

## PDI Piping & Bolting Program Update

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Project Manager  
PDI Piping & Bolting Program

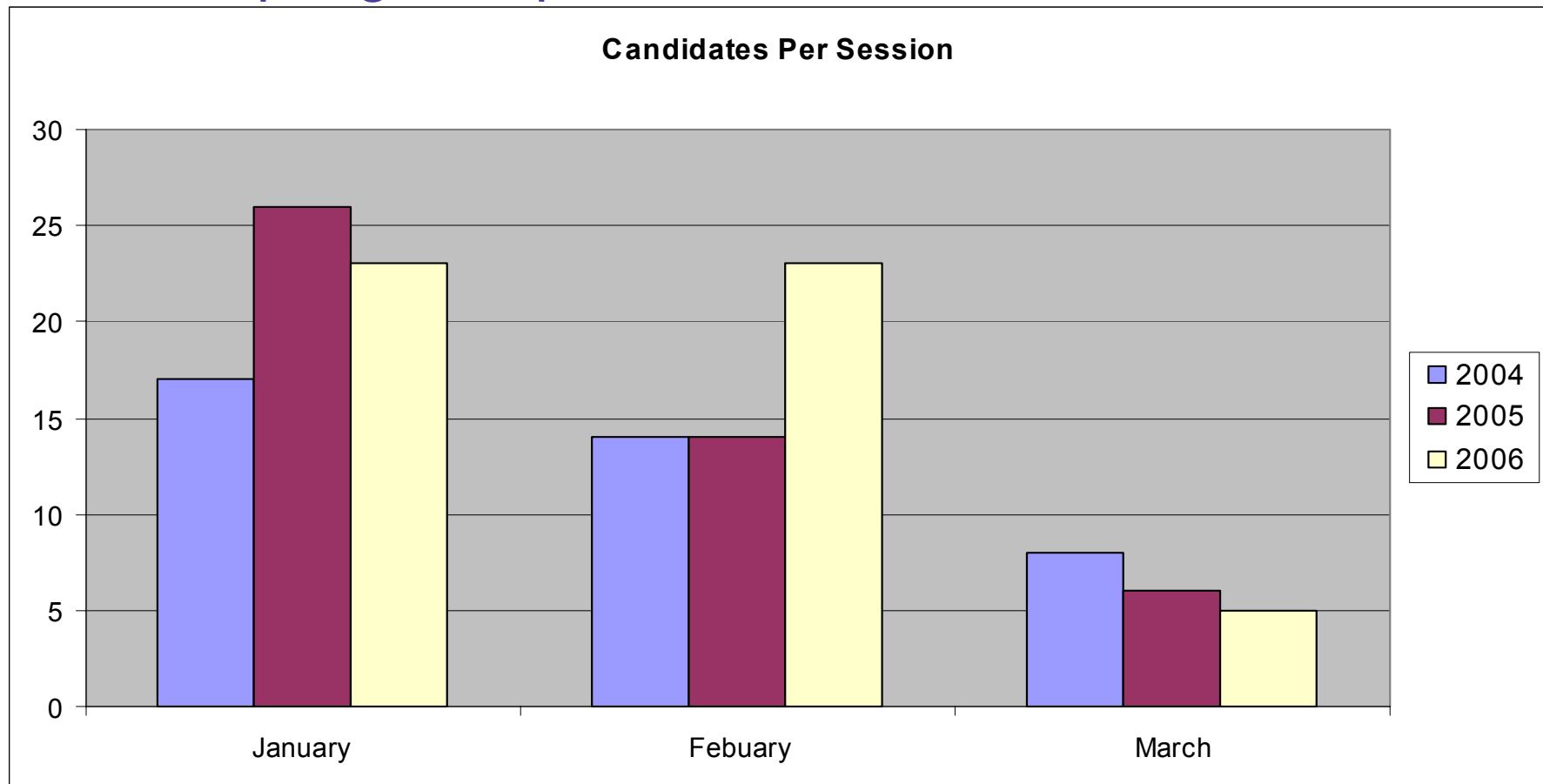
ENCLOSURE 4

# PDI Piping Program: General Update

- Piping & Bolting Program remains highly utilized...
  - Session load based on outage schedules
    - Heavy in early spring, late fall and summer
  - Foreign participation continues to increase
    - Korea, Japan, Spain, Switzerland, Taiwan, Brazil...
  - **Summer Sessions at or near maximum attendance**
    - Increasing capacity
    - Cross training staff
  - Consistently increasing support activities
    - Equipment qualifications
    - Site support
    - Utility questions
    - Vendor questions
    - Scan plan reviews

