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September 20, 1995
BECo Ltr. #95-099

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Docket No. 50-293
License No. DPR-35

RESULTS OF AUGMENTED EXAMINATION OF THE RPV SHELL WELDS AND
RELIEF REQUEST PURSUANT TO 10 CFR 50.55a(g)(6)(ii)(A)(5)

The Final Rule, 57 FR 34666, dated August 6, 1992, required Boston Edison Company (BECo) to conduct an augmented examination of the Reactor Pressure Vessel (RPV) shell welds pursuant to the requirements stipulated in 10 CFR 50.55a(g)(6)(ii)(A). The Subsection 6(ii)(A)(5) requires licensees that are unable to completely satisfy the augmented RPV shell weld examination requirement to submit information to the Commission to support such determination and propose alternatives to the examination requirements that would provide an acceptable level of quality and safety.

In response to the Final Rule, we conducted an augmented examination of RPV shell welds during Refueling Outage (RFO) #10, as presented in BECo letter #95-035 dated March 17, 1995. In that letter we stated a report would be generated detailing the examination coverage achieved and the results, and the report would be submitted to the NRC pursuant 10 CFR 50.55a(g)(6)(ii)(A)(5).

This letter provides the shell weld examination results to address the March 17, 1995 commitment and requests relief from examination of certain reactor vessel shell welds pursuant to 50.55a(g)(6)(ii)(A)(5).

Augmented Examination Method:

The RPV shell welds (ASME Code, Section XI Table IWB-2500-1, item B1.10) were examined a) remotely from the inside of the vessel to the extent practical and b) manually at the lower head shell weld (weld #9-338), and where scheduled bioshield wall disassembly allowed access.

The remote examinations were performed in accordance with an inspection procedure developed by General Electric. The procedure was demonstrated at the "Performance Demonstration Initiative" (PDI) qualification Session No 61-02 in accordance with the 1992 edition 1993 addenda of ASME Section XI, Appendix VIII requirements. The General Electric Company was verbally notified by the representatives of the PDI team that the GERIS 2000 successfully completed the performance demonstration. The actual data will not be released by PDI until sometime in 1996. The procedure does not comply with ASME Section XI paragraph IWA-2232; ASME Section V Article 4; or USNRC Regulatory Guide 1.150 and, as

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such, is considered an alternate examination technique. This procedure was made available to the NRC inspectors during the examinations.

The manual examinations were performed in accordance with ASME Section XI, IWA-2230 as modified by Regulatory Guide 1.150.

The use of PDI qualified procedures results in a more sensitive examination for the detection of potential flaws than the Code described techniques. The error band for sizing has been established within the limits of Appendix VIII. This inspection method's capability to reliably detect flaws in areas of restricted access was satisfactorily demonstrated at the PDI session. This capability increases the effective coverage of the required examination volume.

Enclosure 1 details the examination technique with respect to USNRC Reg. Guide 1.150.
Enclosure 2 details the examination technique with respect to ASME Section V, Article 4.
Enclosure 3 details the method used for the calculation of achieved coverage.

A portion of the examination was witnessed by onsite and regional NRC staff members, and the examination methods were reviewed by them during the examination.

Examination Coverage and Results:

Table 1 presents the examination coverage achieved and restraints for both the GERIS 2000 (auto) and the manual methods. Figures 1 and 2 provide the weld seam scanned for GERIS 2000 and manual methods, respectively.

The RPV was examined to the maximum extent from the inside within the constraints of available tooling and vessel internal restrictions. For vessel areas that could not be inspected from the inside surface, inspection from the outside was evaluated. The exterior vessel is covered with permanent insulation fixed very near the RPV surface and with a structural steel bioshield wall. Access is limited to nozzle and inspection port penetrations in the bioshield wall. Additional coverage was achieved from the nozzle penetrations for welds RPV-L-2-338B and RPV-L-2-339C. In addition, outside diameter access was obtained for the lower head to shell weld (RPV-9-338) from inside the bioshield wall at the lower head area.

A review of bioshield wall penetrations not opened in RFO #10 revealed that coverage cannot be increased by using these locations because coverage was already obtained using GERIS-2000 or because of the remoteness of RPV shell welds from the blockout openings. One weld, RPV-L-1-339B, is above the bioshield wall for a 10 foot length. This weld, however, is obstructed by insulation that is not easily removed.

The GERIS 2000 examination identified 55 indications, all of which were acceptable in accordance with ASME Section XI paragraph IWB-3500; therefore, they did not require analytical evaluation. These indications are concluded to be from small acceptable flaws created at RPV fabrication. No indications were identified with the manual examinations.

Relief Request Pursuant to 10CFR50.55a(g)(6)(ii)(A)(5)

The RPV was examined from the internal surface to the extent practical with an alternate method which is qualified to the highest standard available. Further examination from the inside is not practical without requiring disassembly of vessel internal components. Also further examination of the vessel from the outside is not practical due to the bioshield wall and the close proximity of the insulation. Weld RPV-L-1-339B is located above the bioshield wall and the location of this weld is far from the beltline region.

The RPV shell weld examinations confirmed no flaws in the vessel, even though 90% coverage was not attained. Performing additional examinations to achieve the 90% coverage presents hardship and produces unnecessary radiological exposure and/or requires RPV or RPV bioshield disassembly. Since the examination results confirm that there are no flaws, the underlying objectives of the augmented examination requirements have been met. For these reasons, BECo requests relief from additional augmented examination of the RPV-L-1-339B weld.

Commitments

None

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ETB/WGL/Rap95/RPVEX

Table 1:RPV Shell Welds Examination Coverages

Figure 1: GERIS 2000 Scan Areas (two pages)
Figure 2: Manual Scan Areas (two pages)

Enclosure 1: GERIS 2000 Invessel System Alternative Method for Compliance to R.G. 1.150
Enclosure 2: GERIS 2000 Invessel System Alternative Method of Volumetric Examinations
Enclosure 3: GERIS 2000 Invessel System Calculation of Achieved Coverages, ASME Sec X., App. VIII Examinations.

