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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Three Mile Island, Unit I (TMI Unit 1)
Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Additional Information Regarding Kinetic Expansion Inspection and Repair Criteria (TAC No. MB6475)

Reference: 1) AmerGen Energy Company, LLC letter to NRC, dated May 3, 2005 (5928-05-20102), "Additional Information Regarding Kinetic Expansion Inspection and Repair Criteria."

This letter provides additional information in response to the NRC draft request for additional information received via NRC email, dated July 12, 2005, regarding TMI Unit 1 Once-Through Steam Generator Kinetic Expansion Inspection and Repair Criteria submitted in Reference 1. The additional information is provided in Attachment 1. Please note that the response to Question No. 10 is planned to be submitted separately by August 19, 2005.

If any additional information is needed, please contact David J. Distel at (610) 765-5517.

Respectfully,

Pamela B. Cowan
Director - Licensing & Regulatory Affairs
AmerGen Energy Company, LLC

Attachments: 1) NRC Questions and AmerGen Responses

cc: S. J. Collins, USNRC, Administrator Region I,
D. M. Kern, USNRC, Senior Resident Inspector, TMI Unit 1
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File No. 02077

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ATTACHMENT 1

NRC Questions and AmerGen Responses

Request For Additional Information
Related to TMI-1 Kinetic Expansion
Inspection and Acceptance Repair Criteria
May 3, 2005 Letter

1. **NRC Question**

Page 20 of ECR #02-01121, Rev. 2, states that for sleeved tubes the parent tube is only inspected up to the kinetic expansion transition. Table 3-3 of the licensee's 15R OTSG Report dated 2/24/2004 states that all three roll expansions in the sleeve, including the transitions, are inspected with +Point. Please clarify whether the inspection of the upper-most roll expansion in the sleeve includes inspection of the parent tube at that location. If the parent tube at the upper sleeve joint is not inspected, how is the structural and accident leakage integrity of the upper sleeve joint ensured?

Response

The two documents are correct: all three of the sleeve roll expansions are inspected using Plus-Point probes, but the parent tubing, behind the sleeve, is not inspected above the kinetic expansion transition. Therefore, inspection of the uppermost sleeve roll expansion does not include the parent tube "behind" the sleeve roll.

(TMI-1 *sleeves were installed to prevent fatigue cracking of unexpanded tubing at* the upper tubesheet secondary faces. All OTSG plants installed sleeves in the lane-wedge region to arrest fatigue cracking.)

The integrity of the upper sleeve joints is ensured due to a number of factors: The TMI-1 sleeves are Inconel 690 which has corrosion resistance better than that of the original parent tubing. The upper sleeve joints are protected, by the constraint of the tubesheet, from bending loads and secondary side loose parts. The upper sleeve joints are normally in compression since the sleeve joints were expanded into the tubesheets. The design of the sleeves and sleeve expansions incorporated design features to minimize their subsequent susceptibility to stress corrosion cracking.

Prior to their installation, qualification tests included leak testing to determine normal operating and accident condition leak rates from installed sleeves. The average accident condition leak rate was 0.078 gpm for 5,000 sleeves. An average leak rate was used since testing was performed on specimens of both high and low yield strengths. (TMI-1 has approximately 250 sleeved tubes in each steam generator) The leak testing was performed on specimens, after they were fatigue tested, which included both the upper tubesheet roll joints and the lower sleeve-to-freespan-tube rolled joints. A complete freespan tube severance of the parent tube was present near the secondary faces of the specimens. The qualification work also included pull-out (i.e. tensile) testing of the sleeve joints. There was no significant movement of the sleeves even at the maximum accident loads, indicating a large margin of joint strength. Additional testing and analyses included flow-induced vibration analyses, thermal-hydraulic analyses, fatigue testing, corrosion testing, pressure cycling, axial load cycling, and thermal cycling. A more detailed description of the sleeve qualification work is available in a 1991 B&W Topical Report (BAW-2120P).

Prior to the installation of TMI-1 sleeves testing was performed on ¾" sleeves rolled into parent tube samples with through-wall axial and circumferential cracks in the tubesheet roll area. After installation of the sleeves into the test joints all of the joints were leak and pull tested. Based on the testing it was concluded that axial and circumferential cracks within the parent tubing prior to sleeve installation would not adversely affect the integrity of the sleeves' tubesheet rolled joint. These ¾" sleeves were similar to the TMI-1 sleeves except for the tubing and sleeve size.

The condition of the TMI-1 parent tubing installed behind roll-expanded Inconel 690 sleeves in the upper tubesheets is physically analogous to parent tubing behind thousands of I-690 rolled tube plugs (i.e., rolled joints of I-690 material over parent tubing). Rolled plug-to-tubesheet joints have successfully been utilized in these installations without subsequent inspection of the parent tubing behind the plugs.