# Spring Sessions 2006

## Normal Spring Compared to Past Years



# Summer Sessions 2006

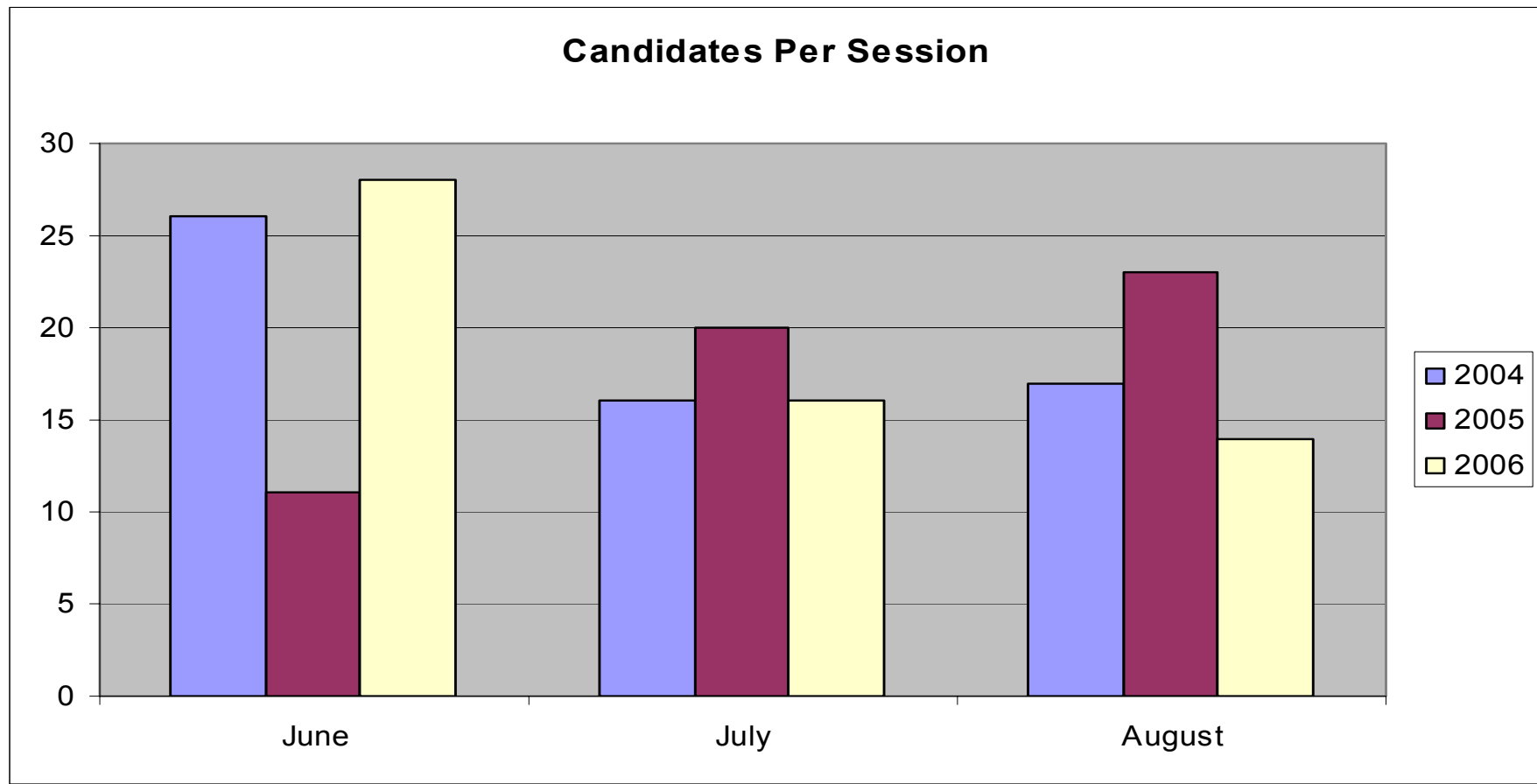
- Piping & Bolting Personnel Qualifications
  - Scheduled thru August (next 3 sessions)
- 87 **personnel** qualifications – Manual & Automated
  - June (Session 123): 41 Qualifications
  - July (Session 124): 29 Qualifications
  - August (Session 125): 17 Qualifications
    - More requests every day