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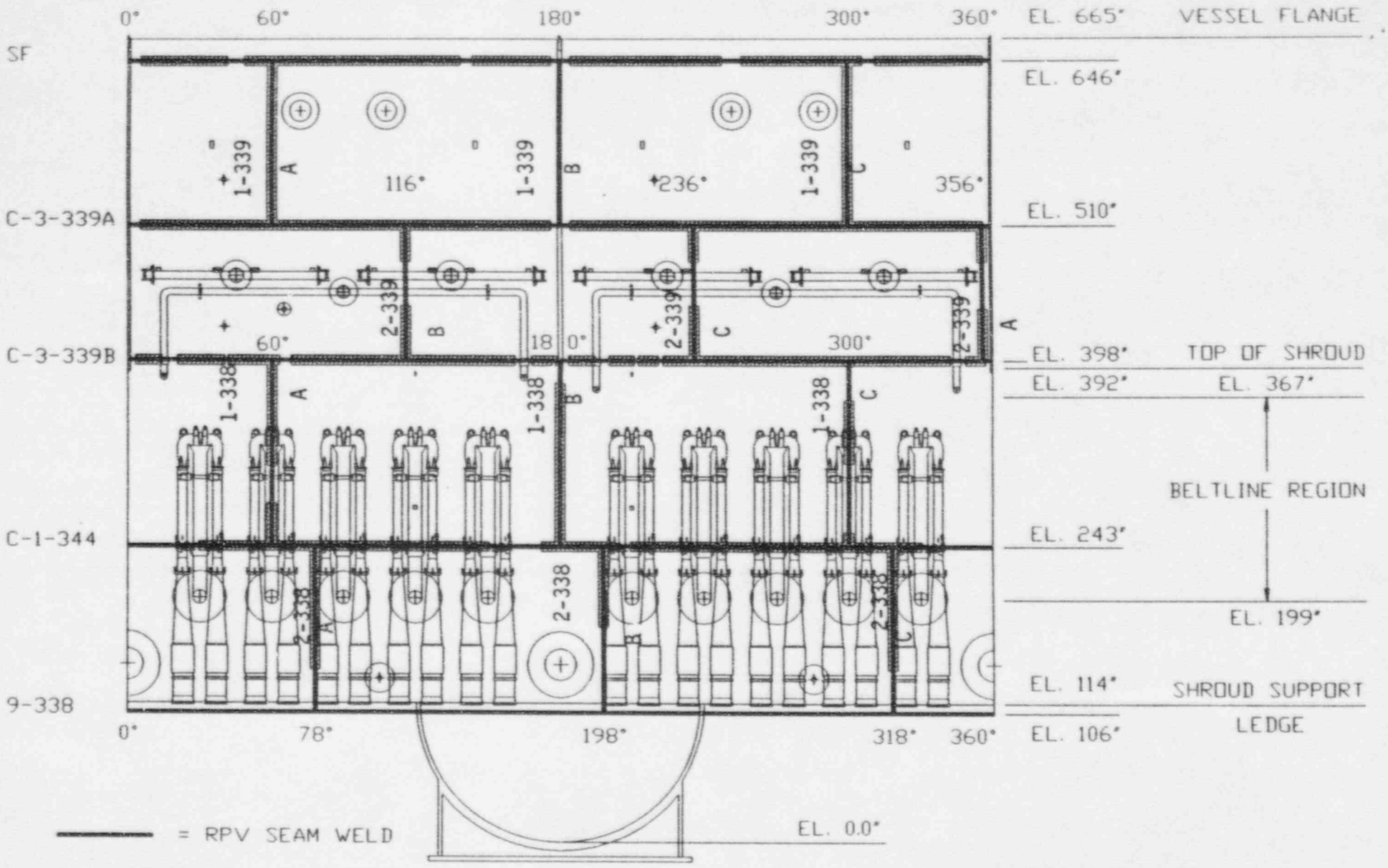
TABLE 1: PILGRIM NUCLEAR POWER STATION - REACTOR PRESSURE VESSEL AUGMENTED EXAMINATION RESULTS

BECO Weld Identification	Code Item	Relief *** Requested	Weld Length (In)	Length Scanned (In)	% Auto Coverage	% Manual Coverage	% Total** Volume Coverage Achieved	Limitations
RPV-9-338	B1.11	Yes	705	705	N/A	71.4	71.4	BS, NRI
RPV-C-1-344 *	B1.11	Yes	705	534.7	71.2	N/A	71.2	JPRB, CSD-GRBC
RPV-C-3-339B	B1.11	Yes	705	612.8	73.2	N/A	73.2	GR, CSD, SSB, IN, CRDRN
RPV-C-3-339A	B1.11	No	705	671.8	93.8	N/A	93.8	GR
RPV-L-2-338A *	B1.12	Yes	137	101.5	75.0	N/A	75.0	N2-C, JPR, MLSL
RPV-L-2-338B *	B1.12	Yes	137	121	49.6	1.0	50.6	N1-B, CSD-GRBC
RPV-L-2-338C *	B1.12	Yes	137	101.5	74.9	N/A	74.9	N2-X, JPR, MLSL
RPV-L-1-338A *	B1.12	Yes	155	124.2	71.4	N/A	71.4	JPRB, CRDRN
RPV-L-1-338B *	B1.12	Yes	155	135.9	87.7	N/A	87.7	GR
RPV-L-1-338C *	B1.12	Yes	155	69.6	34.7	N/A	34.7	JPRB, SSB
RPV-L-2-339B	B1.12	Yes	112	76.6	62.8	N/A	62.8	FS, CSP
RPV-L-2-339C	B1.12	No	112	112	62.8	37.1	99.9	FS, CSP
RPV-L-2-339A	B1.12	Yes	112	74.5	3.0	N/A	3.0	FS, CSP, GR
RPV-L-1-339A	B1.12	No	136	136	98.5	N/A	98.5	N3-A
RPV-L-1-339B	B1.12	Yes	136	0	0.0	N/A	0.0	GR
RPV-L-1-339C	B1.12	No	136	136	90.6	N/A	90.6	N3-D

