NRC/AmerGen Meeting

Proposed License Change Application 291 for TMI-1 Volumetric ID IGA

April 25, 2001

Agenda

- Introductions - George Rombold
- Purpose of Meeting - George Rombold
- Licensing Overview of TMI 1 OTSGs - Bob Knight
- 10 Responses to Draft Questions
  - Questions 2 and 3 - Gene Navratil
  - Question 5 - Rick Barley
  - Question 1, 4, 6 and 7 - Gene Navratil
  - Question 8, 9 and 10 - Rich Freeman
- Summary and Conclusions

Purpose of Meeting

- Discuss Draft NRC Questions
- Provide Draft Response Technical Information for Consideration
- Obtain Technical Understanding/Agreement
- Review Schedule for Acceptance of LCA 291

Licensing Overview

- TMI-1 OTSG-History of ID IGA Repair Criteria
  - December 21, 1984-License Amendment No. 103 Permitted TMI-1 Return To Service With ID IGA Indications Following KE Repairs
  - April 18, 1986-License Amendment No. 116 Permitted 50% TW Flaws To Be Left In Service for Certain ID IGA Indications

Licensing Overview (Cont.)

- October 16, 1997-License Amendment No. 206 Permitted A One Cycle Repair Criteria for ID IGA For Cycle 12 Operation
- April 13, 1999-License Amendment No. 209 Permitted A One Cycle Repair Criteria for ID IGA For Cycle 13 Operation

Tech Spec ID IGA Repair Criteria

- Repair Tube if:
  - ≥40% TW As Measured by Bobbin Depth, or
  - If Measured Length Exceeds 0.25" Axial Length, or
  - If Measured Circumferential Length Exceeds 0.52"

Eddy Current Results Comparisons (Draft Question 2; cont'd)

- Number of ID IGA indications compared outage-to-outage:
  - Indications are identified in different ways:
    - » 0.540" bobbin exam + MRPC exam
    - » MRPC exam only (i.e, not detected by bobbin)
    - » Prior to MRPC 8x1 Array Probe Was Used
  - Some 0.540" bobbin indications have through wall estimates and voltages; some have voltages only
    - » 0.540" bobbin indications with small voltage and small S/N are not given through-wall estimate

Eddy Current Results Comparisons (Draft Question 2; cont'd)

- Indications detected by MRPC, but not by bobbin probe, have axial and circumferential extents; but do not have bobbin voltages or throughwall estimates.
- Therefore, for ID IGA:

The number of axial and circ. extent measurements
is greater than
the number of bobbin voltage measurements,
which is greater than
the number of bobbin through wall estimates

Eddy Current Results Comparisons (Draft Question 2; cont'd)

- In recent outages, increased bobbin and MRPC exam scopes have increased number of identified ID IGA indications.

- In recent outages, plugging has removed ID IGA indications from service (eliminating the opportunity for outage-to-outage comparisons for those tubes)

Eddy Current Results Comparisons (Draft Question 2; cont'd)

	Outage 11R 1995[1]	Outage 12R 1997	Outage 13R 1999
Bobbin Scope (Tubes)	6,821	29,415	29,367
Bobbin BVC and ID %TW Indications (indications/tubes/indications confirmed by MRPC)[2]	471/235/NA	581/284/480	422/254/373
Tubes Receiving first bobbin examination since 1985 Restart	3,690	14,356	0
MRPC Scope (Tubes)	731	8330	13,220
ID IGA MRPC Indications Recorded during outage (Indications/Tubes)[3]	70/40	970/383	1,385/607
ID IGA MRPC Indications Remaining Inservice after Repairs (Indications/tubes)	66/37	871/349	1,123/578
ID IGA Indications Removed From Service (Indications/tubes)	4/3	99/34	262/29

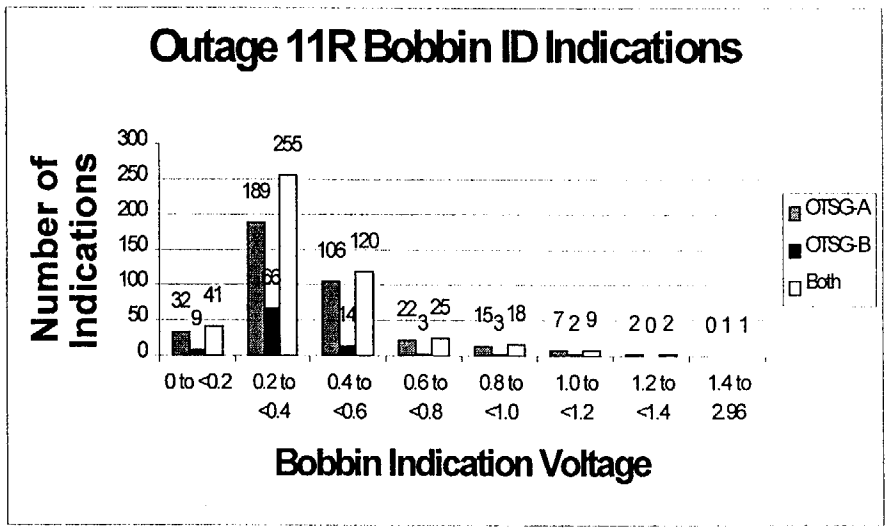
[1] MRPC ID IGA counts for Outage 11R are based on "SVI" signals with a corresponding ID phase plane phase angle and corresponding bobbin coil ID phase plane signal. Indications confirmed by MRPC were not evaluated because very few of the indications were examined with the MRPC probe during Outage 11R.

[2] These are all indications/tubes with 0.540" diameter bobbin coil signals <31 degrees and recorded as "BVC" or as a percent through wall.

[3] Includes bobbin probe indications confirmed as ID IGA by MRPC and ID IGA indications detected by the MRPC probe only.

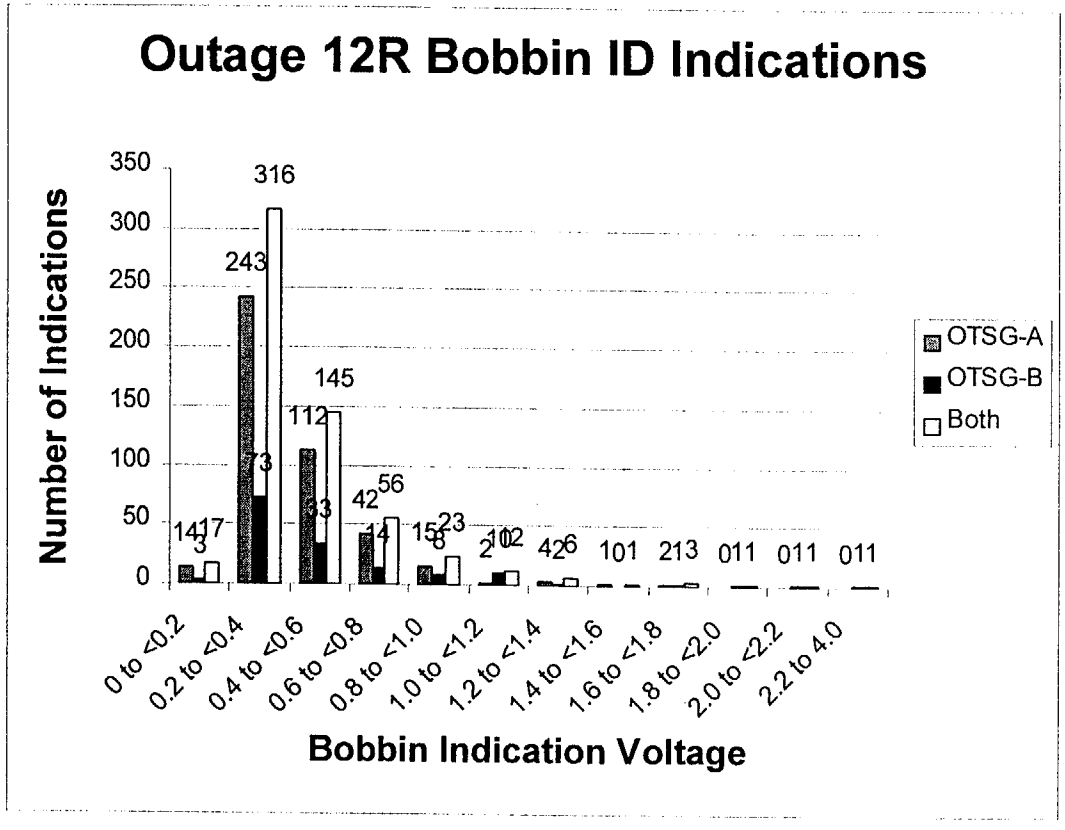
Eddy Current Results Comparisons (Draft Question 2; cont'd)