# Summer Sessions 2006

- Piping & Bolting Procedure Qualifications
  - Scheduled thru August (next 3 sessions)
    - 5 **procedure** qualification activities scheduled
      - 4 OD procedure qualifications
        - Semi-Auto DM Phased Array procedure expansion
        - Semi-Auto IGSCC Phased Array procedure expansion
        - Manual IGSCC Phased Array procedure qualification
        - Manual Overlay Phased Array procedure qualification
      - 1 ID DM procedure qualification
    - Numerous equipment/search unit qualifications scheduled

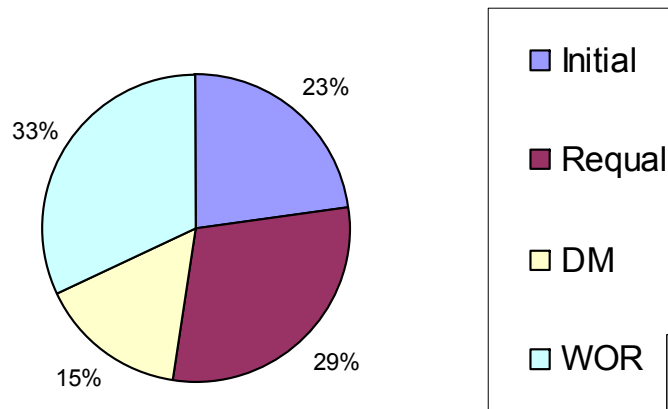
# Summer Sessions 2006

Personnel qualifications scheduled thru August...



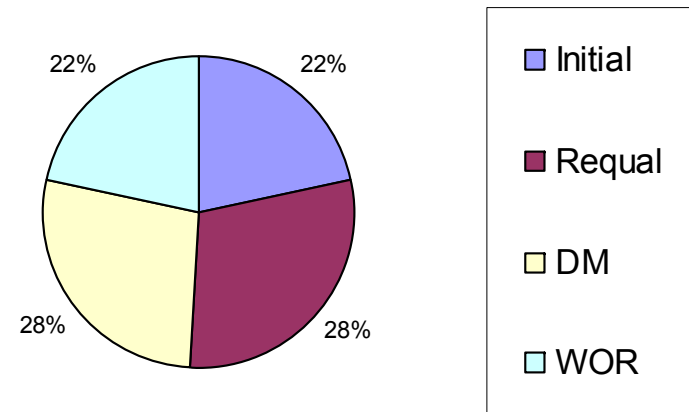
# Summer Qualification Types: 2004 vs. 2006

2004 (June, July, August)



- Qualification types have remained fairly consistent since 2004

2006 (June, July, August)



# Managing the Heavy Session Load

- Increasing Lab capacity
  - Redesigned the footprint of the IGSCC Lab
    - Can now handle 20 Candidates at once
      - Former capacity was 16
- Cross training existing EPRI Staff
  - Increased utilization of personnel
  - Maintain good Monitor to Candidate ratio



# Procedure Qualifications 2006

- 5 procedure qualification activities scheduled so far
  - 4 OD procedure qualifications scheduled
    - Semi-Auto DM Phased Array procedure expansion
      - Existing procedure/new hardware
    - Semi-Auto IGSCC Phased Array procedure expansion
      - Existing procedure/new hardware
    - Manual IGSCC Phased Array procedure qualification
      - New procedure/New equipment
    - Manual Overlay Phased Array procedure qualification
      - New procedure/New equipment
  - 1 ID Automated DM procedure qualification
    - Phased Array

# Equipment Qualification Activities

- Several equipment manufacturers
  - Search unit qualifications for PDI-UT-1, 2, 3 & 10
  - Instrument qualifications to PDI-UT-1, 2 & 3
- Vendors qualifying search unit/instrument combinations
  - PDI-UT-8
  - PDI-UT10
    - Becoming more common
    - Complex geometries require more specialized transducers
    - Several done so far this year, more expected...