* = Beltline Region Weld
**= Volume of Weld Metal Achieved (Estimate)
***= Based On 90% Volume Coverage
BS = Bio-Shield
CSD = Core Spray Downcomer
CSP = Core Spray Piping
CRDRN = Control Rod Drive Return Nozzle
FS = Feedwater Sparger
GR = Guide Rod
IN = Instrumentation Nozzle
JPR = Jet Pump Riser
JFRB = Jet Pump Riser Bracket
MLSL = Manipulator Lower Scan Limit
N1-X = Recirculation Outlet Nozzle X
N2-X = Recirculation Inlet Nozzle X
N3-X = Main Steam Nozzle X
NRI = Non Removable Insulation
SSB = Surveillance Specimen Bracket

FIGURE 1

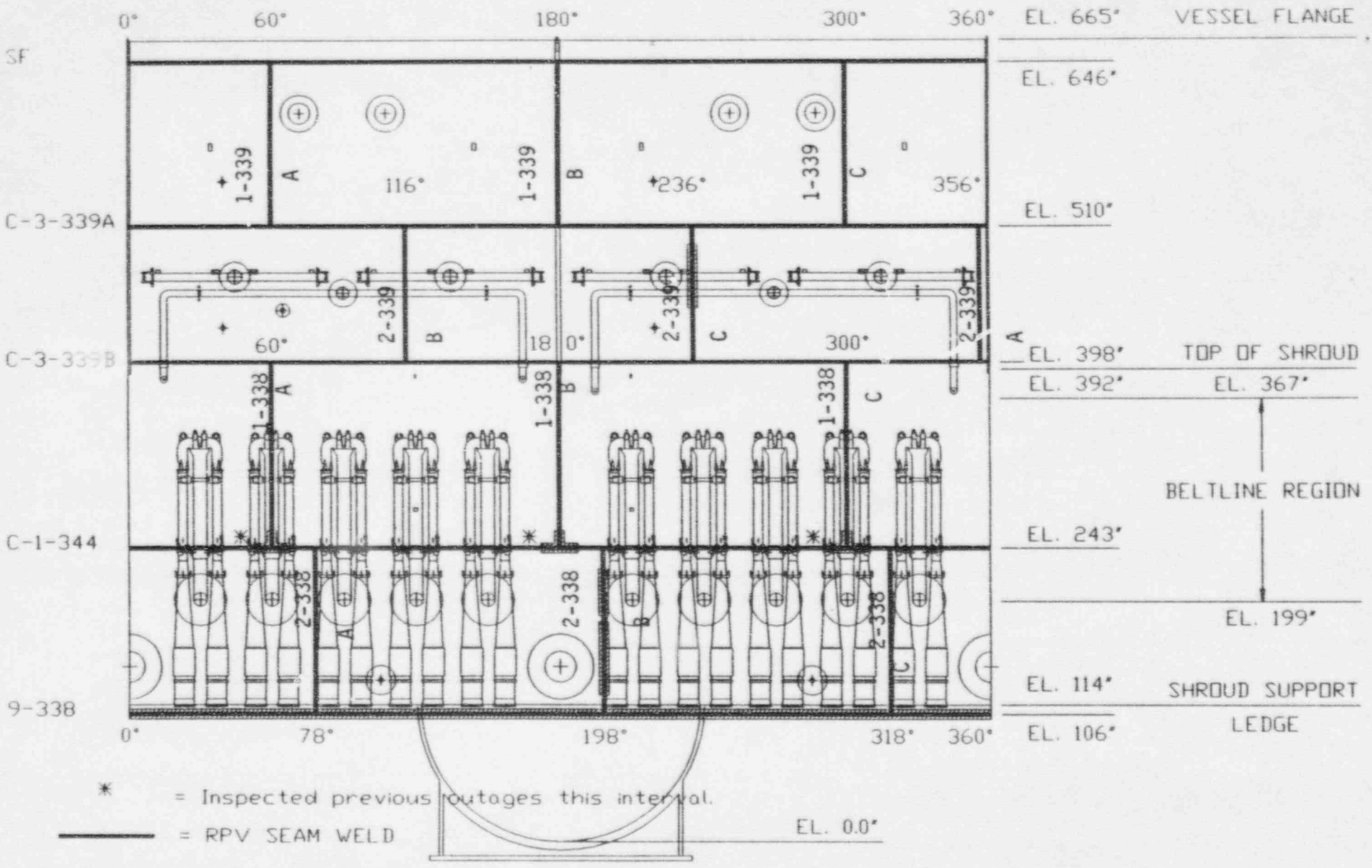
GERIS 2000 SCAN AREAS



GE NUCLEAR ENERGY	BOSTON EDISON, PILGRIM	VESSEL ROLLOUT (ID)	SCALE: NONE	DWG. PLG-VRR	REV 0

FIGURE 2

MANUAL SCAN AREAS



GE NUCLEAR ENERGY	BOSTON EDISON, PILGRIM	VESSEL ROLLOUT (ID)	SCALE: NONE	DWG. PLG-VRR	REV 0

ENCLOSURE 1

GERIS 2000 INVESSEL SYSTEM
CALCULATION OF ACHIEVED COVERAGE'S
ASME SECTION XI - APPENDIX VIII EXAMS

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BECo Quality Assurance

INTRODUCTION

ASME Section XI requires the examination of reactor pressure vessel (RPV) assembly welds each inspection interval. For many years it was not possible to examine some BWR's from the outside surfaces due to access limitations and the technology had not been developed to inspect them from the inside surfaces.

In 1991 General Electric developed the GERIS 2000 Invessel Examination System to examine BWR welds from the ID surfaces using advanced state of the art ultrasonics and an automated scanning device.

The GERIS 2000 Invessel system was designed to examine circumferential shell welds, longitudinal shell welds, shell to flange welds and base material repair welds.

As part of the examination records required to be submitted for the documentation of RPV weld examinations an estimate of the achieved coverage is required. This document is intended to provide guidance to the data analyst for the calculation of the coverage estimate.

ASME SECTION XI / APPENDIX VIII COVERAGE

The 1989 Edition of ASME Section XI with the 1989 Addenda and later Editions of the Code do not specify the techniques required for examination. These Editions of the Code require the use of ultrasonic examination procedures, equipment and personnel that have been qualified by a performance demonstration. The requirements for the performance demonstration are contained in ASME Section XI, Appendix VIII.

Examinations performed to these Code years require an estimate of coverage based on the scanning requirements contained in the qualified procedures. For the purpose of GERIS 2000 Invessel examinations these coverage estimates are referred to as Appendix VIII coverage estimates.