Outage 11R 0.540" Bobbin Coil Probe ID Indication Flaw Distribution



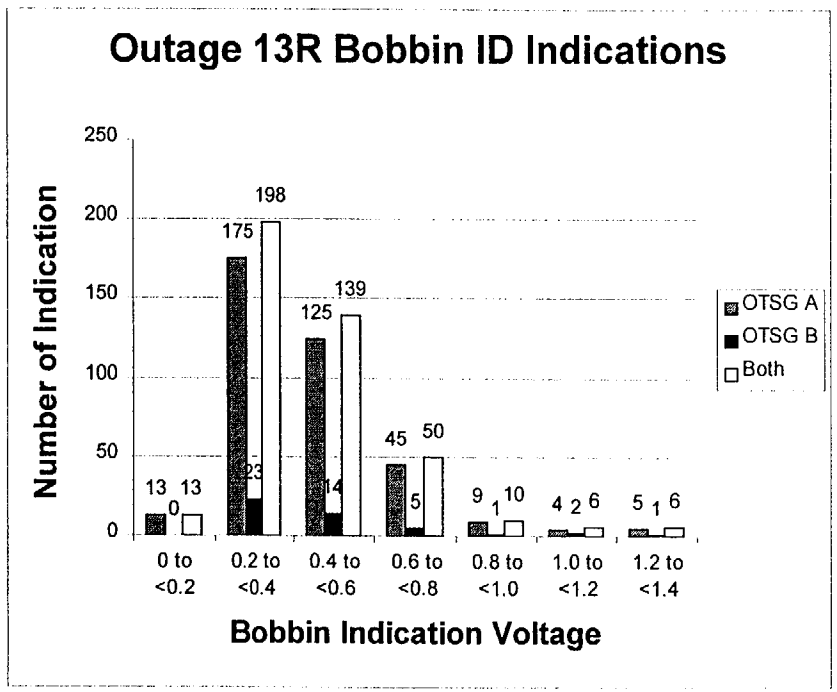
Eddy Current Results Comparisons (Draft Question 2; cont'd)

Outage 12R 0.540" Bobbin Coil Probe ID Indication Flaw Distribution



Eddy Current Results Comparisons (Draft Question 2; cont'd)

Outage 13R 0.540" Bobbin Coil Probe ID Indication Flaw Distribution



10R & 11R Indication Comparison (Draft Question 3)

- 12R Outage (1997) submittal stated "approximately 100" MRPC comparisons of 10R and 11R data with 12R data would be made.
- 13R Outage report had only 11 indications compared from 10R (and 25 from11R).

10R & 11R Indication Comparison (Draft Question 3; cont'd)

- Excerpt from 12R Outage (1997) Report shows 77 10R and 11R MRPC measurements were compared to 12R measurements:

Table III-13

ID IGA Average Change in Length/Width Measurements

Outages	Number of Indications	Average Change in Circumferential Extent	Average Change in Axial Extent
10R → 11R	2	-0.02 in.	-0.09 in.
11R → 12R	14	0.01 in.	-0.01 in.
10R → 12R	63	0.03 in.	-0.02 in.

10R & 11R Indication Comparison (Draft Question 3; cont'd)

- Excerpt from 13R Outage (1999) Report

Average Growth for ID IGA Indications

TMI-1 Outage 13R Compared to Outages 10R Through 12R

	NDE Measurement	Operating Period	SG A		SG B		Both SGs	
			No. of Inds	Avg. Change	No. of Inds	Avg. Change	No. of Inds	Avg. Change
Bobbin ID IGA Indications	Bobbin Volts	12R to 13R	313	0.004 V	43	0.010 V	356	0.005 V
		11R to 13R	237	0.030 V	32	0.090 V	269	0.037 V
	Bobbin %TW	12R to 13R	146	0.3%	24	-3.8%	170	-0.3%
		11R to 13R	86	0.7%	9	-5.9%	95	0.1%
ID IGA Below Kinetic Expansion (MRPC)	Axial Extent	12R to 13R	572	0.011"	43	0.018"	615	0.011"
		11R to 13R	25	-0.013"	0	NA	25	-0.013"
		10R to 13R	10	-0.032"	1	0.00"	11	-0.029"
	Circ Extent	12R to 13R	572	0.005"	43	0.003"	615	0.005"
		11R to 13R	25	-0.013"	0	NA	25	-0.013"
		10R to 13R	10	-0.016"	1	0.030"	11	-0.012"
ID IGA In Kinetic Expansions (MRPC)	Axial Extent	12R to 13R	128	0.003"	20	0.006"	148	0.003"
		11R to 13R	1	-0.04"	1	-0.01"	2	-0.025"
		10R to 13R	0	NA	0	NA	0	NA
	Circ Extent	12R to 13R	128	-0.012"	20	-0.005"	148	-0.012"
		11R to 13R	1	-0.06"	1	-0.01"	2	-0.035"
		10R to 13R	0	NA	0	NA	0	NA

10R

11R

10R & 11R Indication Comparison (Draft Question 3; cont'd)

- How were "the other" (i.e., 77 minus 36 = 41) indications dispositioned?
  - Of 41 indications:
    - » some were plugged and therefore not available for measurement in 13R
    - » some were not examined in 13R (e.g. in kinetic expansions; less than degraded criteria)
    - » some were small and not detected by bobbin in 13R (and therefore not examined by MRPC exam)
  - All Available Data Was Used For Comparison

Outage Growth Assessments (Draft Question 5)

- Question addresses growth assessments each outage.
- TMI-1 has monitored ID IGA indications for growth in all outages since the plant's restart in 1985.
- 0.540" bobbin probe retained as reference (1985 to present)
- 8 X 1 probes used for circ. extent estimates in 1980's; MRPC probes used today

Outage Growth Assessments (Draft Question 5; cont'd)

- Growth assessments have considered both newly detected and previously detected ID IGA indications.
  - Each outage since 1985 Restart TMI-1 has:
    - » assessed whether newly detected indications are consistent with the locations, voltages, and throughwall estimates of previously identified indications.
    - » assessed whether, on the average, the voltages and percent throughwall estimates of individual ID IGA indications have increased (-for the ID IGA indications that could be compared).
    - » using MRPC data in the more recent outages assessed whether, on the average, the circumferential extents or axial extents of individual ID IGA indications have increased (-for the ID IGA indications that could be compared.)
    - » created data scatter plots to visualize the data so as to assess whether the indication population has exhibited growth.