# Generic Procedure Work

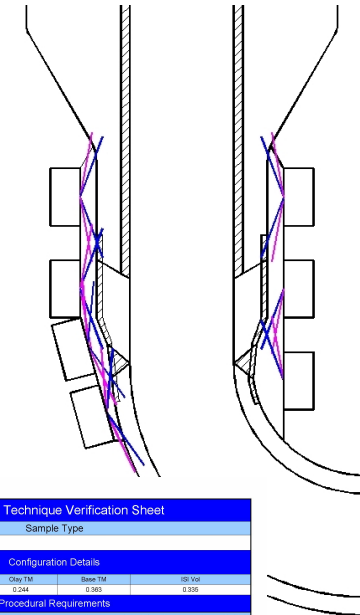
- New Addenda: PDI UT-1 & UT-2
  - 1/2" tolerance on pipe diameter for field applicability
    - brings the procedures into alignment with the tolerance specified in Code Case N-658, approved by ASME April 4, 2002 and accepted by the NRC in Regulatory Guidance 1.147 Revision 14.
  - Reference section changed to format of UT-8 & 10
    - UT-1 includes reference to PDI position letter for small diameter Ferritic piping welds. Allows for the procedure to be used down to 2" welds

# Generic Procedure Work

- PDI UT-8 & 10
  - New revisions based on industry lessons learned
    - Reduced confusion on focusing requirements
- DM manual sizing procedure
  - Initial work very promising
  - Successful demonstration on flat (BWR) configurations
  - No gaps closed/complex configurations still an issue
  - New transducer designs may offer improvements

# Generic Procedure Implementation

- EPRI staff working with utilities and vendors
  - Creating/verifying scan plans
    - DM welds
    - Weld overlays
  - Creating spreadsheet tools to aid in:
    - Equipment selection
    - Mathematical calculations
    - Procedure compliance
  - Equipment qualifications
    - Emergent qualification needs
    - Designing specialty search units
- Working together to close the gaps and assure successful examinations...



PDI WOR Technique Verification Sheet																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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# Generic Procedure Implementation

## • Examples of procedure implementation tools

Measured Angle for circumferential search units

Arc Length: 1.2 "S"  
SDH Depth: 1.2 Inches  
Radius: 12 "R<sub>0</sub>"  
Radius at Hole: 10.823 "R<sub>h</sub>"  
Angle: 5.6196 θ  
Metal Path to SDH: 1.623 "MP"  
SDH Diameter: 0.093 Inches

40.77 Angle at SDH

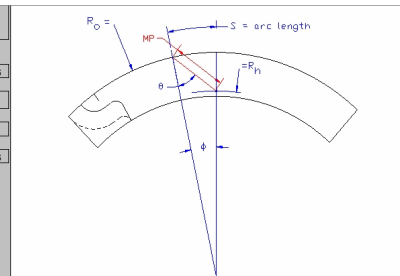
(1) Solve for φ

$$\phi = 360 / (2\pi) = \frac{S}{R_0}$$

(2) Solve for MP

$$MP = \sqrt{(R_h)^2 + (R_0)^2} - 2(R_h) \times R_0 (\cos \phi)$$

(3) Solve solve for θ

$$\sin \theta = \left( \frac{R_h}{MP} \right) \sin \phi$$


Curvature Correction Worksheet

Component ID: \_\_\_\_\_

Component Information:

OPTION # 1			OPTION # 2		
ID	OD	Thickness	ID	OD	Thickness
		0	8.24	11	1.38

Choose your option: OPTION # 2

Circ Scan Formulas:

ID/OD Ratio	OD/ID Ratio	Radius 1	Radius 2
0.7491	1.3350	4.12	5.50

MAXIMUM ANGLE TO IMPINGE ON THE ID: 48.51

ACTUAL ID ANGLE CALCULATION:

Transducer Angle: 45  
Actual ID Angle: 70.73

ANGLE REQUIRED TO PRODUCE A SPECIFIC ID ANGLE:

Desired Angle: 55  
Required Angle: 37.85

METAL PATH TO THE ID FOR A GIVEN ANGLE:

Transducer angle: 45  
Metal Path to ID: 2.53

METAL PATH TO FLAW or FLAW TIP:

Transducer angle:	Metal Path:	R.L.
45	1.95	1.164
Surface Position:	Adjusted Position:	Projection Distance
6.5	8.28	1.776

Scan Direction: Upr ▾

PDI-UT-10 Rev. B Technique Sheet

Component ID  
ENTER COMPONENT ID

Configuration Details

OD	Thickness
11.000	1.380

Procedural Requirements

The items below are the required examination angles, frequencies, search unit contour and size information in accordance with PDI-UT-10 Rev. B. The final technique shall be determined by the qualified examiner.