2. **NRC Question**

The staff acknowledges efforts underway by the BWOG to identify needed changes to the plant licensing bases for plants with OTSGs to address OTSG tube structural and leakage integrity under the most limiting LBLOCA. Pending completion of these efforts and consistent with commitments made by licensees at the time they submitted license applications for reroll repairs, the staff requests that the licensee for TMI-1 commit to the following:

Determine the best estimate total primary-to-secondary leakage that would result from the limiting LBLOCA based on as-found circumferential and volumetric indications along the entire length of tubing inspected with appropriate allowance for flaws that may be located outboard of regions inspected, and demonstrate that it is acceptable. For purpose of this evaluation, acceptable means a best estimate of the leakage expected in the event of a LBLOCA that would not result in a significant increase of radiological release (e.g., in excess of 10 CFR100 limits). A summary of this evaluation shall be included in the 90-day report as required by TS 4.19.5.b.

Response

TMI-1 will provide the results of the best estimate leakage assessment for the limiting LBLOCA in the 90-day report required by TS 4.19.5.b.

3. **NRC Question**

Discuss the calculations performed to confirm that MSLB is the most limiting DBA (when compared to FLB, SBLOCA, Rod Ejection, etc) in terms of satisfying the accident leakage performance criterion in NEI 97-06 (also, TSTF-449, Rev. 4). Figure 15 of ECR #02-01121, Rev 2 indicates that differential pressure for the assumed MSLB accident is at 1300 psi or less throughout the transient. Do these pressure loads bound those that are calculated to occur during FLB or, if not, why is

MSLB the most limiting accident? Axial loads during a SBLOCA, 2097 lb maximum, are higher than those for the assumed MSLB transient, 1310 lb. Has SBLOCA been confirmed by analysis to be less limiting from a leakage and dose standpoint than MSLB?

Response

In 1983, as part of the original work to qualify and implement the TMI-1 steam generator kinetic expansion repairs, analyses were performed of the various transients that could impact the expansions' design. Among the various documents submitted to the staff was the "Three Mile Island Unit 1 Once-Through Steam Generator Repair: Kinetic Expansion Technical Report" (GPUN letter to the NRC dated April 20,1983, 5211-83-122, GPUN TDR-007, Rev. 1/BAW 1760, Rev.1). This proprietary document included the results of analyses of normal operation and transient tube loads. This document stated:
"...Three accident conditions cause significant loads on the steam generator tubes: large break LOCA, main steam line break (MSLB), and feedwater line break (FWLB). The axial loads on the tubes are as follows:

Event	Load, lb
LOCA	2641
Main steam line break	3140
Feedwater line break	-570 "

Based on these analyses the MSLB was selected as the worst-case condition based on tubing axial loads.

The large break LOCA is discussed in Question 2, above, and its response. Primary pressure is rapidly lost during a large break LOCA event.

Tube loads imparted by the Feedwater Line Break (FWLB) transient are compressive, vice tensile. Therefore the FWLB transient is not expected to impact kinetic expansion integrity or postulated leakage from the kinetic expansions. The axial tube load for the FWLB is compression over all tubesheet radial locations. The peak primary pressure reached during the FWLB will not overcome the compressive tube load regardless of the magnitude of the primary-to-secondary pressure difference. In addition, the contact pressure of the kinetically expanded tube-to-tubesheet joint will increase during a FWLB, due to the compressive tube load, resulting in added resistance to primary-to-secondary leakage. Tube compression during an FWLB will not result in buckling of the kinetic expansions because buckling loads are not exceeded and due to the presence of the tubesheet.

Primary-to-secondary pressure difference is quickly lost during hypothetical SBLOCAs. An analysis performed in 1999 of a SBLOCA event did result in peak axial tube loads of 2097 lbs. The peak tube load occurred at a time 0.20556 hours into the initiating transient. At this time in the analysis the calculated primary system pressure was 62 psia and the secondary pressure was 77 psia. The results of the 1999 analysis showed that there was essentially no primary-to-secondary pressure difference, or a negative primary-to-secondary pressure difference, for all times after 0.03 hours into the event. The 1999 analysis assumed a guillotine rupture of the pressurizer surge line so, while calculated axial tube loads were relatively high, the primary system was rapidly depressurized.

Transient analyses performed in 1990, including LOCA analyses, were also described in BAW-10146, "Determination of Minimum Required Tube Wall Thickness for 177-FA Once-Through Steam Generators". (These analyses were not performed specifically for TMI-1; rather they were performed for the BWOG and represent a conservative representation of the various BWOG plants.) A summary of tube loads contained in that document also illustrates the combination of primary-to-secondary pressure difference and tube load for the MSLB with respect to the other transients. The MSLB results were 3140 lbs. peak axial tensile tube load and the peak MSLB primary-to-secondary pressure was 2500 psid, while the FWLB resulted in compressive tube loads and the various analyzed LOCAs resulted in a loss of primary pressure.

In summary, transient analyses have demonstrated that the MSLB transient has a combination of tube tensile axial loading and positive primary-to-secondary pressure difference that are most challenging to structural and leakage integrity of the joint. While SBLOCA and FWLB, respectively, may result in an instance where the postulated axial tensile tube load is greater than that calculated for an MSLB, or an instance where the primary-to-secondary pressure difference is greater than that calculated for an MSLB, these instances do not occur concurrently.