Outage Growth Assessments (Draft Question 5; cont'd)

- Tube pulls have also been used to assess the presence of active IGA (i.e., chemical contaminant analysis). Most recently in 1997.
- "Individual" indication growths to identify outliers
  - bobbin voltage
  - bobbin throughwall estimate
  - axial extent (MRPC)
  - circ. extent (MRPC)

Outage Growth Assessments (Draft Question 5; cont'd)

A Comparison of Indications in Degraded Tubes
[Reprint of Table III-6 from 1995 11R Outage Report]

Period	Number of Indications	Mean Change (%TW)	Std Deviation (% TW)	Mean Change (Volts) **	Std Deviation (Volts) **
1984 to 1986 (Outage 5M)	152	-2.6	6.1	-0.2	0.3
1986 (5M) to 1986 (6R)	118	+1.1	6.6	+0.0	0.2
1986 (6R) to 1988 (7R)	119	+2.6	5.5	+0.2	0.3
1988 (7R) to 1990 (8R)	291	-0.2	7.43	-0.25	0.35
1990 (8R) to 1991 (9R)	229	-2.0	6.96	+0.07	0.31
1991 (9R) to 1993 (10R)	207	-0.6	6.62	+0.16	0.28
1993 (10R) to 1995 (11R)	197	+0.9	6.39	-0.26	0.4

** Note: These voltages are based on a 10V bobbin normalization. These values must be multiplied by 0.4 to compare to current outage voltages.

- Supports no growth conclusion

Outage Growth Assessments (Draft Question 5; cont'd)

Average Growth for ID IGA Indications

TMI-1 Outage 13R Compared to Outages 10R Through 12R

	NDE Measurement	Operating Period	SG A		SG B		Both SGs	
			No. of Inds	Avg. Change	No. of Inds	Avg. Change	No. of Inds	Avg. Change
Bobbin ID IGA Indications	Bobbin Volts	12R to 13R	313	0.004 V	43	0.010 V	356	0.005 V
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		11R to 13R	25	-0.013"	0	NA	25	-0.013"
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	Circ Extent	12R to 13R	572	0.005"	43	0.003"	615	0.005"
		11R to 13R	25	-0.013"	0	NA	25	-0.013"
		10R to 13R	10	-0.016"	1	0.030"	11	-0.012"
ID IGA In Kinetic Expansions (MRPC)	Axial Extent	12R to 13R	128	0.003"	20	0.006"	148	0.003"
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		10R to 13R	0	NA	0	NA	0	NA
	Circ Extent	12R to 13R	128	-0.012"	20	-0.005"	148	-0.012"
		11R to 13R	1	-0.06"	1	-0.01"	2	-0.035"
		10R to 13R	0	NA	0	NA	0	NA

- Supports no growth conclusion

Outage Growth Assessments (Draft Question 5; cont'd)

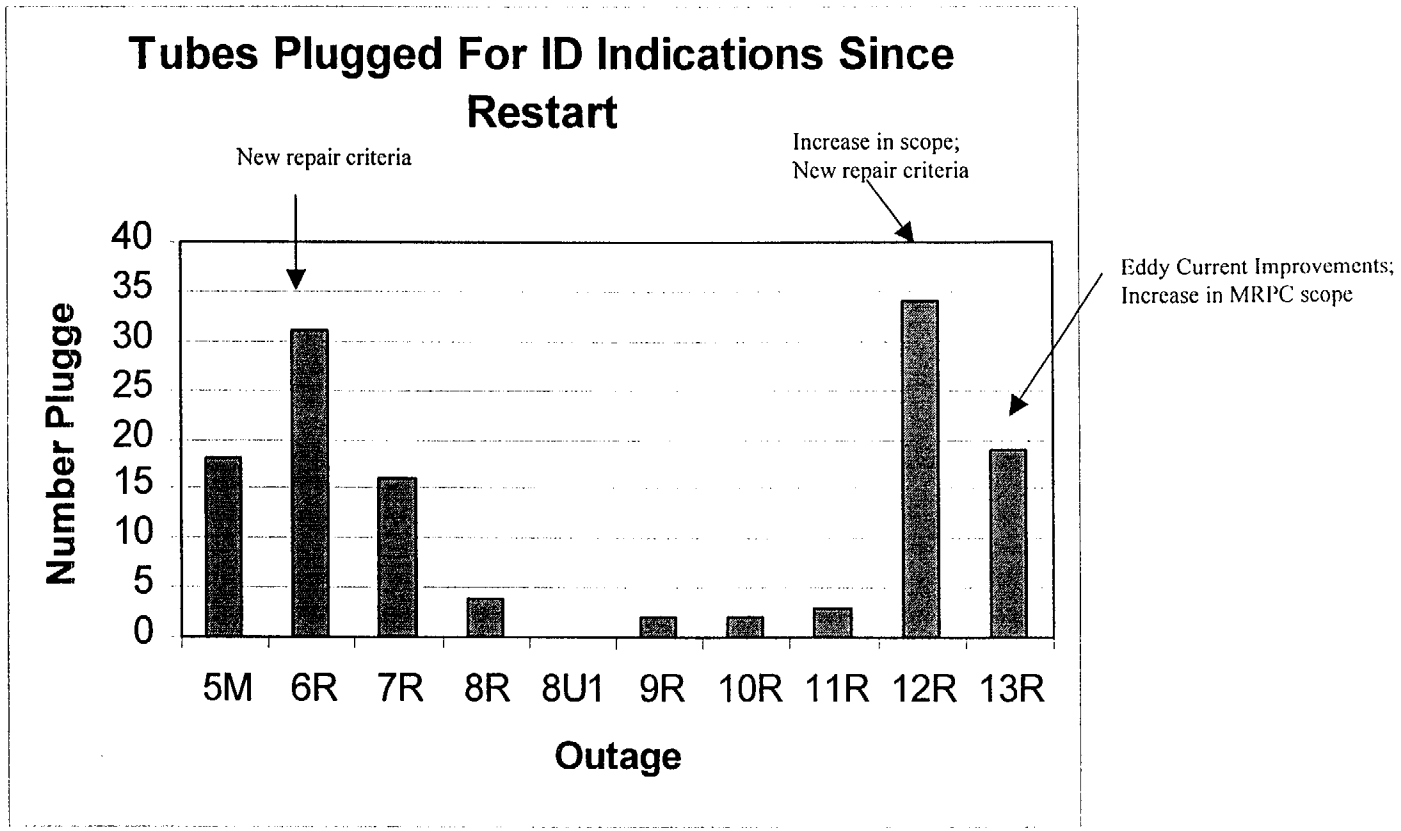
- Growth Assessment Methodology Summary
  - Tabulated and averaged changes in ECT flaw parameters from outage to outage populations.
  - Calculated standard deviations for parameter changes and charted distributions.
  - Evaluated changes as within reasonable ECT repeatability absolute value variations (<6% TW, <0.1 volt, typ.)
  - Interrogated population scatter plot outliers for individual tube growth indications.
  - If above data provided support, concluded no growth.

