



PDI Dissimilar Metal Weld Program Limitations

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Performance Demonstration**

EPRI NDE Center



Outside Surface Examinations

▲ Manual

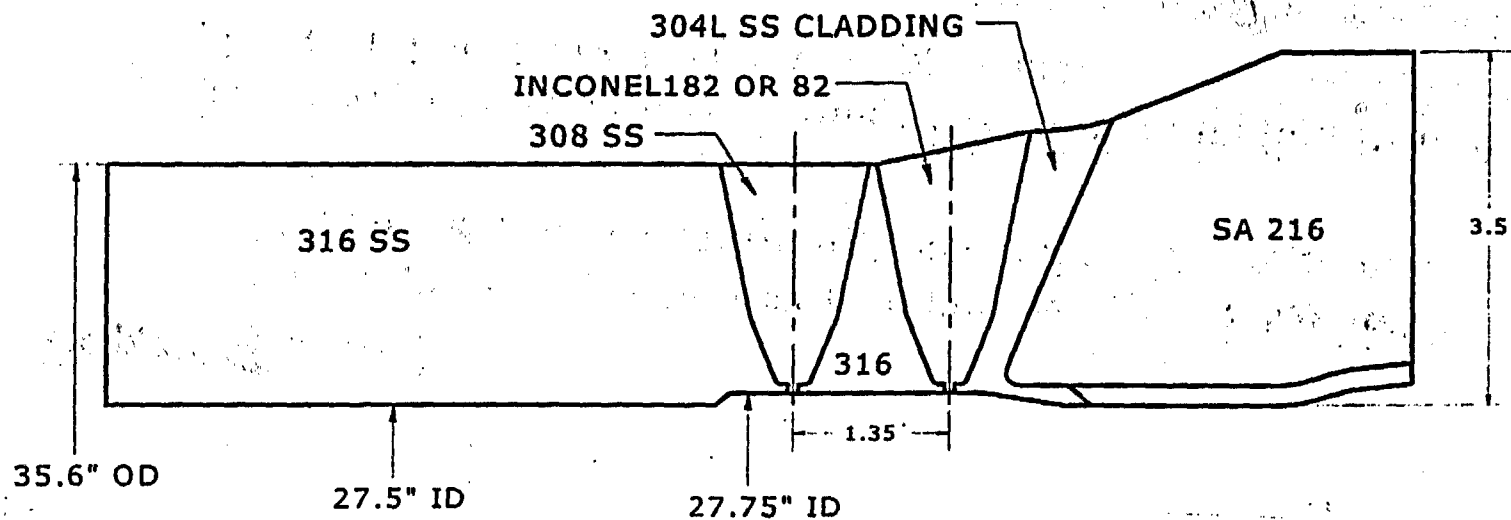
– Standard Procedure/Personnel Limitations contained on PDQS

- This procedure/candidate is not qualified for examinations performed from the cast stainless steel side of a component (Supplement 9)
- This procedure/candidate is not qualified for through wall sizing.
- This procedure/candidate is only qualified to length size circumferentially oriented flaws (Excluded from Supplement 10)
- This procedure/candidate is not qualified for examinations where the ultrasonic sound beam is required to propagate through an adjacent weld prior to impinging on the dissimilar metal weld. The PDI 711 series sample is an example of this configuration



Outside Surface Examinations

36" PWR STEAM GENERATOR NOZZLE CONFIGURATION (711/X)





Outside Surface Examinations

▲ Manual (Cont.)

- Examination of safe-end replacement configurations, identified as 706 and 707 series configurations in the PDI Program are qualified.
- This procedure/candidate is qualified for examination from both single and dual sided access as applicable
- Weld crown must be ground flush and configuration must allow unobstructed access across the entire weld crown



6 6

316 SS SAFE END

INC 182 BUTR

INC 182 WELD

INC 182 WELD

INC 182 BUTR

SA 508 CS NOZZLE

309/308 SS CLAD

INC SB166 REMNANT TRIANGULAR SECTION REMAINED AFTER REPAIR.