Contouring

Contour Determined by Footprint (Paragraph 6.9.1)						Maximum Contour Diameter (Paragraph 6.9.3)
Length	Should	Shall	Dz (A/A)2	Dz (A/A)3	Common	
20	No	No	200	133	7 x 10	15
25	Yes	No	313	208	8 x 14	
30	Yes	Yes	450	300	10 x 18	
40	Yes	Yes	800	533	15 x 25	
50	Yes	Yes	1250	833	20 x 34	
60	Yes	Yes	1800	1200	24 x 42	

Longitudinal Wave				Shear Wave			
Frequency (Paragraph 6.4.1)				Frequency (Paragraph 6.4.1) See Table Note for SCG Matl.			
AX		Circ		AX		Circ	
1.0 - 2.25		1.0 - 1.5		1.5 - 2.25		1.5 - 2.25	
Angle				Angle			
AX (Paragraph 6.6.1 & 6.7.2 a)				Circ (Paragraph 6.6.2 & 6.7.3 a)			
Degree	FS MIN	FS MAX	Degree	FS 75%	FS 125%	Degree	Degree
45	37	62	45	48	80	45	45
60	42	77				60	60
Max Circ. Scan Angle							
46							

Note: The angle listed above is the maximum angle (3°) that will impinge on the ID. An angle lower than the angle above may be used provided that it is on the table one for this procedure or it has been demonstrated on site specific mock-up in accordance with the PDI DM Weld Mock-up Criteria document located at www.eprl.com. The list below contains the maximum angle and lower angles with their focal ranges for reference. One of these and an additional angle may be needed to allow for full volume coverage. These angles are only to be used if the procedural required angle does not impinge on the ID. This angle may need to be adjusted if the component contains a taper (see below).

Angle	75%	125%	FS	Angle	75%	125%	FS	TAPER
46	49	62	66	30	32	53	43	NO
45	47	78	83	29	32	53	42	
44	45	75	80	28	31	52	42	
43	43	72	58	27	31	51	41	
42	42	70	56	26	30	51	40	
41	41	68	54	25	30	50	40	
40	39	66	53	24	30	49	40	
39	38	64	51	23	29	49	39	
38	37	62	50	22	29	48	39	
37	37	61	49	21	29	48	38	
36	36	60	48	20	29	48	38	
35	35	58	47	19	28	47	38	
34	34	57	46	18	28	47	37	
33	34	56	45	17	28	46	37	
32	33	55	44	16	28	46	37	
31	33	54	43	15	27	46	37	

# PDI Database Work

- DM Database fully operational
  - Beta version completed 3<sup>rd</sup> quarter 2005
  - Release version installed and operational December 2005
    - Functionality tests successful
    - Data migration successful
    - 2<sup>nd</sup> version release due soon, correct minor user interface issues
    - VB.Net front end, Sequel Server back end
    - Increased speed and stability
    - Improved data mining capabilities