ID IGA Apparent Growth (Draft Question 1)

- Tube Repairs are Result of:
  - ECT Variability
  - Changes in Tech. Spec. Repair Criteria
  - NDE Improvements
  - Increased Examination Scope

- Plugging ≠ Growth in this case
  - Indications are in service with extents, and/or estimated depths, near conservative plugging criteria.
  - Approx. 130 tubes plugged since 1985 restart due to ID indications in freespan
  - Approx. 30,000 tubes in service

ID IGA Apparent Growth (Draft Question 1; cont'd)



ID IGA Apparent Growth (Draft Question 1; cont'd)

- 1997 Improvements
  - First Time Use At TMI-1 for +Point and 0.080" HF Pancake
- 1999 Improvements
  - Improvement in Data Quality From 1997 to 1999 Examinations (Expect Further Improvements Again in 2001)
  - More MRPC Data Available for Analyst Site Specific Test in 1999

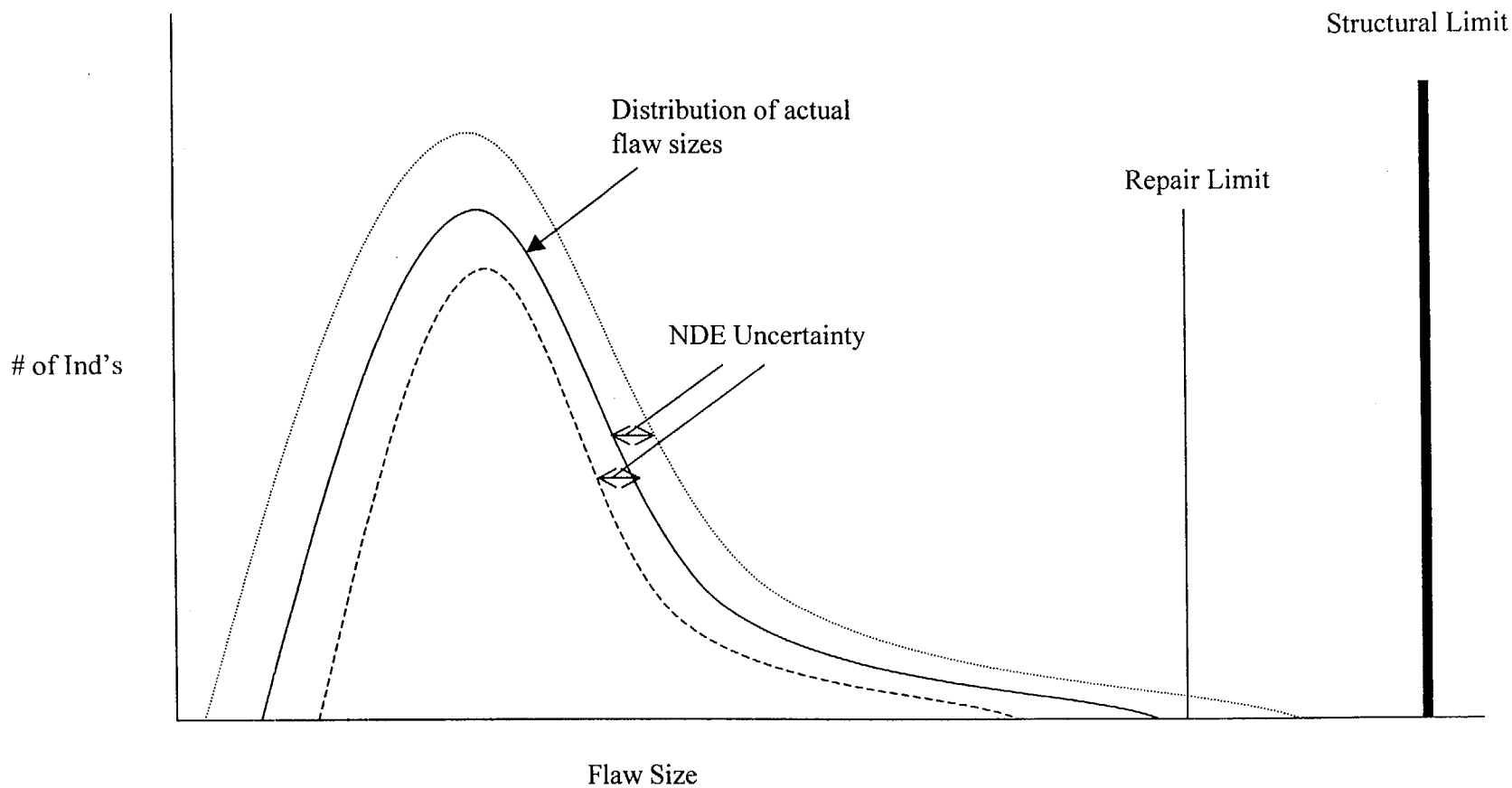
ID IGA Apparent Growth (Draft Question 1; cont'd)

- Changed MRPC Examination Probe Pull Direction In 1999 For More Consistent Measurement of Axial Length
- Increased MRPC Minimum Axial Samples Per Inch (25 samples per inch in 1997 and 30 samples per inch in 1999)
- 1999 Examination Was The Second 100% Bobbin Examination and First Follow-up Examination For MRPC Length and Width

ID IGA Apparent Growth (Draft Question 1;cont'd)

- Specific Outliers (within performance expectations) and Plugged Tubes Are Expected To Be Identified Again In 2001
  - For example, after 13R:
    - 17 ID IGA Indications Measured at 37% TW
    - 30 ID IGA Indications Measured at 0.23" to 0.25" Axial Length
    - About 10,500 New MRPC Exams Planned 1R14

Volumetric ID IGA Apparent Growth



Based upon the present distribution of indications and NDE variability some indications will exceed the Repair Limit each outage

NDE Variabilities (Draft Question 4)

- Bobbin probe wear
  - Probe wear monitoring implemented in Outage 12R (1997), 13R (1999), and future outages.
  - If final bobbin wear standard voltages differ by more than 15% from "start" bobbin wear standard voltages, then data is voided.

NDE Variabilities
(Draft Question 4; cont'd)

- Calibration Standards and Practices
  - Met requirements of ASME Section XI (1986 with no addenda) and EPRI PWR Steam Generator Examination Guidelines. (Outage 1R14 will use ASME 1995 edition with 96 addenda, and guidelines.)
  - Bobbin coil voltages are normalized by setting all voltage measurements equivalent to 4 Volts from the four 20% TW holes of the BWOG "Mother" ASME standard (to minimize small voltage differences between different calibration standards).

NDE Variabilities
(Draft Question 4; cont'd)

- Expected Analyst Variability
  - Prior to Outages 12R and 13R, TMI-1 performed analyses to quantify expected analyst variabilities for volumetric ID IGA MRPC flaw measurements.
  - Pre-13R Study: 95% Lower Confidence Limit for examination technique and analyst variability for axial length measurement was 0.047"; for circumferential length was 0.048".

NDE Variabilities
(Draft Question 4; cont'd)

- Expected Analyst Variability (cont'd)
  - These variabilities are imperceptible in comparison to the overestimate of ID IGA flaw axial and circumferential extents from the MRPC probe (i.e., "overcall")
  - Reference: 1998 TMI-1 Submittal for Tech Spec Change: GPU Nuclear to USNRC, "Technical Specification Change Request (TSCR) No. 277", November 25, 1998. (See next slide.)