75.0°

37.5°

15.0°

15.0°

75.0°

0.21

0.2

0.19

0.42

R0.06

R0.06

R0.06

0.19 CLAD

0.31

5.4

10.0° ID

12.35° OD

5.97

0.03

0.06

57.2

0.56

45.0°

10.38° ID BEFORE CLAD

5.11

5.49

0.48

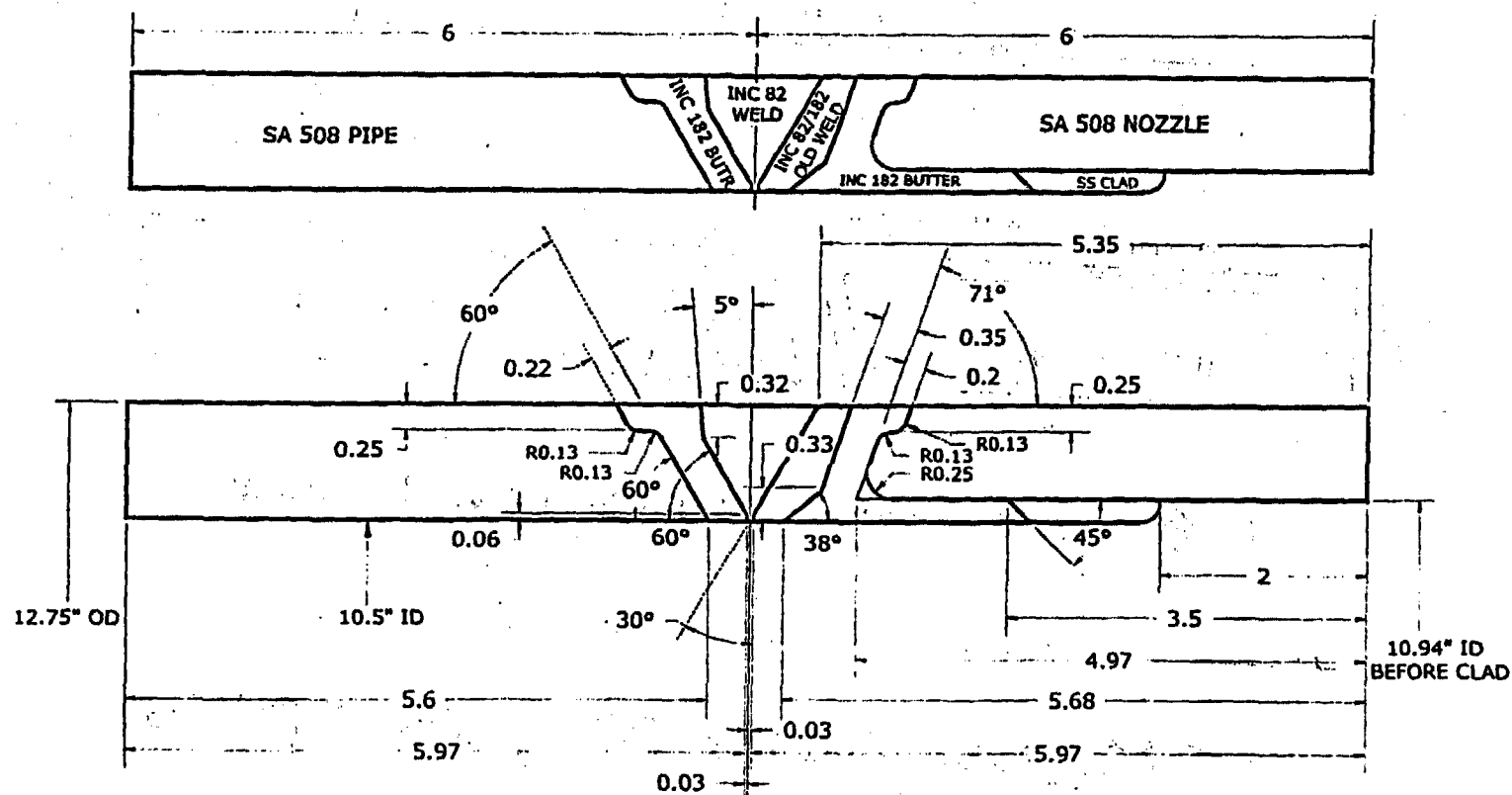
37.5°

37.5°



Outside Surface Examinations

BWR 12" N4, N5, & N6 NOZZLE CONFIGURATIONS (707/X)





Outside Surface Examinations

▲ Automated (Primarily BWR Ranges Only)

- Standard Procedure/Personnel Limitations contained on PDQS
 - This procedure/candidate is only qualified to length size flaws orientated in the circumferential direction (Not included in Supplement 10)
 - This procedure/candidate is not qualified for through wall sizing
 - This procedure/candidate is not qualified for examinations performed from the cast stainless steel side of a component (Supplement 9)



Outside Surface Examinations

▲ Automated (Cont.) (BWR Ranges Only)