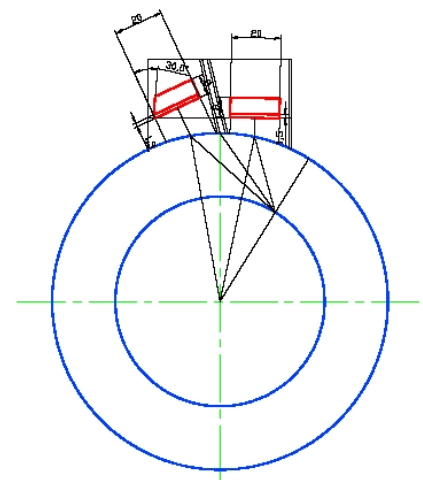
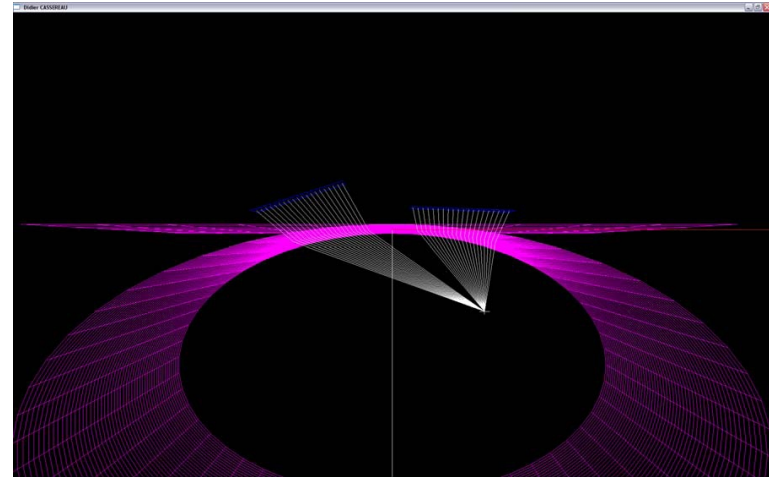
# PDI Database Work

- Piping Database
  - Alpha version at NDE Center
    - Initial testing underway
      - Everything looks good so far...
  - Same structure as new DM database
    - Seamless integration
    - Familiar user interface
  - Database compatibility, a big plus
    - Common platform increases ease of querying data
      - Same queries will work on both databases
      - Results easily compared between material types



# Advanced Conventional Transducer Designs for DM Welds

- MEOG funded transducer research project approaching completion
  - Final prototype probes to be delivered June 2006
  - Initial results very promising
    - Increased penetrating abilities
    - Increased signal to noise ratios
  - If final results are good, probes will be qualified for use with the PDI Generic Procedures and results shared with the industry



# Phased Array Qualification Status

- Several vendors have qualified Phased Array procedures
  - General Electric automated procedure
    - Similar metal piping welds from the OD, including IGSCC
      - Detection, length and depth sizing
      - Based on EPRI procedure
  - Zetec semi-automated procedures
    - Similar metal piping welds from the OD, including IGSCC
      - Detection, length and depth sizing
      - Joint effort with EPRI
    - DM welds from the OD
      - Detection, length and depth sizing
      - Joint effort with EPRI

# Phased Array Qualification Status

- Areva (Germany)
  - DM welds from the ID with Phased Array
- IHISWT
  - DM welds from the ID with Phased Array
- Several additional organizations planning Phased Array qualification work...
  - Existing procedure expansions
  - Manual Phased Array on piping welds, including IGSCC
  - Manual Phased Array on DM welds
  - Manual Phased Array on Overlays
- 2007 EPRI planning work on complex DM weld geometries
  - Initial work underway, looking toward qualification work next year
- New equipment coming to the market
- Phased Array becoming more and more mainstream

# DM Program Status Update

- Qualified NDE (detection & sizing) is available for large population of DM welds
- The PDI sample set spans the majority of configurations present in plants
  - New samples being fabricated to close the gaps
- Remaining limitations to detection are primarily due to geometry
  - Tapers
  - ID geometry
  - Weld crowns
  - Adjacent welds
  - Slope of vessel nozzle
  - Short safe-ends
  - Cast SS
- Where we have good access, UT detection reliability is very high

# DM Program Status Update

- Qualified for detection?

- Procedure must achieve 100% detection of all flaws presented during qualification
  - Minimum of at least 30 flaws in a range of configurations (thickness, diameter, flaw types/location, geometry)
- Not all personnel can achieve 100% detection
  - Average around 80%
- Detection qualification for OD examinations achieved for smooth OD conditions only
  - Addition of a minimum amount of geometry can cause dramatically reduced performance
- ID detection qualification achieved (4 teams qualified even with ID geometry conditions, others have achieved only circumferential detection)
  - In some cases alternative techniques such as ET have been used on ID examinations to fully characterize defects