NEI 97-06's accident-induced leakage performance criterion requires that plants have less than 1 gpm leakage per steam generator (for accidents other than tube rupture). Potential leakage in greater quantities may be acceptable if approved by NRC. Based on analyses of hypothetical leakage from the kinetic expansions, which demonstrated that doses remain within the applicable dose acceptance criteria, TMI-1 Amendment No. 204, dated October 2, 1997, approved leakages greater than 1 gpm (i.e., the leakage limits currently described in ECR 02-01121).

4. <u>NRC Question</u>

Are the 300 KHz +Point coils and the 600 KHz 0.80-inch pancake coils, discussed in Section 4.1.3 of ECR #02-01121, Rev 2, qualified specifically in accordance with EPRI Appendix H guidelines for application to 0.625 diameter, 0.034 thick tubing for detection of PWSCC and ID IGA? For both freespan and Kinetic Expansion (KE) locations? If not Appendix H qualified, what plans does the licensee have to perform an Appendix H qualification of these coils applicable to TMI-1?

<u>Response</u>

The 300 KHz +Point coil examination technique is EPRI Appendix H qualified to detect axial and circumferential PWSCC at expansion transitions and axial PWSCC adjacent dents. These qualifications are based on pulled tube and laboratory induced PWSCC cracking in 0.043", 0.048", and 0.050" wall thickness Inconel 600

tubing. These qualifications do not contain 0.034" wall OTSG tubing. There are no industry Appendix H qualifications directly applicable to expanded tubing. In order to confirm that these qualifications could be conservatively applied to OTSG kinetically expanded tubing the 1997, 1999, and 2001 analyses identified in sections 4.1.2 and 4.1.3 of ECR #02-01121 were performed to evaluate the expected performance for OTSG tubing with flaws similar to those previously identified at TMI-1. The 300 KHz +Point coil is a surface riding probe so fill factor is not a concern for the examination technique provided the area being examined does not have different extraneous test variables (e.g., denting, deposits, tube geometry, noise). The tube noise studies and site validations performed for TMI-1 have confirmed that the TMI-1 kinetic expansion region eddy current data is similar to the Appendix H qualification data and TMI tubes with freespan ID IGA that were previously in situ pressure tested. The studies confirmed that similar performance was expected for OTSG kinetically expanded tubing and the 300 KHZ +Point coil examination technique is considered Appendix H qualified for TMI-1.

The 600 KHz high frequency shielded pancake coil examination technique is used for measuring the axial and circumferential extent of ID IGA indications only and has been qualified to the intent of EPRI Appendix H. Sections H2.2.2 and H2.2.3 of Supplement H2 to the EPRI Guidelines suggest that the majority of the flaws in a qualification data set include flaws that have axial lengths >0.7" or circumferential lengths >100 degrees (>0.55" for an OTSG tube). These lengths greatly exceed the measured lengths of the TMI-1 flaw population (Reference Section 4.1.4 of ECR #02-01121) and would not provide a good measure of the length sizing performance for flaws similar to those encountered at TMI-1. Length sizing performance was evaluated on 23 machined "ID IGA Like" flaws and 9 TMI pulled tube ID IGA indications. This TMI-1 qualification data set of 32 volumetric flaws included flaws that ranged from 0.02" to 0.16" in length. The TMI-1 kinetic expansion measured flaw population from Outage 1R15 (Fall 2003) is very similar to the measured length of the flaw population in qualification data set. TMI-1 also performed site validation.and noise studies for the 600 KHz pancake coil similar to those that were performed for the 300 KHz +Point coil technique, as described above, and it was determined that the 600 KHz high frequency shielded pancake coil technique would perform similarly in the kinetically expanded region. The 600 KHz high frequency shielded pancake coil examination technique used for length sizing of volumetric ID IGA indications at TMI-1 is qualified in accordance with the intent of the EPRI Steam Generator Examination Guidelines by evaluating the performance of the length sizing capability for flaws similar to those encountered at TMI-1.

The studies performed to date have identified performance errors expected for these techniques and TMI-1 is conservatively applying these errors in its dispositioning criteria, therefore, TMI-1 does not plan to perform additional qualifications.

5. <u>NRC Question</u>

On page 32 of ECR #02-01121, Rev 2, the licensee states that machined flaws were introduced into OTSG tubes to represent circumferential, axial, and volumetric damage. It is the staff's experience that machined flaws are not representative of real cracks in terms of the ability of eddy current to detect and size such flaws. This, in part, is because the machined flaws tend to have larger volumes than actual cracks, tending to produce larger amplitude responses for a given length and depth and, thus, making the machined flaws easier to detect and size. Please provide data demonstrating that the machined flaws used in the study produce similar signal characteristics, signal amplitude, and signal to noise ratio for a given flaw size as actual PWSCC and ID IGA flaws at TMI-1.

Response

TMI-1 agrees with the NRC staff that machined flaws will generally produce larger amplitude eddy current signals than those produced from similar depth/length IGA/SCC flaws. Machined flaws generally produce larger amplitude signals and correspondingly larger signal-to-noise ratios. Machined flaws may be used to validate eddy current examination technique performance if the performance from the machined flaws produce errors for measured values that are reasonably similar or conservative when compared to the errors produced from known IGA/SCC flaws.