NDE Variabilities
(Draft Question 4; cont'd)

Comparison of Field Eddy Current Estimated and Laboratory Determined ID IGA Axial Extents of TMI-1 Pulled Tube Flaws

TMI-1 Tube A 52-34 Flaw Type (as called by MRPC)	Location (Field)	Field Axial Length (by MRPC)	Maximum Laboratory Axial Length (How Determined.)	Ratio of Field Axial Length to Lab Axial Length
ID Volumetric IGA	7 + 36.8"	0.11"	0.024" (Radial Grinding / Photo Exam)	4.6
ID Volumetric IGA	13 + 23.1"	0.16"	0.033" (Radial Grinding / Photo Exam)	4.8
ID Volumetric IGA	14 + 12.8"	0.16"	0.054" (Radial Grinding / Photo Exam)	3.0
ID Volumetric IGA	14 + 31.9"	0.16"	0.042" (Radial Grinding / Photo Exam)	3.8
ID Volumetric IGA	15 + 14.7"	0.10"	0.029" (Radial Grinding / Photo Exam)	3.4
ID Volumetric IGA	15 + 24.9"	0.10"	0.030" (Radial Grinding / Photo Exam)	3.3
ID Volumetric IGA	UTS + 0.06"	0.20"	0.040" (Radial Grinding / Photo Exam)	5.0
ID Volumetric IGA	13 + 2.9"	0.10"	≅ 0.066" (By longitudinal grind at 1 of 2 fracture surfaces* / Photo exam)	≅ 1.5
ID Volumetric IGA	15 + 38.2"	0.10"	≅ 0.020" (By longitudinal grind at 1 of 2 fracture surfaces* / Photo exam)	≅ 5

* These two flaws were located at the fracture surfaces resulting from the laboratory burst testing. The flaws were torn in half during the testing and one of the two fracture surfaces was ground to determine the flaw morphology.

NDE Variabilities
(Draft Question 4; cont'd)

Comparison of Field Eddy Current Estimated and Laboratory Determined ID IGA Circumferential Extents of TMI-1 Pulled Tube Flaws

TMI-1 Tube A 52-34 Flaw Type (as called by MRPC)	Location (Field)	Field Circumferential Width (by MRPC)	Maximum Laboratory Circumferential Width (How Determined)	Ratio of Field Circumferential Width to Lab Circumferential Width
ID Volumetric IGA	7 + 36.8"	0.11"	0.022" (Radial Grinding/ Photo Exam)	5.0
ID Volumetric IGA	13 + 23.1"	0.11"	0.020" (Radial Grinding/ Photo Exam)	5.5
ID Volumetric IGA	14 + 12.8"	0.19"	0.025" (Radial Grinding/ Photo Exam)	7.6
ID Volumetric IGA	14 + 31.9"	0.11"	0.019" (Radial Grinding/ Photo Exam)	5.8
ID Volumetric IGA	15 + 14.7"	0.06"	0.018" (Radial Grinding/ Photo Exam)	3.3
ID Volumetric IGA	15 + 24.9"	0.11"	0.018" (Radial Grinding/ Photo Exam)	6.1
ID Volumetric IGA	UTS + 0.06"	0.14"	0.025" (Radial Grinding/ Photo Exam)	5.6
ID Volumetric IGA	13 + 2.9"	0.11"	≅ 0.032" (By longitudinal grind at 1 of 2 fracture surfaces* /Photo exam)	≅ 3.4
ID Volumetric IGA	15 + 38.2"	0.06"	≅ 0.016" (By longitudinal grind at 1 of 2 fracture surfaces* /Photo exam)	≅ 3.8

* As mentioned above, these two flaws were located at the fracture surfaces resulting from the laboratory burst testing. The flaws were torn in half during the testing and one of the two fracture surfaces was ground to determine the flaw morphology. The circumferential extent listed in Table 3 for these two flaws were estimated by doubling the circumferential extent that was determined for one of the two fracture surfaces.

NDE Variabilities
(Draft Question 4; cont'd)

- TMI-1 provided information on acquisition hardware for Outage 13R. (Reference: GPU Nuclear Letter to USNRC, TSCR No. 277, Supplement 1, GPU Nuclear Response to NRC RAI, February 12, 1999.) See next slide. Table has been updated to provide information for planned inspections in Outage 1R14 (September 2001)

- No eddy current changes planned for 1R14

NDE Variabilities
(Draft Question 4; cont'd)

Characteristic	Used During Outage 11R	Used During Outage 12R	Used During Outage 13R	Planned for Outage 1R14	Comment
Remote Data Acquisition Unit	Zetec MIZ-30	Zetec MIZ-30	Zetec MIZ-30	Zetec MIZ-30	No Difference
Drive Gain and Voltage	Gain Times 2 and Voltage Set to 12 Volts for All Flaw Detection Channels	Gain Times 2 and Voltage Set to 12 Volts for All Flaw Detection Channels	Gain Times 2 and Voltage Set to 12 Volts for All Flaw Detection Channels	Gain Times 2 and Voltage Set to 12 Volts for All Flaw Detection Channels	No Difference
Bobbin Coil Flaw Detection Probe, Lengths	Zetec 0.510" Diameter High Frequency, 83' and 100'	Zetec 0.510" Diameter High Frequency, 100'	Zetec 0.510" Diameter Mid Frequency, 100'	Zetec 0.510" Diameter Mid Frequency, 100'	Note 1
Bobbin Coil ID IGA Flaw Evaluation Probe; Lengths	Zetec 0.540" Diameter High Frequency, 83' and 100'	Zetec 0.540" Diameter High Frequency, 100'	Zetec 0.540" Diameter High Frequency, 100'	Zetec 0.540" Diameter High Frequency, 100'	Note 1
Bobbin Coil Detection/ Evaluation Channels	400 kHz in the freespan or 400/200 kHz Mix at support structures	400 kHz in the freespan or 400/200 kHz Mix at support structures	400 kHz in the freespan or 400/200 kHz Mix at support structures	400 kHz in the freespan or 400/200 kHz Mix at support structures	No Difference
MRPC Probe	Zetec 3-Coil Head with 0.115" MR Pancake, Axial, and Circ Coils	Zetec 3-Coil Head with 0.115" MR Pancake, + Point MR, and 0.080" HF (shielded)	Zetec 3-Coil Head with 0.115" MR Pancake, + Point MR, and 0.080" HF (shielded)	Zetec 3-Coil Head with 0.115" MR Pancake, + Point MR, and 0.080" HF (shielded)	Note 2
Extension Cables	Zetec-50' Shielded Low Loss	Zetec-50' Multipurpose	Zetec-50' Multipurpose	Zetec-50' Multipurpose	Note 3
Slip Ring	Zetec	Zetec	Zetec	Zetec	No Difference
Bobbin Coil Sample Rate	≥30 Samples per Inch of Tubing	≥30 Samples per Inch of Tubing	≥30 Samples per Inch of Tubing	≥30 Samples per Inch of Tubing	No Difference
MRPC Sample Rate	> 30 Samples/Inch Circ and ≥ 25 Samples/Inch Axial	> 30 Samples/Inch Circ and ≥ 25 Samples/Inch Axial	> 30 Samples/Inch Circ and ≥ 30 Samples/Inch Axial	> 30 Samples/Inch Circ and ≥ 30 Samples/Inch Axial	No Difference Because These Are Minimum Values
MRPC Evaluation Channel	300 kHz Pancake or 300/100 kHz Pancake Mix for Detection. 300 kHz Axial and Circ for Morphology.	300 kHz + Point or 300/100 kHz + Point Mix for Detection and Morphology.	300 kHz + Point or 300/100 kHz + Point Mix for Detection and Morphology.	300 kHz + Point or 300/100 kHz + Point Mix for Detection and Morphology.	Note 4
MRPC Axial and Circ Length Measurement Channel for Volumetric ID IGA	Not Performed for Tube Dispositioning. 300 kHz 0.115" Pancake for Flaw Growth Studies.	600 kHz 0.080" HF Coil for Tube Dispositioning. 300 kHz 0.115" Coil for Flaw Growth Studies.	600 kHz 0.080" HF Coil for Tube Dispositioning. 600 kHz 0.080" HF Coil for Flaw Growth Studies (Where 0.080" Data is Available). 300 kHz 0.115" Coil for Flaw Growth Studies (Where 0.115" Data is Available).	600 kHz 0.080" HF Coil for Tube Dispositioning. 600 kHz 0.080" HF Coil for Flaw Growth Studies (Where 0.080" Data is Available). 300 kHz 0.115" Coil for Flaw Growth Studies (Where 0.115" Data is Available).	Note 5
Bobbin Coil Voltage Normalization	Set the 400 kHz Differential Response to 10 Volts From the Four ASME 20% TW Holes in Each Standard and Store to All Other Channels.	Set the 400 kHz Differential Response Equivalent to 10 Volts From the Four 20% TW Holes in the BWOG Mother ASME Standard and Store to All Other Channels.	Set the 400 kHz Differential Response Equivalent to 4 Volts From the Four 20% TW Holes in the BWOG Mother ASME Standard and Store to All Other Channels.	Set the 400 kHz Differential Response Equivalent to 4 Volts From the Four 20% TW Holes in the BWOG Mother ASME Standard and Store to All Other Channels.	Note 6