- This procedure/candidate is qualified for examinations performed from either single or dual sided access as applicable
- This procedure/candidate is not qualified for examinations conducted from tapered surfaces
- The techniques defined in this procedure require unobstructed access across the weld and butter material



Outside Surface Examinations

▲ Automated

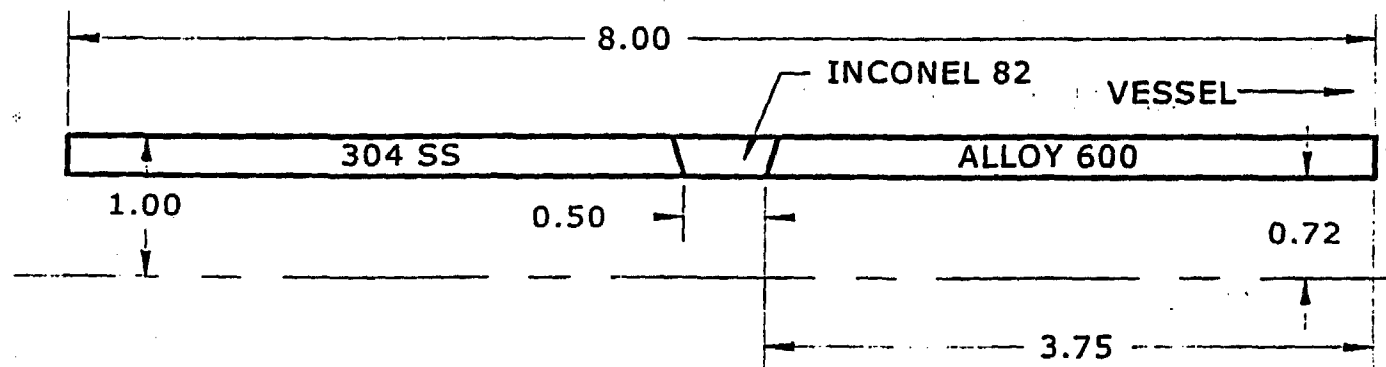
- 2 vendors have qualified procedures for detection and length sizing
 - General Electric
 - Framatome ANP
- Both procedures are primarily for BWR configurations and have the same limitations listed for manual procedures
 - Diameter ranges 4.0" to 28"
 - Thickness ranges 0.50" to 2.0"
- Neither procedure is qualified for depth sizing, but the demonstrated performance has been documented
 - 0.155 RMS
 - 0.154 RMS



Outside Surface Examinations

- ▲ Configurations not covered in present automated qualifications

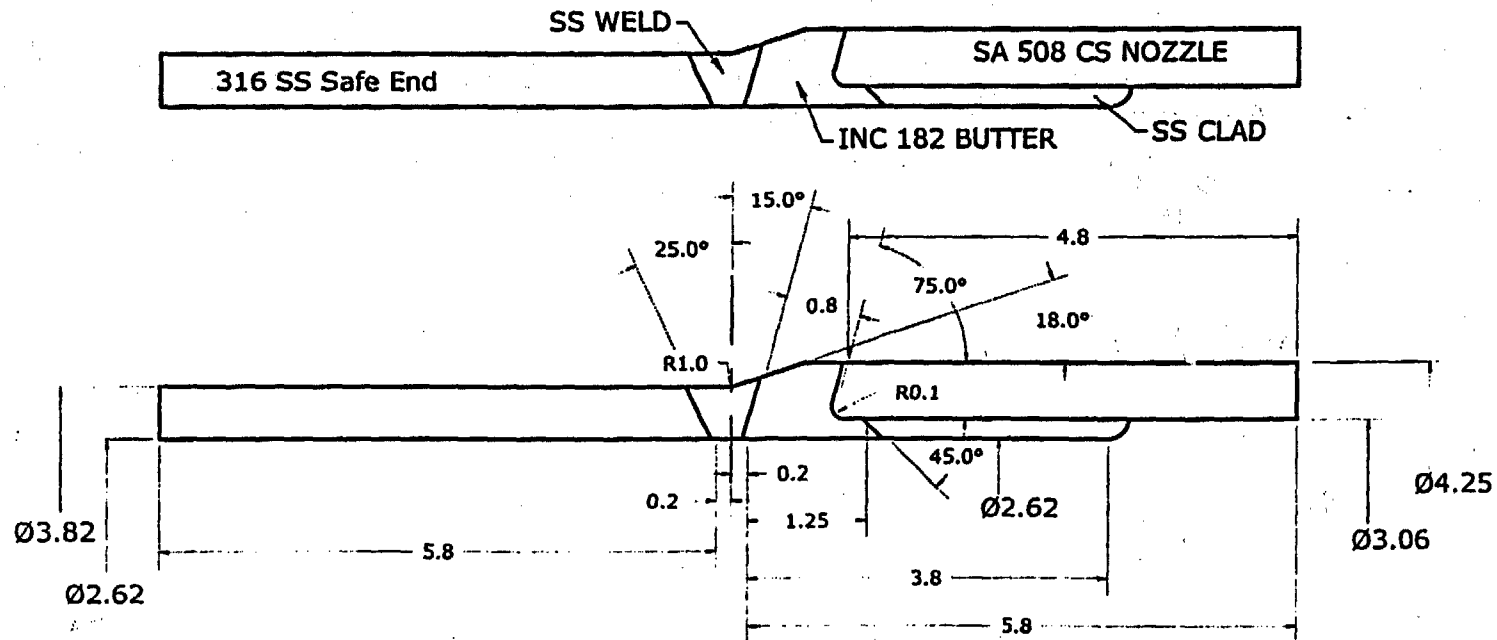
BWR STANDBY LIQUID CONTROL CONFIGURATION (701/X)