Table 1 below provides the analyst measured depths from 1997-2001 testing for machined ID notches and OTSG tube laboratory grown axial PWSCC. A review of the data in this table reveals that the worst average eddy current underestimate of through wall depth involved flaw M1111, which is a machined notch. (Each flaw was evaluated by five eddy current analysts, so the average of the five analysts' calls is reported herein) Table 2, below, provides analyst measured depths for machined ID pits and TMI-1 pulled tube ID IGA and, again, the worst average underestimate of through wall depth involved a machined flaw (M1294). Of the 36 flaws evaluated in Table 1, 23 were measured as having a through wall depth less than actual. Of the 32 flaws evaluated in Table 2, 13 were measured as having a through wall depth less than actual.

These results can be compared to the +Point depth measurement performance for the 300 KHz +Point probe phase angle depth measurement technique in EPRI Appendix H qualification for Examination Technique Specification Sheet (ETSS) #20510.1. This ETSS is typically cited for industry qualification of +Point probe use in steam generator tubing. ETSS #20510.1, Revision 5, included 23 laboratory grown and 6 pulled tube PWSCC flaws. (One flaw was not detected.) Of the 28 detected flaws included in ETSS #20510.1, 6 were estimated with through wall extent less than the actual and there were underestimates similar to those in Table 1 and 2. This type of performance is not unexpected for "thumbnail" type flaws that are small in size because the eddy current response is based on the average of the depth over the eddy current field so an underestimate of maximum through wall extent is an expected result. This indicates that machined flaws can be used to provide a conservative error for estimate of depth using phase angle analysis. TMI-1 uses conservative results for calculating estimated leakage from kinetic expansion flaws by assuming that all flaws >67% through wall by eddy current be considered 100% through wall for leakage calculation purposes.

Table 3, below, provides the analyst measured 300 KHz +Point length measurements for machined ID axial notches and OTSG tube laboratory grown axial PWSCC. Tables 4 and 5, below, provide analyst measured axial length and circumferential length, respectively, for machined ID pits (i.e., ID IGA like indications) and TMI-1 pulled tube ID IGA. There are no OTSG circumferential PWSCC or additional ID IGA flaws available for inclusion in the TMI-1 sizing error study and, in fact, the industry has done little qualification work for small circumferential PWSCC flaws of the sizes typically detected in the TMI-1 required kinetic expansion region.

Review of the 6 laboratory grown flaws in Table 3 results indicates that the 300 KHz +Point coil examination technique average axial length measurement ranged from approximately 1 to 4 times the actual flaw length. The average axial length measurement error for the 10 machined ID axial notches ranged from approximately 2 to 5 times the actual flaw length. The error indicates that there is reasonable correlation between the laboratory grown PWSCC flaws and the machined notches included in Table 3. It should also be noted that the 300 KHz +Point coil examination technique is used for depth sizing (all kinetic expansion flaws) and length sizing of circumferential indications only. TMI-1 has recently committed to plug all crack-like indications in the required kinetic expansion region (i.e., plug on detection regardless of length) so length sizing error for the 300 KHz +Point coil examination technique will no longer be applicable to repair decisions. Length sizing error for the 300 KHz +Point coil examination technique will only be applicable for calculating as found leakage and growth evaluations.

Review of Tables 4 and 5 provides the eddy current measured axial and circumferential lengths for TMI-1 pulled tube ID IGA and machined simulated ID IGA using the 600 KHz shielded pancake coil examination technique. The estimated average axial length of the 9 pulled tube flaws ranged from ~1.5 to ~4 times the actual flaw length compared to ~2 to 8 times the actual length for the machined flaws. The estimated average circumferential length of the 9 pulled tube flaws ranged from ~4 to ~8 times the actual length compared to ~2 to ~7 times for the machined flaws. This demonstrates reasonable consistency between the machined and pulled tube flaws for this examination technique.

In summary TMI-1 has performed a comprehensive study of the expected eddy current performance for the TMI-1 kinetic expansion region and is applying the results of this study in a conservative manner that meets the intent of the EPRI Steam Generator Examination and Tube Integrity Guidelines.

Table 1

+Point Probe Depth Sizing Performance for Machined Notches and Axial PWSCC

Flaw Depth (% TW)	Analyst						
Flaw	A	B	C	D	E	Averages	Actual
M1101	69	47	65	48	71	60.0	79
M1102	49	43	51	45	56	48.8	62
M1103	26	37	38	28	39	33.6	36
M1104	19	17	22	21	23	20.4	20
M1111	52	44	44	46	40	45.2	74
M1112	30	22	22	26	31	26.2	51
M1113	13	9	5	17	15	11.8	37
M1114	0	0	0	0	3	0.6	17
M1121	78	78	70	78	74	75.6	79
M1122	46	44	38	41	40	41.8	56
M1123	21	22	17	21	27	21.6	39
M1124	9	17	5	9	12	10.4	18
M1131	99	100	99	99	100	99.4	74
M1132	46	70	50	46	62	54.8	57
M1133	30	38	22	30	31	30.2	36
M1134	26	1	22	9	27	17.0	17
M1141	52	50	44	52	51	49.8	56
M1142	93	93	85	78	81	86.0	77
M1143	93	100	93	86	94	93.2	100
M1144	26	32	17	21	22	23.6	39
M1145	17	0	13	0	3	6.6	17
M1151	65	85	70	65	68	70.6	63
M1152	100	99	99	71	100	93.8	74
M1153	100	100	100	93	100	98.6	100
M1531	56	65	58	55	59	58.6	66
M1532	41	40	44	42	46	42.6	42
M1533	19	21	24	33	26	24.6	23
M1541	69	69	69	86	75	73.6	67
M1542	38	43	47	45	42	43.0	41
M1543	26	23	24	26	26	25.0	21
P1	91	91	82	85	78	85.4	91
P71	97	96	82	80	86	88.2	99
P72	92	91	89	93	87	90.4	96
P131	19	32	26	53	40	34.0	53
P132	45	29	48	35	26	36.6	35
P24	97	92	70	98	97	90.8	88