REFERENCES

The requirements for the GERIS 2000's targeted examinations are specified by the following references.

ASME Section XI, Figures IWB-2500-1, 2500-2, 2500-4 define the examination volumes.

ASME Section XI, IWA-2232 "Ultrasonic Examination".

ASME Section XI, Appendix VIII "Performance Demonstration for Ultrasonic Examination Systems".

General Electric procedure GE-UT-700, "Procedure for the Examination of Reactor Pressure Vessel Welds with the GERIS 2000".

Other documents pertaining to RPV examinations are:

USNRC Regulatory Guide 1.150 requires reporting of the achieved coverage.

ASME Code Case N-460 requires a minimum of 90% coverage of the examination volume.

ASME Interpretation XI-1-89-32 clarifies Code Case N-460.

COVERAGE REQUIREMENTS

ASME Section XI, Figures IWB-2500-1, 2500-2, 2500-4 define the examination volumes for the welds targeted for examination by the GERIS 2000 Invessel system. Typically the examination volume is the weld and adjacent base material for a distance of 1 / 2 T on either side of the weld.

General Electric demonstrated the GERIS 2000 Invessel examination system procedures during PDI Session 61-02 in the fall of 1994. The examination procedure was demonstrated in two parts. The first part permitted the data analyst access to the full range of data normally collected during an examination. The second part permitted the data analyst access to a limited range of data defined in the procedure as the minimum required for effective coverage.

The minimum requirements for effective examination coverage as qualified by the performance demonstration of General Electric procedure GE-UT-700 Version 1 are:

Para. 7.2.3 a.) Effective examination of the clad / base material interface region for the detection of flaws oriented perpendicular to the weld axis requires, as a minimum, examination by at least one 70 degree RL search unit directed parallel to the weld axis.

Para. 7.2.3 b.) Effective examination of the clad / base material interface region for the detection of flaws oriented parallel to the weld axis requires, as a minimum, examination by at least one 70 degree RL search unit directed perpendicular to the weld axis.

Para. 7.2.3 c.) Effective examination of the exam volume (not including the interface region) for the detection of flaws oriented perpendicular to the weld axis requires, as a minimum, examination by at least one 45 degree shear wave search unit directed parallel to the weld axis.

Para. 7.2.3 d.) Effective examination of the exam volume (not including the interface region) for the detection of flaws oriented parallel to the weld axis requires, as a minimum, examination by at least one 45 degree shear wave search unit directed perpendicular to the weld axis.

COVERAGE VALUES

Coverage of the examination volume requires a variety of scan angles and beam directions. To calculate achieved coverage a value must be assigned to each scan. This value can be logically determined based on the examination volume each scan is responcible for inspecting and the number of scans required to reliably detect any flaws in the examination volume.

To achieve effective coverage of the examination volume GE-UT-700 V. 1 requires a minimum of four scans.

1. A 70 degree RL angle beam (70° T) scanning for underclad flaws oriented parallel to the weld.
2. A 70 degree RL angle beam (70° P) scanning for underclad flaws oriented transverse to the weld.
3. A 45 degree shear wave angle beam (45° T) scanning for flaws oriented parallel to the weld.
4. A 45 degree shear wave angle beam (45° P) scanning for flaws oriented transverse to the weld.

The examination volume can be considered to require two separate examinations. One examination for the detection of flaws parallel to the weld axis and one for flaws transverse to the weld axis. As both examinations are of the same volume each examination can be considered to have a value of 50% of the overall coverage of the examination volume.

For clad reactor vessels Appendix VIII requires two performance demonstrations. Supplement 4 provides the qualification requirements for the clad / base material interface of the reactor vessel. Supplement 6 provides the qualification requirements for reactor welds other than the clad / base material interface. Supplement 6 references Supplement 4 for flaws located in the inner 10 % thickness of clad vessels. Therefor the Supplement 4 examination represents 10 % of the overall coverage of the examination volume.

This results in the following examination coverage values:

1. 70° T-Scan. (5 %)
2. 70° P-Scan. (5 %)
3. 45° T-Scan. (45 %)
4. 45° P-Scan. (45 %)

For a total of 100 % of the required coverage for the examination volume.

ACHIEVED COVERAGE (PATCH)

Due to scanning characteristics the weld examinations performed by the GERIS 2000 Invessel system consists of a number of connecting rectangular scan areas or "patches". The Data Analyst must determine the achieved coverage for each patch.

This is done by using a "to scale" Auto Cad cross sectional drawing of the weld and required examination volume. Using the scan parameters from the setup records the analyst will plot the search unit positions at the scan start and end points and determine the amount of achieved coverage for that scan.

To illustrate how the data analyst determines the achieved examination coverage for a given scan patch consider the following example.

EXAMPLE 1: Determine the percentage of the examination coverage for a given patch.

Step 1: Determine the area of the required examination volume.

a.) Using the "to scale" AutoCad drawing measure the cross sectional area (A1) of the examination volume.

b.) Using the "to scale" AutoCad drawing measure the cross sectional area (A2) of the 70 degree RL examination volume.

Note: The 70 degree RL examination volume is limited to 1 inch in depth.

c.) Calculate the cross sectional area (A3) of the 45 degree shear wave examination volume.

$$A3 = A1 - A2$$

Step 2: Determine the achieved coverage of the 70° T-Scans.

a.) Using the "as scanned" parameters plot the scan start and end positions of the 70 degree search units directed perpendicular to the weld axis.

b.) Measure the cross sectional area of the examination volume effectively scanned (A4).

c.) Calculate the 70° T-Scan coverage (70TC):

$$70TC = A4 / A2$$

Step 3: Determine the achieved coverage of the 45° T-Scans.

a.) Using the "as scanned" parameters plot the scan start and end positions of the 45 degree search units directed perpendicular to the weld axis.

b.) Measure the cross sectional area of the examination volume effectively scanned (A5).

c.) Calculate the 45° T-Scan coverage (45TC):

$$45TC = A5 / A3$$

Step 4: Determine the achieved coverage of the 70° P-Scans.

a.) Using the "as scanned" parameters plot the scan start and end positions of the 70 degree search units directed parallel to the weld axis.

b.) Measure the cross sectional area of the examination volume effectively scanned (A6).