Outside Surface Examinations

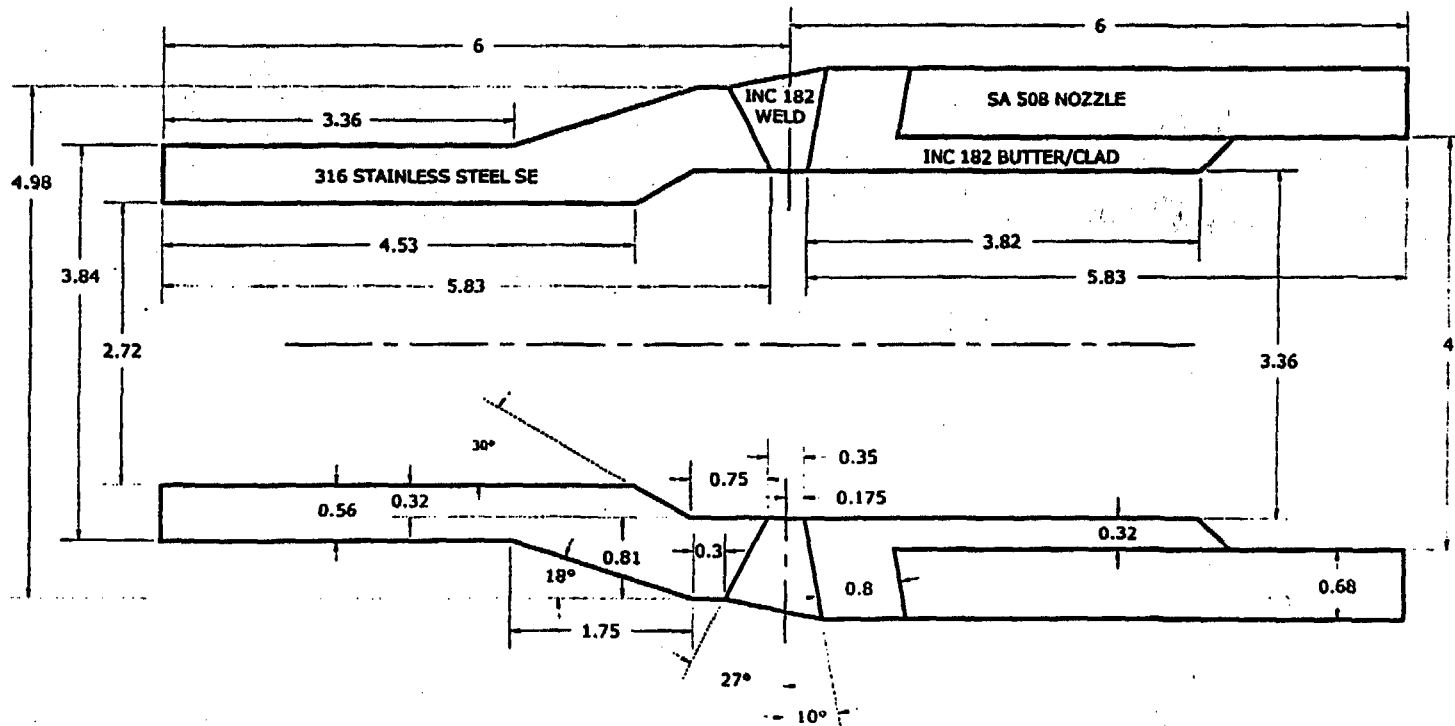
PWR PRESSURIZER SPRAY CONFIGURATION (702/X)