Note- Flaw identifications beginning with "M" are machined notches and flaw identifications beginning with "P" are laboratory grown axial PWSCC flaws.

Table 2

+Point Probe Depth Sizing Performance for Machined ID Pits and TMI-1 Pulled Tubes With ID IGA

Flaw Depth (% TW)	Analyst						
Flaw	A	B	C	D	E	Averages	Actual
M1291	26	23	29	31	31	28.0	20
M1292	26	28	35	36	26	30.2	43
M1293	35	47	38	39	39	39.6	57
M1294	49	58	51	36	52	49.2	83
M1301	41	31	44	33	15	32.8	20
M1302	41	34	44	45	46	42.0	40
M1303	60	54	62	55	63	58.8	63
M1304	60	74	62	74	63	66.6	83
M1311	19	31	22	23	23	23.6	20
M1312	29	19	32	33	34	29.4	17
M1313	38	54	41	42	42	43.4	23
M1314	41	43	44	45	46	43.8	20
M1321	38	31	41	42	42	38.8	20
M1322	35	34	38	39	39	37.0	17
M1323	26	37	29	31	34	31.4	20
M1324	29	28	32	33	34	31.2	17
M1331	52	40	54	26	56	45.6	20
M1332	29	47	58	33	34	40.2	43
M1333	49	58	62	62	36	53.4	59
M1341	45	31	47	48	26	39.4	23
M1342	41	65	44	45	46	48.2	20
M1343	38	28	41	42	42	38.2	20
M1344	26	28	29	31	31	29.0	20
TMI1	33	37	36	29	30	33.0	32
TMI2	21	21	25	33	25	25.0	30
TMI3	17	21	25	28	25	23.2	49
TMI4	39	33	22	26	42	32.4	38
TMI5	39	36	39	52	39	41.0	32
TMI6	19	17	20	33	20	21.8	32
TMI7	24	12	16	26	16	18.8	43
TMI8	21	39	25	38	42	33.0	19
TMI9	1	1	0	28	3	6.6	38

Note- Flaw identifications beginning with "M" are machined ID pits similar to TMI-1 ID IGA shapes and flaw identifications beginning with "TMI" are TMI-1 pulled tube volumetric ID IGA flaws.

Table 3

+Point Probe Axial Length Sizing Performance for Machined Axial Notches and Axial PWSCC

Ax Length (Inches)	Analyst						
Flaw	A	B	C	D	E	Average	Actual
M1101	0.33	0.33	0.37	0.33	0.3	0.332	0.063
M1102	0.3	0.33	0.34	0.3	0.34	0.322	0.063
M1103	0.27	0.33	0.4	0.33	0.3	0.326	0.063
M1104	0.2	0.36	0.17	0.2	0.34	0.254	0.063
M1531	0.47	0.47	0.47	0.5	0.54	0.490	0.247
M1532	0.47	0.47	0.5	0.46	0.5	0.480	0.247
M1533	0.5	0.5	0.5	0.53	0.5	0.506	0.248
M1541	0.43	0.43	0.43	0.43	0.53	0.450	0.188
M1542	0.43	0.43	0.43	0.43	0.43	0.430	0.188
M1543	0.33	0.43	0.43	0.46	0.47	0.424	0.187
P1	0.17	0.39	0.17	0.17	0.47	0.274	0.13
P71	0.39	0.39	0.26	0.43	0.26	0.346	0.21
P72	0.43	0.43	0.21	0.43	0.47	0.394	0.1
P131	0.12	0.42	0.25	0.21	0.21	0.242	0.16
P132	0.21	0.33	0.25	0.21	0.17	0.234	0.08
P24	0.37	0.37	0.29	0.37	0.29	0.338	0.32

Note- Flaw identifications beginning with "M" are machined ID notches similar to TMI-1 flaw shapes and flaw identifications beginning with "P" are laboratory grown axial PWSCC indications in OTSG tubing.