c.) Calculate the 70° P-Scan coverage (70PC):

$$70PC = A6 / A2$$

Step 5: Determine the achieved coverage of the 45° P-Scans.

a.) Using the "as scanned" parameters plot the scan start and end positions of the 45 degree search units directed parallel to the weld axis.

b.) Measure the cross sectional area of the examination volume effectively scanned (A7).

c.) Calculate the 45° P-Scan coverage (45PC):

$$45PC = A7 / A3$$

Step 6: Calculate the Supplement 4 Coverage (S4C).

$$S4C = (70TC \times .5) + (70PC \times .5)$$

Step 7: Calculate the Supplement 6 Coverage (S6C).

$$S6C = (45TC \times .5) + (45PC \times .5)$$

Step 8: Calculate the Combined Coverage (CC) for the scan patch.

$$CC = (S4C \times .1) + (S6C \times .9)$$

COMBINING PATCH COVERAGE'S

In Example 1 we determined the achieved coverage for a single patch. Due to scan characteristics, invessel limitations and memory considerations most welds examined by the GERIS 2000 will require more than one scan patch.

To determine the achieved coverage for the complete weld we must combine the coverage's from a number of scan patches. The Data Analyst will plot the scanner's position limits for each patch on a "to scale" Auto Cad vessel map drawing. This will allow the analyst to identify any areas that have been skipped inadvertently or areas where the scan patches have been overlapped.

Areas that overlap require the analyst to reduce the claimed coverage by the amount of overlap. Scans that have been limited may permit the analyst to increase the claimed coverage due to additional coverage obtained by search unit offset considerations. To accurately calculate the coverage the analyst must be fully aware of all the details of the examination with special attention given to package configurations.

To illustrate how the data analyst determines the achieved examination coverage for a weld consider the following example.

EXAMPLE 2: Determine the combined coverage for a weld.

Step 1: Calculate the weld length (L).

Step 2: Plot the patch scan limits on the "to scale" Auto Cad vessel map drawing.

a.) For each patch print the scanner parameters from the patch setup record.

b.) Using the as scanned parameters draw the outline of each scanned patch.

c.) Print the drawing and review the patch limits. Verify that all limitations have been documented. Verify that there are no unjustified skip areas between patches. Note any patch overlap areas.

Step 3: Combine the patch coverage's.

a.) For each patch calculate the patch length (PL).

For circumferential welds: PL = X Max - X Min

For longitudinal welds: PL = Y Max - Y Min

b.) Calculate the patch length value (PL_X).

$$PL\_X = (PL / L) \times CC$$

c.) Calculate the weld combined coverage (WCC).

$$WCC = PL\_1 + PL\_2 + ...$$

Where: PL_1 is Patch 1, PL_2 is Patch 2, etc.

d.) Calculate the percent total coverage (%TC)

$$\%TC = WCC \times 100$$

The percent total coverage is the value that will be reported as the achieved coverage for the weld on the examination summary sheet.

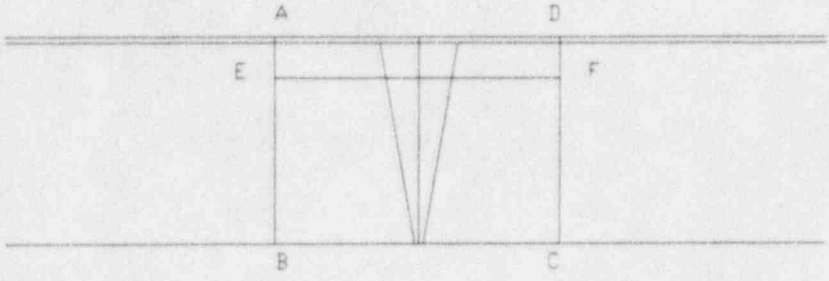
When the patches do not overlap it is a relatively simple matter to combine the coverage's from multiple patches into a single coverage value for the weld.

For weld examinations that include overlapping patches the L Analyst must determine the weld length that has been repeated and reduce the claimed coverage accordingly.

For weld examinations that include manual or automated supplemental examinations the Data Analyst must determine the amount of additional coverage and increase the claimed coverage accordingly.

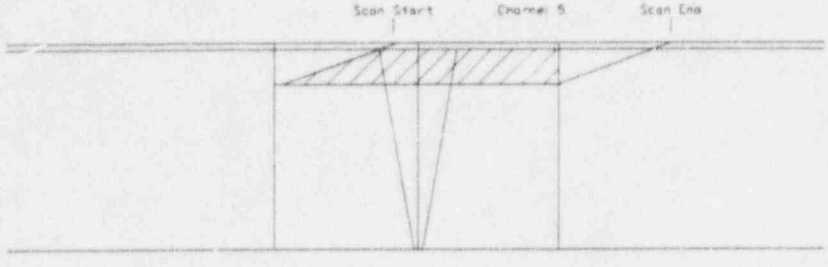
Example 2 provides an illustration of how the combined coverage's can be calculated manually. Typically the scan patch limits and patch coverage values are entered into a spreadsheet and the overall coverage calculated automatically. The Data Analyst is responsible for ensuring that all values have been entered correctly and that any overlapping scans or supplemental examinations have been considered.