Outside Surface Examinations

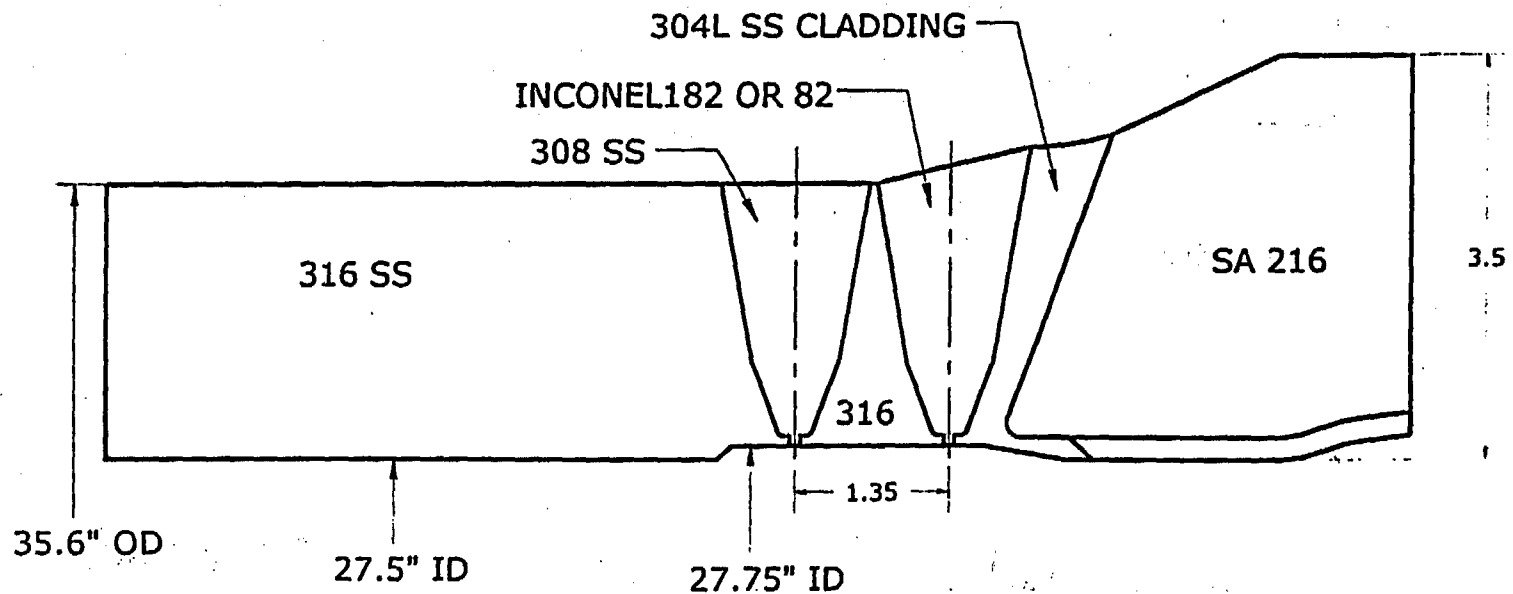
PWR PRESSURIZER SPRAY NOZZLE CONFIGURATION (704/X)