Table 4
600 KHz Shielded Pancake Coil Axial Length Sizing Performance for Machined IGA Flaws and Pulled Tube ID IGA

Axial Length (inches)	Analyst							
Flaw	A	B	C	D	E	FIELD	Average	Actual
M1291	0.19	0.23	0.23	0.19	0.19		0.206	0.079
M1292	0.23	0.23	0.23	0.23	0.23		0.230	0.078
M1293	0.23	0.23	0.23	0.23	0.23		0.230	0.078
M1294	0.28	0.23	0.23	0.28	0.23		0.250	0.0798
M1301	0.19	0.19	0.14	0.19	0.14		0.170	0.02
M1302	0.23	0.19	0.19	0.23	0.23		0.214	0.042
M1303	0.23	0.19	0.23	0.23	0.28		0.232	0.0615
M1304	0.33	0.28	0.23	0.33	0.33		0.300	0.111
M1311	0.23	0.18	0.23	0.18	0.23		0.210	0.079
M1312	0.23	0.18	0.23	0.23	0.23		0.220	0.078
M1313	0.23	0.23	0.23	0.23	0.23		0.230	0.079
M1314	0.23	0.18	0.19	0.23	0.23		0.212	0.079
M1321	0.14	0.19	0.14	0.19	0.19		0.170	0.0395
M1322	0.23	0.19	0.19	0.19	0.23		0.206	0.079
M1323	0.33	0.28	0.28	0.33	0.33		0.310	0.1602
M1324	0.28	0.24	0.28	0.28	0.28		0.272	0.119
M1331	0.19	0.23	0.19	0.19	0.24		0.208	0.079
M1332	0.24	0.23	0.19	0.28	0.24		0.236	0.0795
M1333	0.24	0.23	0.19	0.28	0.24		0.236	0.0785
M1341	0.19	0.19	0.19	0.19	0.19		0.190	0.079
M1342	0.24	0.19	0.19	0.23	0.28		0.226	0.0793
M1343	0.24	0.23	0.19	0.23	0.24		0.226	0.078
M1344	0.24	0.23	0.24	0.23	0.24		0.236	0.079
TMI1	0.16	0.05	0.09	0.11	0.13	0.11	0.108	0.024
TMI2	0.11	0.11	0.06	0.11	0.11	0.1	0.100	0.066
TMI3	0.11	0.11	0.06	0.11	0.11	0.16	0.110	0.033
TMI4	0.22	0.11	0.11	0.17	0.17	0.16	0.157	0.054
TMI5	0.11	0.06	0.06	0.11	0.11	0.16	0.102	0.042
TMI6	0.11	0.06	0.11	0.11	0.11	0.1	0.100	0.029
TMI7	0.17	0.11	0.06	0.11	0.17	0.1	0.120	0.03
TMI8	0.11	0.06	0.06	0.11	0.11	0.1	0.092	0.02
TMI9	0.11	0.06	0.11	0.11	0.06	0.2	0.108	0.04

Note- Flaw identifications beginning with "M" are machined ID pits similar to TMI-1 ID IGA shapes and flaw identifications beginning with "TMI" are TMI-1 pulled tube volumetric ID IGA flaws.

Table 5

600 KHz Shielded Pancake Coil Circumferential Length Sizing Performance for Machined IGA Flaws and Pulled Tube ID IGA

Circ Length (inches)	Analyst							
Flaw	A	B	C	D	E	FIELD	Average	Actual
M1291	0.2	0.2	0.26	0.13	0.2		0.198	0.079
M1292	0.2	0.2	0.2	0.2	0.2		0.200	0.078
M1293	0.26	0.2	0.26	0.2	0.27		0.238	0.078
M1294	0.26	0.2	0.26	0.26	0.27		0.250	0.0798
M1301	0.13	0.2	0.13	0.13	0.13		0.144	0.02
M1302	0.2	0.2	0.2	0.2	0.2		0.200	0.042
M1303	0.2	0.2	0.2	0.26	0.27		0.226	0.0615
M1304	0.33	0.2	0.27	0.39	0.33		0.304	0.111
M1311	0.26	0.16	0.21	0.16	0.27		0.212	0.079
M1312	0.2	0.16	0.16	0.16	0.2		0.176	0.078
M1313	0.2	0.16	0.16	0.16	0.2		0.176	0.079
M1314	0.2	0.16	0.16	0.16	0.27		0.190	0.079
M1321	0.13	0.2	0.13	0.13	0.2		0.158	0.0395
M1322	0.2	0.2	0.27	0.2	0.27		0.228	0.079
M1323	0.26	0.26	0.27	0.26	0.27		0.264	0.1602
M1324	0.2	0.26	0.27	0.33	0.27		0.266	0.119
M1331	0.26	0.2	0.2	0.27	0.26		0.238	0.079
M1332	0.2	0.2	0.2	0.27	0.26		0.226	0.0795
M1333	0.26	0.2	0.2	0.27	0.26		0.238	0.0785
M1341	0.2	0.2	0.26	0.2	0.2		0.212	0.079
M1342	0.2	0.2	0.26	0.2	0.26		0.224	0.0793
M1343	0.26	0.2	0.26	0.2	0.26		0.236	0.078
M1344	0.26	0.2	0.26	0.27	0.26		0.250	0.079
TMI1	0.11	0.06	0.11	0.17	0.17	0.11	0.122	0.022
TMI2	0.21	0.1	0.1	0.1	0.1	0.11	0.120	0.032
TMI3	0.26	0.16	0.1	0.16	0.21	0.11	0.167	0.02
TMI4	0.21	0.16	0.1	0.1	0.16	0.19	0.153	0.025
TMI5	0.21	0.1	0.1	0.1	0.1	0.11	0.120	0.019
TMI6	0.1	0.05	0.05	0.1	0.1	0.06	0.077	0.018
TMI7	0.21	0.1	0.1	0.1	0.16	0.11	0.130	0.018
TMI8	0.1	0.05	0.05	0.1	0.1	0.06	0.077	0.016
TMI9	0.1	0.05	0.1	0.1	0.1	0.14	0.098	0.025

Note- Flaw identifications beginning with "M" are machined ID pits similar to TMI-1 ID IGA shapes and flaw identifications beginning with "TMI" are TMI-1 pulled tube volumetric ID IGA flaws.