Example 1 Step 1



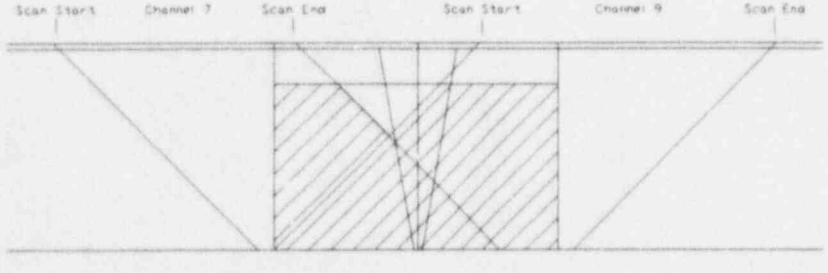
A1 = ABCD
A2 = AEFD
A3 = EBCF

Example 1 Step 2



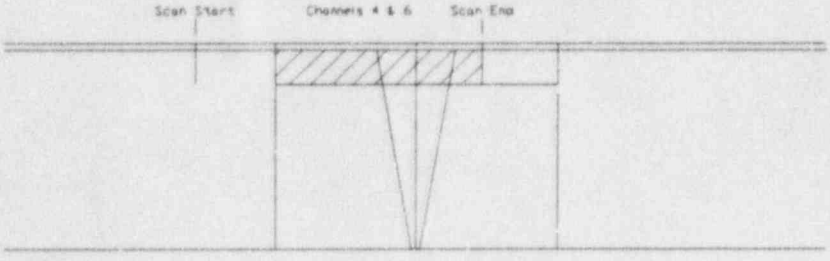
A4 = Hatch area

Example 1 Step 3



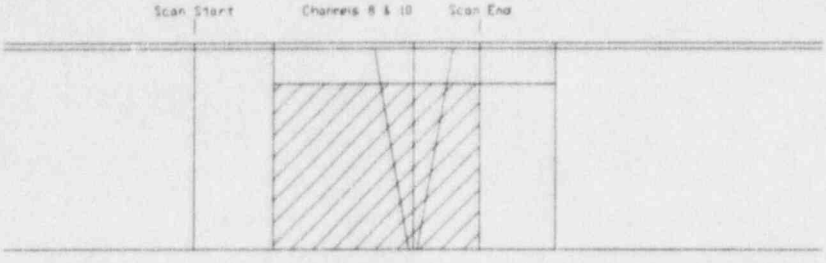
A5 = Hatch area

Example 1 Step 4



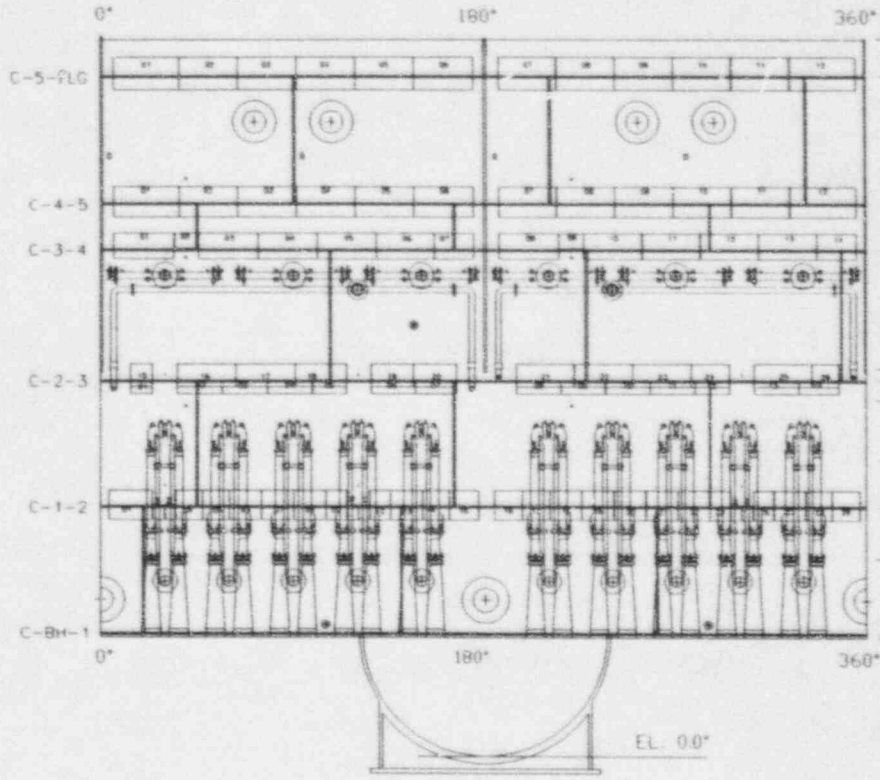
A6 = Hatch area.

Example 1 Step 5



A7 = Hatch area.

SCAN PATCH MAP – CIRC WELDS ONLY



GE NUCLEAR ENERGY	TYPICAL 251" ID BWR	VESSEL ROLLOUT WITH PATCH LOCATIONS	DWG. 251-VMA	REV. 0

Glossary

A1	The cross sectional area of the Section XI examination volume.
A2	The cross sectional area of the Supplement 4 examination volume.
A3	The cross sectional area of the Supplement 6 examination volume.
A4	The cross sectional area effectively examined by the 70° T-Scan search units.
A5	The cross sectional area effectively examined by the 70° P-Scan search units.
A6	The cross sectional area effectively examined by the 45° T-Scan search units.
A7	The cross sectional area effectively examined by the 45° P-Scan search units.
CC	Combined Coverage. A value from 0 to 1 = (S4C x .1) x (S6C x .9).
45PC	45° P-Scan Coverage. A value from 0 to 1 = A7 / A3.
45 P-Scan	A 45° shear wave scan for the detection flaws oriented perpendicular to the weld axis.
45TC	45° T-Scan Coverage. A value from 0 to 1 = A6 / A3.
45 T-Scan	A 45° shear wave scan for the detection flaws oriented parallel to the weld axis.
70TC	70° T-Scan Coverage. A value from 0 to 1 = A4 / A2.
70 T-Scan	A 70° RL scan for the detection of flaws oriented parallel to the weld axis.
70PC	70° P-Scan Coverage. A value from 0 to 1 = A5 / A2.
70 P-Scan	A 70° RL scan for the detection flaws oriented perpendicular to the weld axis.
PL	Patch Length. The distance parallel to the weld traveled by the search unit package.
PL_X	Patch Length value. A value from 0 to 1 = (PL / L) x CC
S4C	Supplement 4 Coverage. A value from 0 to 1 = (70TC x .5) + (70PC x .5).
S6C	Supplement 6 Coverage. A value from 0 to 1 = (45TC x .5) + (45PC x .5).
WCC	Weld Combined Coverage. A value from 0 to 1 = (PL_1) + (PL_2) + ...
%TC	Percent Total Coverage. A value from 0 % to 100 % = WCC x 100

ENCLOSURE 2

GERIS 2000 INVESSEL SYSTEM ALTERNATE METHOD OF VOLUMETRIC EXAMINATIONS

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Approved By: _____
BECo Quality Assurance

INTRODUCTION

Reactor vessels must periodically be volumetrically examined according to Section XI of the ASME Code. The rules of Section XI require a program of examinations, testing, and inspections to evidence adequate safety. To ensure the continued structural integrity of reactor vessels, it is essential that flaws be reliably detected and evaluated.