Outside Surface Examinations

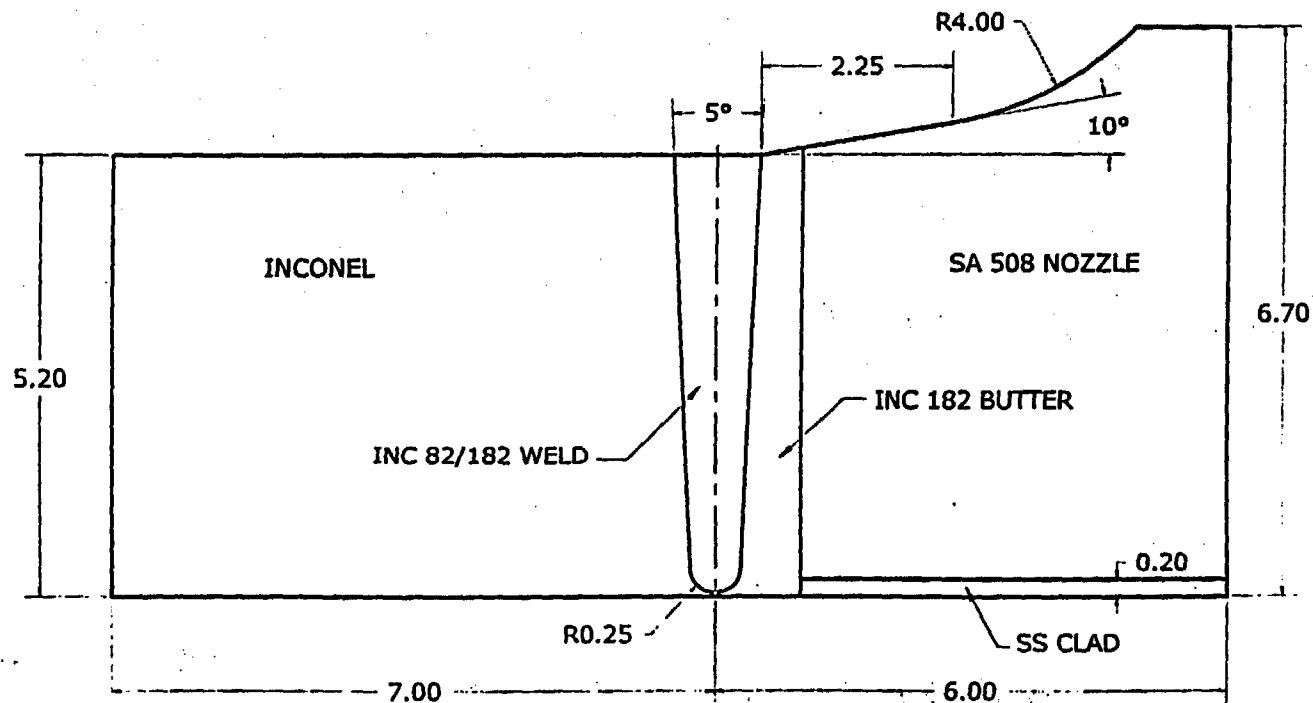
36" PWR STEAM GENERATOR NOZZLE CONFIGURATION (711/X)





Outside Surface Examinations

PWR STEAM GEN NARROW GROOVE WELD NOZZLE CONFIGURATION (712/X)
(FLAT PLATE CONFIGURATION)





Inside Surface Examinations

▲ Automated (Inside Surface Examinations)

- Standard Procedure/Personnel Limitations contained on PDQS
 - This procedure/candidate is not qualified to length or depth size axial flaws in Supplements 2 and 3 piping welds
 - This procedure/candidate is not qualified to detect, length or depth size embedded flaws
 - This procedure/candidate is not qualified for depth sizing of flaws in Supplement 10 welds
 - This procedure/candidate is not qualified for examinations performed from the cast stainless steel side of a component.
 - This procedure/candidate is not qualified to detect axial flaws in either Supplement 2 or 10 closure weld (field weld) configurations.



Problems

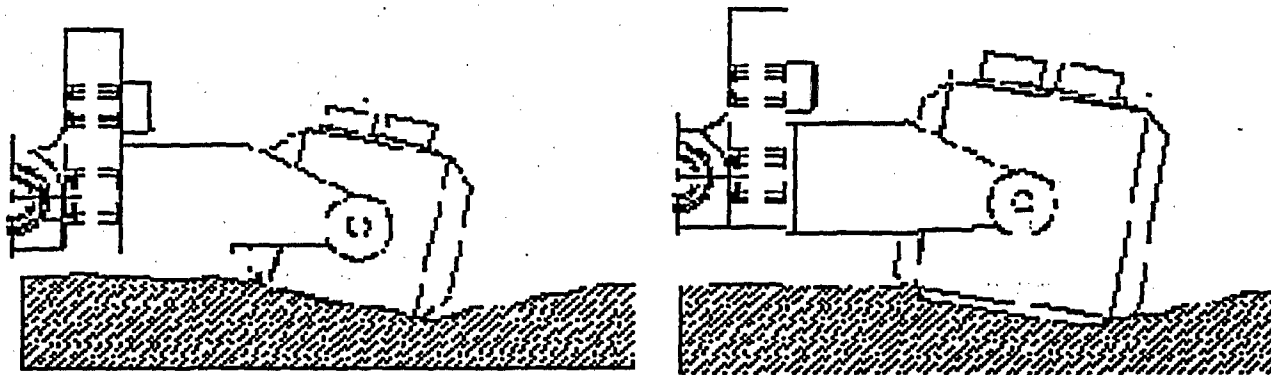
▲ Detection

- Detection limitations may not be overcome
 - Inside Surface Examinations
 - Inside surface conditions too severe to overcome
 - Root/counterbore
 - This is not a ultrasonic technique problem, but a surface condition problem
 - If successful detection is achieved with ultrasonic techniques examination times will likely increase substantially
 - Very small search units moving over geometry at a very slow rate
 - Outside Surface Examinations
 - Complex Geometries may prohibit scanning with automated techniques
 - Location of adjacent welds prohibit meaningful examination