6. **NRC Question**

On page 33 of ECR #02-01121, Rev. 2, top paragraph, the licensee states that a comparison of the Appendix H qualification results (for 0.75 and 0.875 inch tubing) with the OTSG machined flaw results confirmed the validity of the defined examination performance in the study. Please provide that comparison. In addition, describe the number and type of specimens (e.g., pulled tube ID IGA, pulled tube ID IGA, laboratory ID cracks and IGA, machined flaws) represented in the Appendix H qualification data set.

Response

See Tables 1 through 5 in the response to Question 5, above, for TMI-1 examination technique performance for flaw specimens and technique results for flaws included in the TMI-1 examination technique performance study. Table 6, below, provides length and depth-sizing performance results for three EPRI PWSCC +Point examination techniques that are available for industry use.

Sections 6.2.4 and 6.2.5 of the EPRI Steam Generator Examination Guidelines require that examination technique performance be adjusted as appropriate for the conditions being encountered. A review of the EPRI Appendix H PWSCC Qualification depth sizing performance provided in Table 6 reveals that the two worst underestimates of depth were –19% TW and –23% TW. In fact the depth sizing performance in Table 6 is dominated by overestimates of through wall extent. TMI-1 assumes that any flaws measured as >67% TW be considered 100% TW for leakage calculation purposes. Thus, in the kinetic expansions TMI-1 applies a depth sizing performance that is significantly more conservative than the performance supported by the EPRI Appendix H qualifications in Table 6.

As stated in the answer to Question 5, above, the industry has done little sizing qualification work with short circumferential PWSCC flaws so there is a limited database for comparison. TMI-1 has committed to plug all "crack-like" flaws in the required kinetic expansion length so length measurement error is only applicable for calculating as found accident induced leakage and assessing growth, and is no longer used for repair decisions.

There are no industry Appendix H qualifications for the 600 KHz high frequency shielded pancake coil examination technique for comparison. Tables 4 and 5, above, provided the examination performance for this technique. This performance included 9 TMI-1 pulled tube flaws and the machined flaws in the study provided verification of expected performance. See the response in Question 5 for further validation.

Table 6 - EPRI ETSS Performance

ETSS #20510.1 Circumferential PWSCC at Expansion Transitions			
Actual Depth	ECT Measured Depth % TW	Actual Length (Degrees)	ECT Measured Length (Degrees)
70	66	186	140.3
100	98	178	110.8
96	100	148	127.5
79	90	360	360
89	100	77	79.5
66	83	331	336.6
77	98	46	54.7
67	99	153	183.3
89	99	123	55.4
100	100	240	223
49	99	222	185
67	100	205	195.1
100	100	256	232.3
53	56	115	111.5
100	99	192	184
100	99	170	127.6
100	100	193	147.7
100	100	236	185.8
75	56	182	185.8
49	61	170	157.9
31	86	162	148.6
53	52	177	148.6
22	NDD	177	NDD
90	99	88	69.2
42	100	360	229.3
38	100	360	307.3
57	97	360	187.2
44	52	22.68	30.9
84	100	209	216
Data set is comprised of 6 pulled tube specimens and 23 laboratory grown circumferential PWSCC cracks.			

ETSS #20511.1 Axial PWSCC at Expansion Transitions			
Actual Depth	ECT Measured Depth % TW	Actual Length (Inches)	ECT Measured Length (Inches)
39	NDD	0.187	NDD
47	77	0.203	0.26
60	61	0.156	0.19
47	50	0.163	0.15
66	87	0.547	0.19
35	57	0.125	0.15
64	73	0.295	0.38
84	100	0.504	0.67
41	57	0.224	0.27
40	82	0.245	0.19
37	NDD	0.205	NDD
38	NDD	0.152	NDD
47	50	0.268	0.34
63	73	0.738	0.49
44	73	0.116	0.15
89	100	0.909	0.67
64	86	0.176	0.27
68	82	0.196	0.19
57	77	0.198	0.19
75	86	0.808	0.45
62	69	0.171	0.15
100	98	0	0
Data set is comprised of 1 pulled tube specimen and 21 laboratory grown axial PWSCC cracks.			

ETSS #96701.1 Circumferential PWSCC at Expansion Transitions			
Actual Depth	ECT Measured Depth % TW	Actual Length (Degrees)	ECT Measured Length (Degrees)
42	30	360	360
38	38	360	360
57	42	360	360
84	96	209	222
79	82	360	360
22	NDD	177	NDD
100	99	240	204
49	48	222	158
67	44	205	176
100	98	256	241
53	56	115	139
100	99	236	185
75	76	182	185
49	56	170	167
31	48	162	130
53	56	177	167
90	100	88	71
Data set is comprised of 5 pulled tube specimens and 12 laboratory grown circumferential PWSCC cracks.			