NDE Variabilities
(Draft Question 4; cont'd)

Characteristic	Used During Outage 11R	Used During Outage 12R	Used During Outage 13R	Planned for Outage 1R14	Comment
Bobbin Coil Phase Rotation (0.510" and 0 540" Diameter)	Set the ASME 0.052" 100% TW Hole Response to 30° on the 400 kHz and 400/200 kHz Mix Channels.	Set the ASME 0.052" 100% TW Hole Response to 30° on the 400 kHz and 400/200 kHz Mix Channels.	Set the ASME 0.052" 100% TW Hole Response to 30° on the 400 kHz and 400/200 kHz Mix Channels.	Set the ASME 0.052" 100% TW Hole Response to 30° on the 400 kHz and 400/200 kHz Mix Channels.	No Difference
MRPC Voltage Normalization	Set the ASME 100% TW Hole 300 kHz Pancake Coil Response to 10 Volts and Store to All Other Channels	Set the ASME 100% TW Hole 300 kHz Pancake Coil Response to 10 Volts and Store to All Other Channels Except +Point. Set the ASME 100% TW Hole 300 kHz + Point Response to 10 Volts and Store to All Other + Point Channels.	Set the EPRI Guidelines 100% TW Axial Notch 300 kHz Response for Each Axial and Pancake Coil Channel to 20 Volts and Store to All Other Axial Channels With That Coil. Set the EPRI Guidelines 100% TW Axial Notch 300 kHz Response for Each Circumferential Channel to 20 Volts and Store to All Other Circumferential Channels. If the 100% TW Notch Response Saturates, Set the EPRI Guidelines 60% TW ID Notch 300 kHz Response for That Channel to 7 Volts and Store to All Other Channels Using the Same Coil.	Set the EPRI Guidelines 100% TW Axial Notch 300 kHz Response for Each Axial and Pancake Coil Channel to 20 Volts and Store to All Other Axial Channels With That Coil. Set the EPRI Guidelines 100% TW Axial Notch 300 kHz Response for Each Circumferential Channel to 20 Volts and Store to All Other Circumferential Channels. If the 100% TW Notch Response Saturates, Set the EPRI Guidelines 60% TW ID Notch 300 kHz Response for That Channel to 7 Volts and Store to All Other Channels Using the Same Coil.	Note 7
MRPC Phase Rotation	Set Probe Motion Horizontal and Flaw Response Forming in the Up Direction on All Channels.	Set EPRI Guidelines 40% TW ID Axial Notch Response to 15° on Raw Frequency Channels. Set + Point Circ Sensitive Process Channel Response Rotated 180° From Raw Frequency Channel Above.	Set EPRI Guidelines 40% TW ID Axial Notch Response for Axial and Pancake Coil Channels to 15° on Raw Frequency Channels. Set EPRI Guidelines 40% TW ID Circumferential Notch Response for Circumferential Detection Channels to 15° on Circumferential Detection Channels.	Set EPRI Guidelines 40% TW ID Axial Notch Response for Axial and Pancake Coil Channels to 15° on Raw Frequency Channels. Set EPRI Guidelines 40% TW ID Circumferential Notch Response for Circumferential Detection Channels to 15° on Circumferential Detection Channels.	Note 8

Draft Question 4 (cont'd)
NOTES

1. 83' and 100' probe cable lengths were used during Outage 11R. 100' probe cable lengths were used during Outages 12R and 13R and are planned for future outages. This practice provides more consistency during the later outages. An 83' probe cable length could potentially provide a slightly larger signal than that provided by a 100' probe cable length. To avoid this effect and assure consistency, the displayed signal size is "normalized" during calibration where the signal is related to a specific flaw and a voltage value is assigned to that response regardless of signal size. Voltages are set using the entire examination system to eliminate any voltage variations due to cabling differences between the 83' and 100' cable length probes. This change does not effect flaw growth studies.

2. TMI-1 has evaluated in-steam generator ID IGA flaw responses for both the mid frequency and high frequency 0.510" bobbin coil probes and determined that the probes provide equal ID IGA flaw detection capability. TMI-1 is changing to the mid frequency 0.510" bobbin coil probe to use the same coil as the other OTSG design plants.

3. The + Point probe is recognized for providing better quality data for initial flaw detection and information for determining the flaw morphology (i.e., determining whether a flaw is axially or circumferentially oriented, volumetric, and whether the surface of origin is ID or OD), without the need for other coils. Studies performed for AmerGen Energy determined that the 0.080" HF shielded coil probe provides the most accurate, yet conservative, axial and circumferential length measurements for ID IGA type flaws. This sizing conservatism was also confirmed by destructive tests performed on a tube pulled during the 12R Outage.

4. Both cable designs use wire of the same impedance values. The difference between the two is that the multipurpose cable has more leads to allow using any one cable for several different probe designs. This change does not affect eddy current data acquisition or analysis; nor does it affect the flaw growth studies.

5. The + Point probe is recognized as a probe that provides better quality data for initial flaw detection and provides information for determining flaw morphology (i.e., determining whether a flaw is axially or circumferentially oriented, volumetric, and whether the surface of origin is ID or OD), without the need for other coils.

6. See Note 2. The most accurate, yet conservative, method (0.080" HF shielded pancake) was used for estimating axial and circumferential flaw length for tube repair decisions during Outage 12R and 13R and will be used again during future outages. Flaw growth studies are best performed using the same equipment and procedures. Outage 12R was the first outage where 0.080" HF coil data was obtained. Flaw growth studies will be performed using 0.080" HF pancake coil data where data exists for at least 2 outages. Where only 0.115" MR pancake coil data exists (e.g. Outage 11R) flaw growth will be evaluated with the 0.115" MR pancake coil data.

7. The change from 10 volts normalization to 4 volts normalization was discussed in TSCR# 277. For flaw growth studies, flaw voltage measurements from previous outages will be normalized by multiplying the previous measured value by 0.4. The "BWOG Mother Standard" normalization removes subtle calibration standard voltage differences by correcting all calibrations to be equivalent to 4 volts on the four 20% TW holes in one standard.