Problems

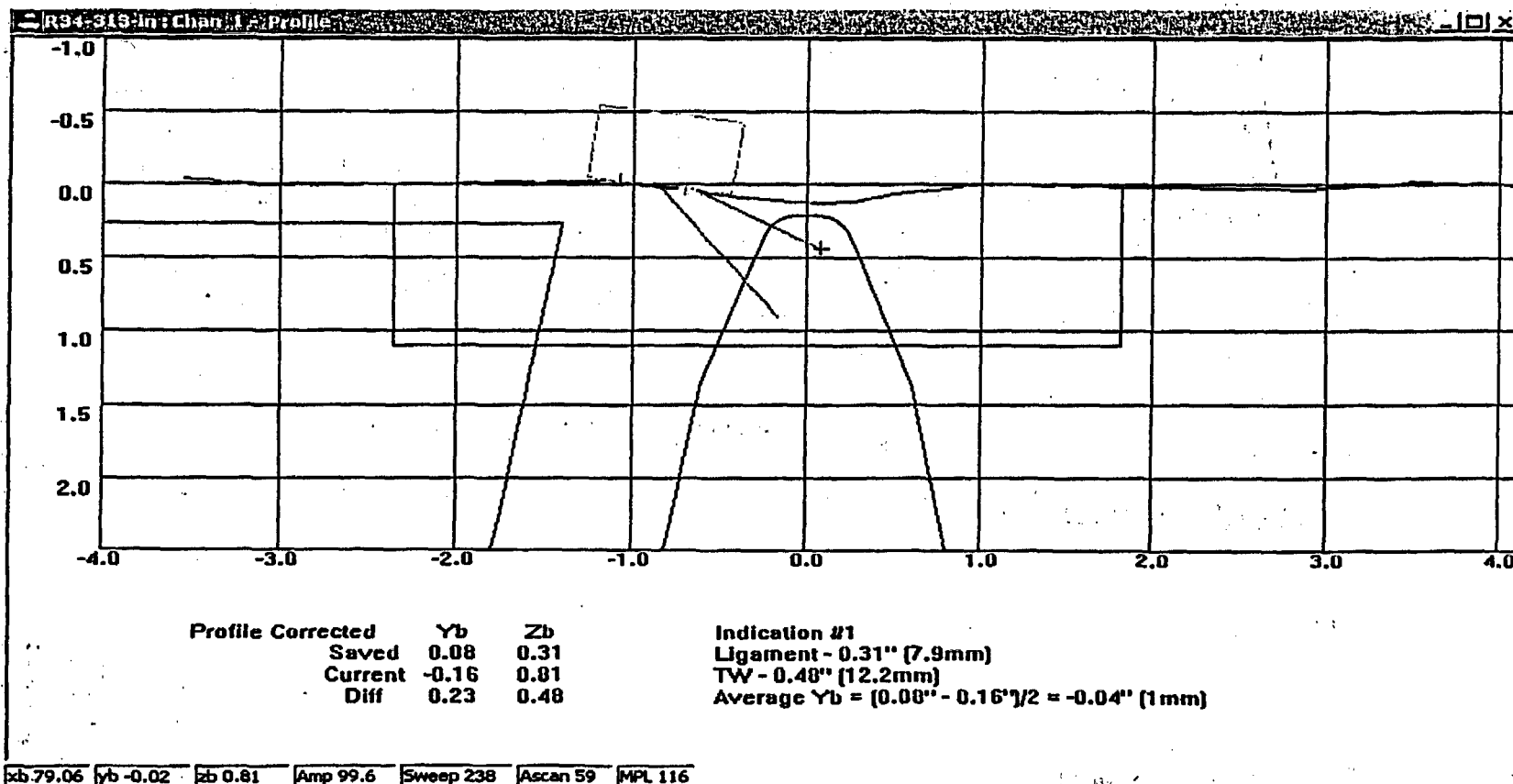
- ▲ **Small Search Units Utilized to Improve Detection on Inside Surface Examinations**