During the mid 1970's, the USNRC became concerned with the adequacy of ASME Section XI examinations performed on Reactor Pressure Vessel (RPV) assembly welds. These concerns were well founded, since the examinations being performed were not consistent.

The USNRC did a study of NDE methods, procedures, and ASME Section XI, PSI / ISI data. The results of this study showed that some standardization of methods and recording criteria was required. In July of 1981, Regulatory Guide 1.150 (RG 1.150) was issued. Revision 1 of this Regulatory Guide, which allowed approved alternate methods of compliance, was issued in 1983. General Electric has been complying with Revision 1, using the alternate method, since then.

Later Editions and Addenda to the Code have attempted to address the evident short comings of the volumetric examinations specified for reactor pressure vessels. The most comprehensive attempt to improve the reliability of examinations has been Appendix VIII, ASME Section XI which requires that procedures, equipment, and personnel who detect or size flaws be qualified by performance demonstration.

In November of 1994 General Electric successfully completed a performance demonstration of the GERIS 2000 Invessel system administered by representatives of the Performance Demonstration Initiative (PDI). The performance demonstrations were in accordance with the PDI-RPV Protocol document implementing the requirements of Appendix VIII, ASME Section XI, 1992 Edition with the 1993 Addenda.

General Electric's previous experience with RPV performance demonstrations using implanted flaws indicated that examination procedures based on Article 4 of Section V methods were not capable of reliably detecting or sizing flaws with the degree of accuracy required for an Appendix VIII demonstration.

Due to this experience the examination and sizing procedures submitted for performance demonstration specifically did not comply with the requirements of Article 4. The procedures were written to incorporate the lessons learned from industry experiences with IGSCC, weld overlay examinations and RPV sample specimens where actual flaws directed technique development.

General Electric's qualified procedures meet the requirements of IWA-2240 "Alternative Examinations" by providing an examination that significantly increases the probability that flaws be reliably detected and evaluated.

This document is intended to itemize those areas where the qualified procedures do not comply with ASME Section XI, IWA-2230 and Article 4 of Section V and General Electric's basis for non-compliance.

ASME SECTION XI, DIVISION 1

IWB-2500 EXAMINATION AND PRESSURE TEST REQUIREMENTS

(a) Components shall be examined and tested as specified in Table 2500-1. The method of examination for the components and parts of the pressure retaining boundaries shall comply with those tabulated in Table IWB-2500-1 except where alternate examination methods are used that meet the requirements of IWA-2240.

General Electric's procedure complies with IWB-2500.

IWA-2230 VOLUMETRIC EXAMINATION

A volumetric examination indicates the presence of discontinuities throughout the volume of material and may be conducted from either the inside or outside surface of a component.

General Electric's procedure complies with IWA-2230 by use of an inside surface ultrasonic examination.

IWA-2232 Ultrasonic Examination

(a) Ultrasonic examination of Class 1 and Class 2 vessel welds in ferritic material greater than 2 in. (51 mm) in thickness shall be conducted in accordance with Article 4 of Section V, amended as follows:

(1) The requirements of T-431, Instrument Calibration shall be verified at the beginning and end of the weld examination performed on a vessel during one outage.

General Electric's procedure does not comply with IWA-2232. The procedure is not in accordance with Article 4 of Section V. The requirements of T-431 are not verified as part of the qualified procedure.

IWA-2240 ALTERNATIVE EXAMINATIONS

Alternative methods, a combination of methods, or newly developed techniques may be substituted for the methods specified in this Division, provided the Inspector is satisfied that the results are demonstrated to be equivalent or superior to those of the specified method.

In November of 1994 General Electric successfully completed a performance demonstration of the GERIS 2000 Invessel system administered by representatives of the Performance Demonstration Initiative (PDI). The performance demonstrations were in accordance with the PDI-RPV Protocol document implementing the requirements of Appendix VIII, ASME Section XI, 1992 Edition with the 1993 Addenda. The results of this demonstration are superior to those of the specified method. General Electric's procedure qualifies as an alternative examination permitted by IWA-2500 and IWA-2240.

ASME SECTION V, ARTICLE 4

Article 4 describes the requirements which are to be used for developing ultrasonic examination procedures for Code Sections referencing Article 4. These procedures are to be used for the ultrasonic examination of the required volume and the dimensioning of indications detected for comparison with acceptance standards.

General Electric's procedures were specifically written to incorporate the lessons learned from industry experiences with IGSCC, weld overlay examinations and RPV sample specimens where actual flaws directed technique development. Article 4's procedures are dependent on the amplitude characteristics of the basic calibration block and General Electric's qualified procedures are dependent on the echo-dynamic motion and tip diffraction characteristics of the flaw itself. Due to the fundamental difference in technique the areas where General Electric's procedure differs from Article 4 must be in general terms.

In general the following are the basic requirements addressed by Article 4:

a) Instrument calibration; linearity and beam spread measurements
b) System calibration requirements
c) Calibration confirmation
d) Scanning requirements
e) Recording examination data
f) Evaluation of recorded flaws

Instrument Calibration

Linearity

Due to the design characteristics of the GERIS 2000 the linearity checks specified by T-431.2 do not verify any portion of the ultrasonic system's electronics or displays.

Beam spread measurements

Beam profile measurements are not obtained as part of the qualified procedure. Angle beam profile data is required for amplitude based sizing techniques using beam spread correction. Amplitude based sizing is not used by the GERIS 2000 Invessel system.

System Calibration Requirements

General Electric's procedure complies with Article 4's calibration requirements.

Calibration Confirmation

Article 4 requires a calibration check at the finish of each examination and every 12 hours during the examination. General Electric's procedures do not rely on any characteristic of the basic calibration block for flaw detection or sizing and as such no intermediate calibration verifications are performed

Scanning Requirements

Article 4 requires scanning of the weld and adjacent base material with straight and angle beam techniques. The angle beam scans are generally 45° and 60° shear waves, other angles are permitted. The examination volume is required to be scanned with the angle beams directed both at right angles to the weld axis and along the weld axis. Wherever feasible the examination is to be performed in both directions.

