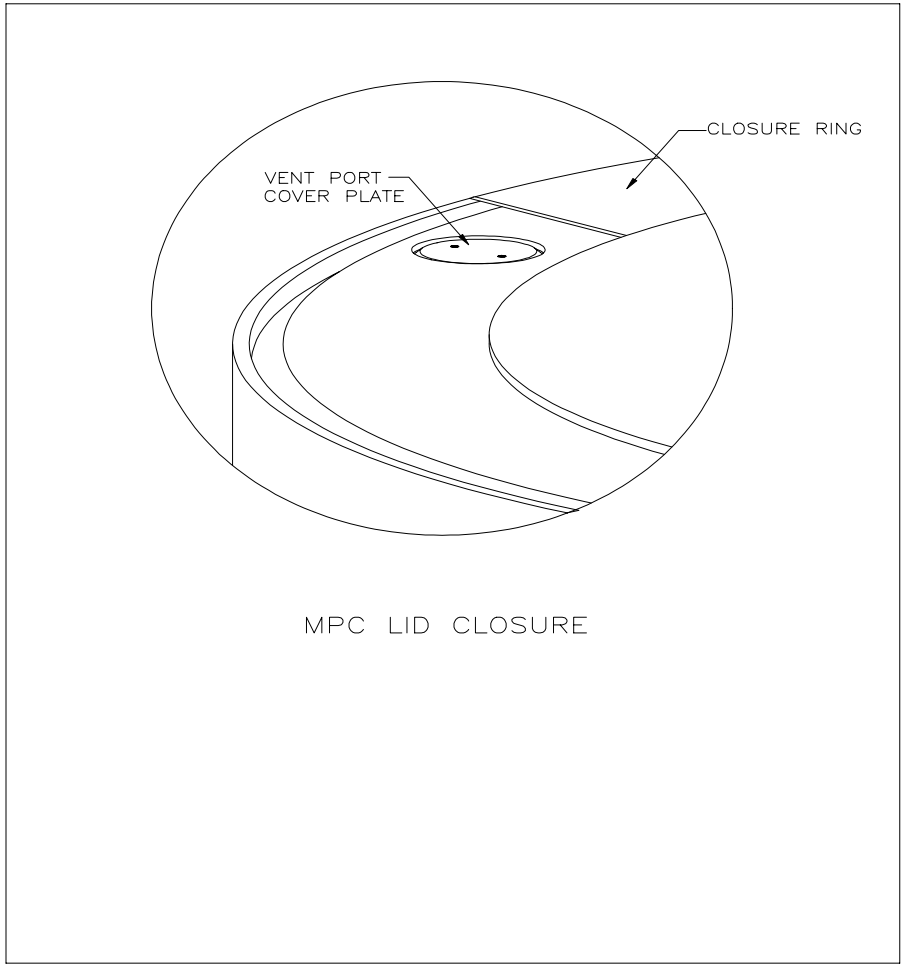
MPC Lid Material (cont'd)

- Corrective Actions (cont'd)
  - Add weldability requirements to all purchase specifications for metal which is to be welded
  - Provide training to Holtec & UST&D regarding insufficient evaluation of initial lid welding problems
  - Revise Holtec checklist for SMDR issuance to provide additional guidance for evaluating impact of deviations

Material NDE Issue

- MPC Closure Ring
  - Provides redundant confinement boundary closure – not normally pressure-retaining, but analyzed
  - Meets ASME Code Section III Subsection NB
  - UT examination required per NB-2530
- MPC Cover Plates
  - Part of confinement boundary
  - Meets ASME Code Section III Subsection NB
  - UT examination required per NB-2530

Material NDE Issue (cont'd)



Material NDE Issue (cont'd)

- Missed NDE
  - Closure rings and cover plates made from non-UT'd plate delivered to clients
    - Three (3) closure rings placed in service (2 at Dresden and 1 at Hatch) without UT
    - No cover plates in service without UT

Material NDE Issue (cont'd)

- Acceptability of Closure Rings In-Service
  - Closure ring provides redundant confinement boundary closure (not pressure retaining)
  - MPC lid-to-shell weld and port cover plates can withstand all normal, off-normal, and accident conditions
  - Straight beam UT examinations detect laminations parallel to surface of plate, which are not potential leak paths