Problems

Profilometry



Problems

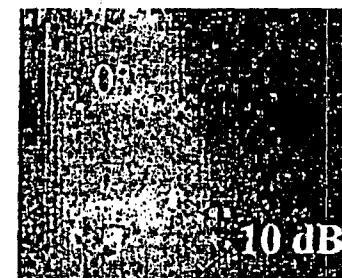
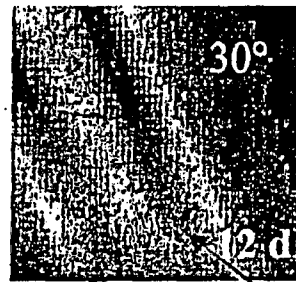
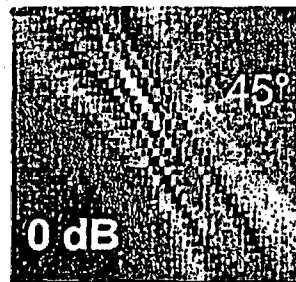
Contact UT transducer

Coupling

Variable coupling

Regular profile

Irregular profile



Nominal beam
characteristics

Degraded and distorted
beam



Problems

▲ Depth Sizing

- Depth sizing utilizing automated techniques may be possible from outside surface
- Successful depth sizing qualification very unlikely for inside surface examinations
 - Too many variables to overcome
 - Depth sizing error may be too large to be useful
 - *Error added to sized flaw height may force immediate repair due to high growth rates*



Depth Sizing Evaluation Criteria

- ▲ In lieu of a qualified procedure PDI has developed a screening criteria for evaluating depth sizing procedures**
 - Not an acceptance criteria
 - Used to gage performance of procedures that were unsuccessful



Depth Sizing Evaluation Criteria

- ▲ RMS error is used as the criterion for acceptable depth sizing performance in Appendix VIII and is calculated according to the following equation:

- Equation 1:

$$RMS = \left[\frac{\sum_{i=1}^n (m_i - t_i)^2}{n} \right]^{1/2}$$

- *where*
- m_i = *measured flaw size*
- t_i = *true size of a flaw*
- n = *number of flaws measured*



Depth Sizing Evaluation Criteria

▲ What is an Credible Depth Sizing Error?

- If a procedure does not make the 0.125" RMS what is an credible number?
 - PDA has developed a position (03-01) that states that a 0.187" RMS will be the break point for documenting sizing performance for procedures and personnel unless other statistical analysis can be performed to show adequate sizing
 - No PDI letter unless $\leq 0.187"$
 - Personnel will not be considered successful unless their results are $\leq 0.187"$
- This approach will only be used for procedures that fail to make 0.125" RMS criteria



Depth Sizing Evaluation Criteria

▲ PDI Policy follows the following steps

- Calculate RMS according to Equation 1.
 - Step A. If $RMS \leq 0.125''$, this is acceptable to Appendix VIII criteria, and the PDQS can be issued
 - Step B. If $RMS > 0.125''$ and $\leq 0.187''$, this does not meet appendix VIII criteria, but the sizing error can be documented in a separate letter to PDI members upon request
 - Step C. If $RMS > 0.187''$, then calculate Root Mean Square Percentage (RMSP) according to equation 2



Depth Sizing Evaluation Criteria

$$RMSP = \left[\frac{\sum_{i=1}^n \left(\frac{m_i - t_i}{t_{wall}} \right)^2}{n} \right]^{1/2}$$

– Equation 2

– where

- m_i = measured flaw size
- t_i = true size of a flaw
- n = number of flaws measured
- t_{wall} = wall thickness of the sample containing each flaw



Depth Sizing Evaluation Criteria

- ▲ This calculation expresses the RMS error in terms related to the wall thickness. If $\text{RMSP} \leq 0.10$ the sizing error can be documented in a separate letter to PDI members upon request
- ▲ Documenting sizing errors in this way is for the sole purpose of
 - Providing information to PDI members on the sizing performance of procedures and personnel for their use in evaluating indications
 - Ensuring that documented sizing errors are meaningful and reliable



Depth Sizing Evaluation Criteria

- ▲ If the procedures documented sizing error exceeds all three of the previously stated steps the documented error may be provided to the license if requested, but the license will be responsible for developing the technical basis on how they will be applied
- ▲ Documentation of sizing errors that exceed Appendix VIII criteria does not imply that the procedures or personnel are qualified to Appendix VIII or PDI criteria.



Summary

▲ Senior PDA staff will be working with vendors full time

- Helping with technique development (if needed)
- Facilitating demonstrations
- Documenting results
- Work with vendors to improve sizing techniques
 - Profilometry
 - Phased array

▲ Utilities

- Tracking Progress
- Assisting PDA
- Pushing Vendors for best achievable results

▲ Vendors

- Applying massive resources and technology to the problem