8. This voltage normalization change will not affect any of the growth data because MRPC voltage is not typically used for flaw growth studies at TMI-1. The Outage 13R change was made to comply with Revision 5 of the EPRI PWR Steam Generator Examination Guidelines. The alternate setting using the 60% notch provides a setting equivalent to 20 volts on the 100% TW notch. Saturated flaw signals should not be used for setting voltage values because in that

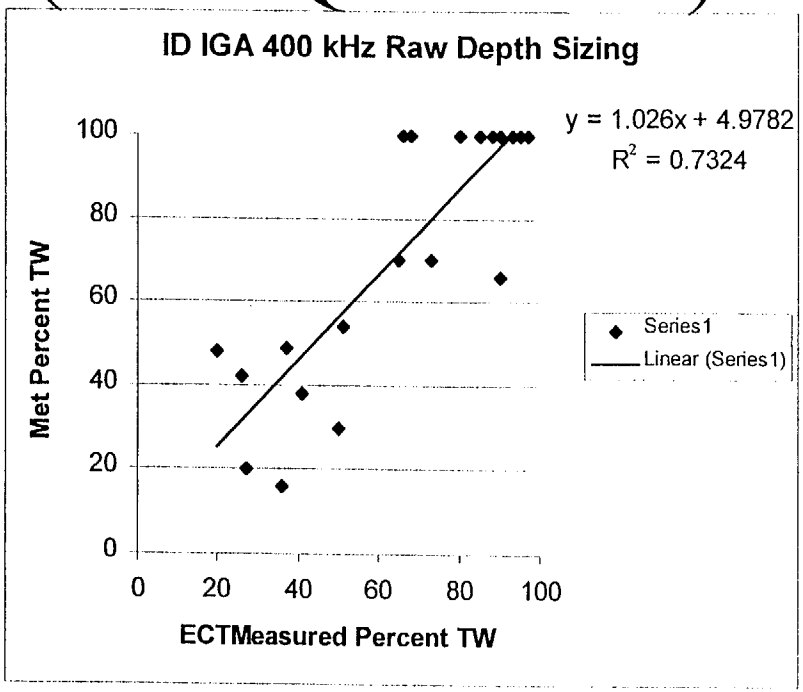
Bobbin Technique Qualification (Draft Question 6)

- Tech Spec Change Required To Leave ID IGA Not Depth Sizeable In Service
- Bobbin Coil Qualification Based On TMI-1 Pulled Tubes and Two Lab Samples
- Data Is Representative of TMI-1 Because It Used TMI-1 Pulled Tubes
- Leakage Integrity Assured By Depth, Length, Width Sizing and In-Situ Testing

ID IGA/SCC Flaw Detection and Sizing Data Set

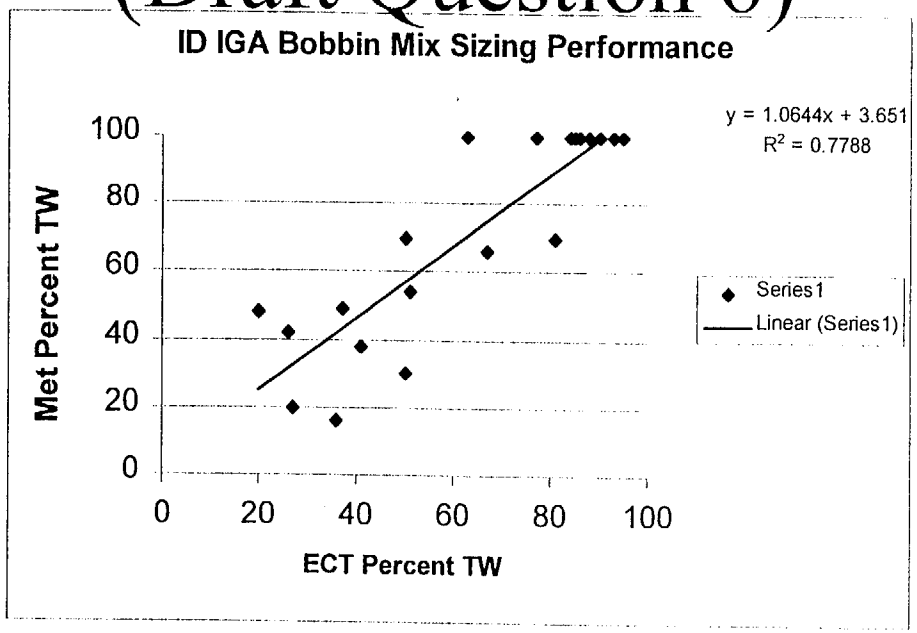
% TW ECT Depth	Flaw Type	DE Depth % TW	Count	Tube/Row	Data Location	Probe Size	Bobbin Detected
77	IGSCC	100	1	10--29	tape 12, uts +16.3	0.51	Y
84	IGSCC	100	2	11--66	tape 55, uts +12.3	0.51	Y
93	IGSCC	100	3	146-6	tape 40, uts +15.8	0.51	Y
67	IGSCC	66	4	112-7	tape 33, uts +13.4	0.51	Y
93	IGSCC	100	5	133-74	tape 44, 015 +39.7	0.51	Y
90	IGSCC	100	6	133-74	tape 44, 015 +38.2	0.51	Y
85	IGSCC	100	7	13-63	tape 11, 015 +44.0	0.51	Y
81	IGSCC	70	8	146-8	tape 40, uts +20.8	0.51	Y
50	IGSCC	70	9	24-94	tape 230, uts +11.8	0.51	Y
95	IGSCC	100	10	24-94	tape 230, 015 +37.6	0.51	Y
27	IGSCC	20	11	111-13	tape 33, 010 +3.4	0.51	Y
86	IGSCC	100	12	112-5	tape 33, uts +16.2	0.51	Y
63	IGSCC	100	13	112-5	tape 33, uts +17.9	0.51	Y
88	IGSCC	100	14	112-5	tape 33, uts +18.3	0.51	Y
20	IGA	48	15	8--45	tape 1, 015 +39.4	0.54	Y
36	IGA	16	16	35-83	tape 1, 015 +35.7	0.54	Y
26	IGA	42	17	141-3	tape 1, 015 +30.3	0.54	Y
41	IGSCC	38	18	sample 23	Archive Evaluation Used	0.54	Y
51	IGSCC	54	19	sample 24	Archive Evaluation Used	0.54	Y
37	IGA	49	20	52-34	Cal 364, 013 +23.1	0.54	Y
50	IGA	30	21	52-34	Cal 364, 013 +2.9	0.54	Y
BVC	IGA	19	22	52-34	Cal 364, 015 +38.3	0.54	Y
BVC	IGSCC	100	23	112-5	tape 33, uts +20.0	0.51	Y
BVC	IGSCC	100	24	112-5	tape 33, uts +20.5	0.51	Y
BVC	IGA	32	25	52-34	Cal 364, 014 +31.9	0.54	Y
BVC	IGA	32	26	52-34	Cal 364, 015 +14.7	0.54	Y
BVC	IGA	43	27	52-34	Cal 364, 015 +24.9	0.54	Y
INR	IGA	32	28	52-34	Cal 364, 007 +36.3	0.54	N
INR	IGA	38	29	52-34	Cal 364, 014 +12.8	0.54	N
NDD	IGA	38	30	52-34	Cal 364, UTS +0.0	0.54	N

Bobbin Technique Qualification (Draft Question 6)



Root Mean Square Error	16.93% TW
Correlation Coefficient	0.86
Standard Error of Regression	13.63% TW
Standard Error of Regression @ 90/50 Confidence Level	17.45% TW

Bobbin Technique Qualification (Draft Question 6)



Root Mean Square Error	16.93% TW
Correlation Coefficient	0.86
Standard Error of Regression	13.63% TW
Standard Error of Regression @ 90/50	17.45% TW

ECT Probes
(Draft Question 7)