7. **NRC Question**

Please provide a table or graph comparing the axial (and/or circumferential) and depth measurements by the mid-range +Point and HF pancake coils for all machined flaws, laboratory grown PWSCC, and pulled tube IGA flaws considered in the "1999 Analyses" discussed beginning on page 33 of ECR #02-01121, Rev. 2. If this information has been previously provided to the staff, please cite the reference.

Response

See Tables 1 through 5 in the response to Question 5, above. Note that the 600 KHz shielded pancake coil technique is not used for depth sizing so there is no depth sizing data available for this technique.

8. **NRC Question**

Please provide a table or graph comparing the axial (or circumferential) and depth measurements by the mid-range +Point and HF pancake coils to the destructive examination measurements for the six laboratory grown PWSCC flaws described on page 35 of ECR #02-01121, Rev. 2. If this information has been previously provided to the staff, please cite the reference.

Response

See Tables 1 and 3 in the response to Question 5, above. Note that the 600 KHz high frequency shielded pancake coil technique is not used for length sizing PWSCC (crack like) flaws so no data is available for length sizing of PWSCC with this technique.

9. **NRC Question**

Please provide a table or graph comparing the depth measurements by the mid-range +Point and HF pancake coils to the destructive examination measurements for the nine TMI-1 pulled tube ID IGA flaws described on page 35 of ECR #02-01121, Rev. 2. If this information has been previously provided to the staff, please cite the reference. Please comment on the staff's observation that the range of flaw depths in the pulled tube specimen (which range to 49% maximum depth) does not address the range of flaw depth of interest which are depths higher than 49% and ranging to 100%. In particular, comment on what the pulled tube data contributes to the licensee's conclusion that depth measurement error is 95% bounded by –28.1%.

Response

Table 2 in the response to Question 5, above, provides the ID IGA depth sizing performance for the 300 KHz +Point coil examination technique. Note that TMI-1 does not use the 600 KHz high frequency shielded pancake coil examination technique for depth measurements so there are no depth sizing results to present.

Five of the machined flaws in Table 2 ranged from 57% TW to 83% TW in actual depth. The measurement errors for these five flaws were similar to the errors observed for the pulled tube specimens of Table 2, as was discussed in the response to Question 5. As discussed above, the similarity of nine pulled tube flaws in terms of depth sizing errors provides validation that the machined flaws can be used in a full spectrum of depth samples supports the –28.1% TW error. This approach meets the intent of the EPRI Steam Generator Examination Guidelines by evaluating the sizing error for flaws ranging from 17% TW to 83% TW. TMI-1's evaluation was similar to some industry Appendix H qualifications (ETSSs), shown in Table 6, where pulled tube flaws are supplemented by lab-grown flaws in order to obtain a broader spectrum of sizes and depths in the flaw datasets.

10. <u>NRC Question</u>

Provide leak rate estimates (in terms of gallons per minute), based on the licensee's PICEP leakage model, for circumferential cracks with lengths of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, and 0.7 inches for 0.625 inch diameter, 0.034 inch thick tubes. Utilize assumptions on pressure and temperature consistent with those used to generate PICEP leak rates for axial cracks shown on Table 6 of the licensee's report ECR No. TM 01-00328, which was enclosed with the licensee's letter, dated July 13, 2001. Describe values of all other input parameters used to generate these estimates (e.g., material properties, crack tortuosity, surface roughness, etc.).

<u>Response</u>

A response to this question is planned for submittal by August 19, 2005.

11. <u>NRC Question</u>

In its letters dated August 16, 2004, and May 3, 2005, the licensee provided its updated inspection acceptance criteria and leakage assessment methodology for the TMI-1 OTSG Kinetic Expansion examinations. This information was submitted for the NRC's review and acceptance in accordance with Section IWB-3630 of ASME Code Section XI. However, Attachment 3 of the May 3, 2005 submittal purports to identify commitments made in the document (presumably the May 3, 2005 letter and the attached ECR #02-01121, Rev. 2) by the licensee. Attachment 3 states that any other actions discussed in the submittal representing intended or planned actions by the licensee are described to the NRC for the NRC's information and are not regulatory commitments. The staff does not understand what the licensee is trying to accomplish here. The list of "commitments" in Attachment 3 are but a small subset of the inspections, inspection acceptance criteria, and leakage assessment methodology discussed in ECR #02-01121, Rev. 2 which the staff is currently reviewing. Upon the staff's review and acceptance of the report, the report becomes part of the TMI-1 licensing basis. Any changes to the methods and criteria contained the report would be subject to prior NRC review and approval. Therefore, we recommend that the list of regulatory commitments in Attachment 3 be deleted.

Response

Attachment 3 of the May 3, 2005 AmerGen submittal will be deleted upon submittal of the final ECR #02-01121, Revision 2. These commitments are being incorporated into the final ECR #02-01121, Rev. 2, which will become part of the TMI-1 licensing basis.