# DM Program Status Update

- Qualified for depth sizing?
  - The procedure must achieve the Appendix VIII criterion of 0.125" RMS for a minimum of 30 flaws
  - Qualification has been achieved from the OD with automated systems (smooth surfaces up to ~5.2" in thickness)
  - Sizing error for ID exceeds 0.125 RMS, but is measurable and useable in flaw evaluations
  - 0.125" criteria may not be fully achievable for ID examinations
    - Vendors have made significant changes to software and techniques in order to achieve meaningful sizing results

# DM Program Status Update

- Qualification status from the OD
  - Automated
    - 5 vendors have qualified procedures for detection and length sizing
      - General Electric
      - Framatome ANP
      - WESDYNE
      - LMT
      - Zetec (semi-automated)
    - 4 vendors have qualified acceptable ( $<0.125''$  RMS ) depth sizing procedures
      - General Electric
      - Framatome
      - WESDYNE
      - Zetec (semi-automated)
  - Procedures are limited primarily to BWR configurations/thickness
    - No tapers or transitions, flush weld crowns

# DM Program Status Update

- Manual DM Qualifications
  - Number of People Qualified
    - $\approx$  80 people have detection
    - $\approx$  55 people have length sizing
    - 0 people have depth sizing
  - New procedure for manual depth sizing to be developed
    - Initial work on manual depth sizing shows promise on smooth configurations
      - No tapers/complex configurations
      - No gaps closed



# DM Program Status Update

- Qualification status from the ID
  - 5 vendors have qualified procedures for detection and length sizing
    - WESDYNE (USA)
    - AREVA (USA)
    - AREVA (GERMANY)
    - INTETEC (CROATIA)
    - IHISWT (USA)
  - A total of  $\approx 15$  candidates have successfully qualified for detection and length sizing
  - 3 vendors have demonstrated reliable depth sizing capability, but above code acceptance criteria
    - AREVA (USA)
    - AREVA (GERMANY)
    - WESDYNE
    - A total of  $\approx 12$  analyst have demonstrated depth sizing capability within the procedure limits

# Sample Fabrication Activities

- **Site specific mock ups**
  - Steam Generator Mockups
    - McGuire
    - Kewaunee
    - Prairie Island
    - Callaway
    - Beaver Valley
    - Watts Bar
    - Ft. Calhoun
    - Byron/Braidwood (currently in process)

# Sample Fabrication Activities

- **Site specific mock ups cont.**
  - Pump Stud Mockups
    - V.C. Summer
  - Head Spray Nozzle Mockup
    - Oyster Creek
  - Control Rod Drive Return Line Mockup
    - Nine Mile Point
  - Residual Heat Removal 24" Valve & Tee Mockups
    - J.A. FitzPatrick
  - Core Spray and Low Pressure Coolant Injection Surface Condition Mockups
    - Limerick

# Sample Fabrication Activities

- **PDI Program gap samples**
  - Small Diameter Pressurizer DM Welds
    - B&W Configurations
      - Cold Leg Drain Nozzle
      - Surge Nozzle
      - Hot Leg Surge Nozzle
      - Decay Heat Nozzle
    - Combustion Engineering Configurations
      - Surge Nozzle
      - Spray Nozzle
    - Westinghouse Configurations
      - Surge Nozzle
      - Spray Nozzle
      - Safety/Relief Nozzle

# Sample Fabrication Activities

- **R&D Samples**
  - MEOG/MTAG Rough Surface Condition Mockups
  - 703 series
  - 705 Series
  - 706 Series
  - 707 Series
- **Proposed or In-Process Mockup and Sample Activity**
  - Combustion Engineering Cast Safe End Mockups
  - Safety/Relief Nozzle Detection Sample
  - Surge Nozzle Detection Sample
  - Surge Nozzle PWOL
  - J.A. FitzPatrick 24" RHR Valve to Tee Mockup
  - PWOL 6" Spray Nozzle (Rhino Horn #2)

# Summary

- Program Utilization High
  - Increasing capacity
  - New business tools to increase efficiency
- Utilities/Vendors aggressively embracing new technology
  - Phased Array
- Generic Procedure work
  - New revisions
  - Working on new procedures
- Working with advanced conventional transducer designs
  - Initial results promising
- Procedure implementation tools
- Fabrication Program
  - Site specific mock ups
  - PDI program samples
  - R&D samples
- Lots and lots going on!!!!