- Question addresses probes other than bobbin and MRPC/Plus Point
- TMI-1 accepts the NRC staff's position.
  - Presently:
    - 0.510" bobbin used as general screening coil
    - 0.540" bobbin used for ID Volumetric IGA indications
    - .080" HF Pancake Coil on MRPC probe used for axial and circumferential extent measurement
    - .115" Pancake Coil on MRPC probe used for axial and circumferential extent measurement for comparison to old .115" coil measurements
    - Plus-Point Coil on MRPC probe used for determination of surface of initiation and volumetric morphology

In Situ Pressure Testing (Draft Question 8)

- In Situ pressure tests, as well as pulled tube leak and burst tests, have been performed.
- In situ pressure tests at TMI-1
  - 1997 Outage 12R
    - » 2 "A" OTSG tubes, 5 "B" OTSG tubes
  - 1999 Outage 13R
    - » 3 "B" OTSG tubes

1997 Outage 12R In Situ Tests

"A" OTSG In Situ Pressure Test Results from 1997 Outage 12R

TUBE AND EDDY CURRENT INFORMATION										
Region	Tube Information				Plus Point Data			Bobbin Data		Comments
	Row	Tube	Location	Length (in.)	Volts**	Est.% TW	Orientation	Volts*	Est.% TW	
Upper Tubesheet	93	119	UTS + 1.50	0.25C	5.87	87%	ID SCI	0.96	93%	Upper Tubesheet Circ
	93	119	UTS +1.93	0.21A x 0.25C	3.15	N/A	ID VOL	0.96	93%	UTS Volumetric
	93	119	UTS +0.55	0.24A x 0.27C	1.26	N/A	ID VOL	0.38	40%	UTS Volumetric
	107	120	ETL – 0.49	0.27A x 0.25C	0.81	N/A	ID VOL	NDD	N/A	KET Volumetric
	107	120	ETL – 2.85	0.12A x 0.19C	1.30	N/A	ID VOL	0.59	27%	UTS Volumetric
	107	120	ETL – 3.95	0.16A x 0.16C	0.83	N/A	ID VOL	0.58	13%	UTS Volumetric

"B" OTSG In Situ Pressure Test Results from 1997 Outage 12R

TUBE AND EDDY CURRENT INFORMATION										
Region	Tube Information				Plus Point Data			Bobbin Data		Comments
	Row	Tube	Location	Length (in.)	Volts**	Est.% TW	Orientation	Volts*	Est.% TW	
Upper Tubesheet	58	13	UTS – 0.17	0.29C	2.39	N/A	ID SCI	1.71	67%	UTSF Circ
	134	19	UTS – 0.20	0.14A x 0.30C	2.07	N/A	ID VOL	1.15	60%	UTSF Volumetric
	118	38	UTS + 1.74	0.51C	1.75	N/A	ID SCI	3.95	43%	UTS Circ
Freespan	79	58	15 + 40.30	0.86A x 0.50C	0.48	N/A	OD VOL	0.55	13%	Freespan NQI
Freespan	79	60	15 + 41.57	0.69A x 0.39C	1.20	N/A	OD VOL	1.91	28%	Freespan NQI

*** Bobbin voltages revised by factor of 0.4 to equate to 13R Outage bobbin coil voltages.**
****Plus Point voltages revised by factor of 0.342 to equate to 13R Outage Plus Point coil voltages.**

1999 Outage 13R In Situ Tests

Table 3 – "B" OTSG In Situ Pressure Test Results from Outage 1999's 13R

Region	Tube Information			Plus Point Data					Bobbin Data			Comments
	Row	Col	Location	Axial Length	Circ Length	Volts	Est. %	Orientation	Ind	Volts	Est. %	
Upper TS	61	19	ETL -0.31		0.31	4.51	94	ID SCI	NDD			UTS Circ
Freespan	80	50	15S +29.05 to +33.79	4.74		0.46		OD SAI	NQI	0.37	47	Freespan Ax
	113	2	14S +27.94 to +29.07	1.13		0.43		OD SAI	NQI	0.67	67	Freespan Ax

In Situ Pressure Testing (Draft Question 8; cont'd)

- No leakage has been observed during any TMI-1 in situ pressure test.
- 13R Volumetric ID IGA examination results were bounded by 12R and 13R tests:
  - 13R highest ID IGA bobbin voltage = 1.39 V
  - 13R highest ID IGA Plus-Point voltage = 5.1 V
  - 13R highest ID IGA bobbin throughwall estimate = 43%
  - 13R longest ID IGA axial extent = 0.36"
  - 13R longest ID IGA circ. extent = 0.39"

In Situ Pressure Testing (Draft Question 8; cont'd)

- EPRI <u>In Situ Pressure Test Guidelines</u> screening criteria were used. (Revision 1 during 13R Outage.)
- In situ test pressurization rates were relatively slow; hold times were relatively long; bladders were not used

CM / OA
(Draft Question 9)

- TMI-1 steam generator program requires that CM and OA be performed.
- For ID Volumetric IGA 13R (1999) Outage OA conservatively assumed:
  - 5% TW growth per cycle (though exam results gave no appearance of growth)
  - 23.9% TW NDE uncertainty @ 95% uncertainty
  - LTL material properties at 95/95 confidence
- For ID Volumetric IGA 13R (1999) Outage OA projected:
  - EOC Defects less than structural limits
    - →No impact on accident leakage
    - →No impact on burst probability

CM / OA
(Draft Question 9; cont'd)

- A basis of TMI-1's Tech Spec Change Requests, and NRC's approval thereof, has been that ID IGA is dormant.
- If ID IGA is not dormant:
  - Existing Tech. Spec. 4.19.5,a, (2) requires that NRC be notified before startup (i.e., before exceeding RCS temperature of 250F).
  - TMI will perform CM and OA to assess ID IGA impact on TMI-1 tube structural and leakage integrity performance criteria.

OD IGA
(Draft Question 10)

- TMI-1 Has Detected OD Volumetric IGA and It Is Considered An Active Mechanism

OTSG OD Volumetric Indications from Recent TMI-1 Outages

Outage (Year)	"A" OTSG OD volumetric IGA indications (Indications / Tubes)	"B" OTSG OD volumetric IGA indications (Indications / Tubes)	Total OTSG OD volumetric IGA indications (Indications / Tubes)
13R (1999)	3 / 3	3 / 2	6 / 5
12R (1997)	4 / 4	0 / 0	4 / 4
11R (1995)	0 / 0	1 / 1	1 / 1

OD IGA
(Draft Question 10; cont'd)

- OD IGA Has Been Present In TMI-1 OTSGs Since Before Outage 1995
- No Large Population Identified To Date
- Locations Are At LTS, Upper Spans, and Locations Between
- One Reason for 100% Bobbin Coil Scope
- Discovered By Bobbin Coil Probe And Confirmed By MRPC

OD IGA
(Draft Question 10; cont'd)

- Normal EPRI Appendix H Site Qualified Techniques Used For Detection Of OD IGA
- OD IGA is repaired on detection
- ECT Can Detect And Differentiate Coincident ID and OD Flaws
- Chances For Total Coincidence Are Extremely Small (Requires Near Perfect Alignment in Both Axial and Circumferential Planes)

OD IGA
(Draft Question 10; cont'd)

- 1986 Tube Pull Identified OD Surface IGA But No Mechanism Speculated
- Pulled Tube For OD Groove IGA In 1997
- Secondary Side Sulfur has been identified as a cause of OD IGA in OTSGs.

Summary

- Review of Open Items
- Schedule
- Degradation Mechanism Remains Stable
- NDE Continues To Improve
- Bases For Approval Unchanged
- Tube Integrity Not Challenged
- Resolves Tech Spec Issue For Repair Criteria Application For Low Voltage Volumetric IGA