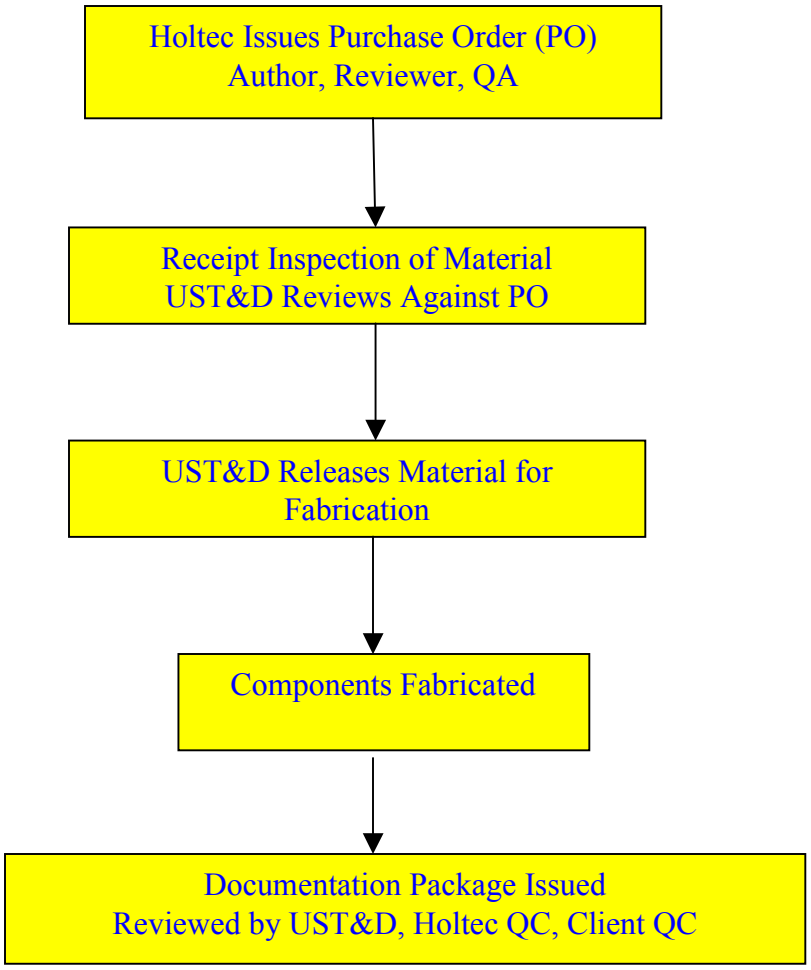
Material NDE Issue (cont'd)

- Acceptability of Closure Rings In-Service (cont'd)
  - 3/8" thick Type 304SS rarely fails UT
  - As part of corrective actions, **52** cover plates and **22** closure ring segments from same heat number as closure rings in-service were UT examined with no failures
  - Safety factor of 3/8" thick closure ring under normal design pressure of 100 psig (HI-STAR FSAR, Appendix 3.E)

Material NDE Issue (cont'd)

- Acceptability of Closure Rings In-Service (cont'd)
  - No mechanism available to cause any potential indications or laminations to propagate
    - No cyclical loading, closure ring is normally under no stress, environment not conducive to SSC
  - Closure ring material is 304 stainless steel, which is very ductile

Material NDE Issue (cont'd)



Material Flow Chart

Material NDE Issue (cont'd)

- Root Cause
  - Inadequate self-checking of procurement documents by author/reviewer
- Contributing Cause
  - Technical and quality information not easily accessible/organized for procurement agent

Material NDE Issue (cont'd)

- Corrective Actions
  - One-time Code alternative request made for 3 in-service closure rings to exempt UT inspection
  - UT all other affected items not placed into service
  - Add applicable ASME Code subsection to Holtec drawings for each affected bill-of-material item
  - Modify Holtec PO database to include "smart" bill-of-material
  - Enhance Holtec documentation package review process
  - Enhance UST&D receipt inspection and documentation package review processes

QA Perspective

- Overview
  - Each of the three issues thoroughly addressed under Holtec's corrective action process
  - Extensive root cause evaluations performed, including interfacing with Holtec's licensee clients, Holtec's suppliers, and third party experts
  - No similar occurrences since actions were implemented

QA Perspective (cont'd)

- Positive Issues
  - Holtec Information Bulletins (HIBs) are effective in providing real-time information on operating events to licensees, NRC, and other parties
  - Corrective actions resulted in broad-based enhancements of processes to reduce human error
- Areas for Improvement
  - Looking at "the big picture"
  - Need pro-active vs. reactive implementation of electronic barriers to prevent human performance errors.