General Electric's procedure also requires scanning of the weld and adjacent base material with straight and angle beam techniques. The angle beam scans are 45°, 60° shear and 70° refracted longitudinal waves. The examination volume is required to be scanned with the angle beams directed both at right angles to the weld axis and along the weld axis. Wherever feasible the examination is to be performed in both directions. The minimum requirements for effective examination coverage as qualified by the performance demonstration are:

Para. 7.2.3 a.) Effective examination of the clad / base material interface region for the detection of flaws oriented perpendicular to the weld axis requires, as a minimum, examination by at least one 70 degree RL search unit directed parallel to the weld axis.

Para. 7.2.3 b.) Effective examination of the clad / base material interface region for the detection of flaws oriented parallel to the weld axis requires, as a minimum, examination by at least one 70 degree RL search unit directed perpendicular to the weld axis.

Para. 7.2.3 c.) Effective examination of the exam volume (not including the interface region) for the detection of flaws oriented perpendicular to the weld axis requires, as a minimum, examination by at least one 45 degree shear wave search unit directed parallel to the weld axis.

Para. 7.2.3 d.) Effective examination of the exam volume (not including the interface region) for the detection of flaws oriented parallel to the weld axis requires, as a minimum, examination by at least one 45 degree shear wave search unit directed perpendicular to the weld axis.

The minimum requirements for effective examination coverage as qualified do not include any contribution from the straight beam or 60° shear wave examinations. As General Electric is not using the technique described in Article 4 the term "Code" coverage is not applicable. All coverage reported is effective coverage as defined by the qualified procedure.

Recording Examination Data

Article 4 requires the recording of all reflectors equal to or exceeding 50% of DAC and all surface reflectors that equal or exceed the response from the opposite surface notch.

General Electric's procedure requires the investigation of all relevant reflectors, regardless of amplitude, that possess the echo-dynamic characteristics of planar reflectors. All reflectors that are accompanied by tip diffracted signals are recorded. Relevant reflectors exceeding 20% of DAC are also recorded.

Evaluation of Reflectors

Article 4 requires the dimensioning of flaws using amplitude based techniques. Reflectors exceeding 100% of DAC are dimensioned at the 50% of maximum amplitude points. Reflectors exceeding 50% of DAC are dimensioned at the 50% of DAC points. Reflector lengths are determined at the 50% of DAC end points.

General Electric's procedure requires the dimensioning of flaws using tip diffraction techniques. Reflector lengths are determined at the 50% of maximum amplitude end points.

SUMMARY

An examination performed in accordance with General Electric's procedure will result in the examination volume being interrogated by the same straight and angle beam search units as an Article 4 procedure. Any areas of limited access would be common to the Article 4 procedure. An additional examination by the 70° RL search units, not required by Article 4, is also being performed.

The recording criteria of General Electric's procedure will result in the recording of any flaw required to be recorded by an Article 4 procedure. Flaws considerable below the 50% of DAC threshold i.e. less than 5% of DAC are routinely recorded and evaluated with the GERIS 2000 Invessel system.

General Electric's flaw dimensioning techniques have been demonstrated to be within the tolerances of Appendix VIII as implemented by the PDI. Article 4's flaw dimensioning techniques have not been successfully demonstrated within the tolerances of Appendix VIII.

ENCLOSURE 3

GERIS 2000 INVESSEL SYSTEM
ALTERNATE METHOD FOR COMPLIANCE
TO REGULATORY GUIDE 1.150

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BECo Quality Assurance

INTRODUCTION

Reactor vessels must periodically be volumetrically examined according to Section XI of the ASME Code. The rules of Section XI require a program of examinations, testing, and inspections to evidence adequate safety. To ensure the continued structural integrity of reactor vessels, it is essential that flaws be reliably detected and evaluated.

During the mid 1970's, the USNRC became concerned with the adequacy of ASME Section XI examinations performed on Reactor Pressure Vessel (RPV) assembly welds. These concerns were well founded, since the examinations being performed were not consistent.

The USNRC did a study of NDE methods, procedures, and ASME Section XI, PSI / ISI data. The results of this study showed that some standardization of methods and recording criteria was required. In July of 1981, Regulatory Guide 1.150 (RG 1.150) was issued. Revision 1 of this Regulatory Guide, which allowed approved alternate methods of compliance, was issued in 1983. General Electric has been complying with Revision 1, using the alternate method, since then.

RG 1.150 provided a much needed first step in the continuing improvements of RPV assembly weld examination techniques. These improved techniques, along with changes in the ASME Code, have rendered parts of the Regulatory Guide obsolete.

Later Editions and Addenda to the Code have attempted to address the evident short comings of the volumetric examinations specified for reactor pressure vessels. The most comprehensive attempt to improve the reliability of examinations has been Appendix VIII, ASME Section XI which requires that procedures, equipment, and personnel who detect or size flaws be qualified by performance demonstration.

In November of 1994 General Electric successfully completed a performance demonstration of the GERIS 2000 Invessel system administered by representatives of the Performance Demonstration Initiative (PDI). The performance demonstrations were in accordance with the PDI-RPV Protocol document implementing the requirements of Appendix VIII, ASME Section XI, 1992 Edition with the 1993 Addenda.

General Electric's previous experience with RPV performance demonstrations using implanted flaws indicated that examination procedures based on Article 4, ASME Section V methods were not capable of reliably detecting or sizing flaws with the degree of accuracy required for an Appendix VIII demonstration.

Due to this experience the examination and sizing procedures submitted for performance demonstration specifically did not comply with the requirements of Article 4. The procedures were written to incorporate the lessons learned from industry experiences with IGSCC, weld overlay examinations and RPV sample specimens where actual flaws directed technique development.

As RG 1.150 was written to standardize examinations based on Article 4, General Electric's qualified procedure does not comply with many of its requirements. General Electric's position is that the qualified procedures meet the intent of RG 1.150 by providing an examination that significantly increases the probability that flaws be reliably detected and evaluated.

This paper is intended to itemize those areas where the qualified procedure does not comply with RG 1.150 and General Electric's basis for non-compliance.

1.0 INSPECTION SYSTEM PERFORMANCE CHECKS

The performance checks specified are not performed as part of the qualified procedure.

The checks specified are required to document the performance characteristics of the inspection system for the purpose of comparison of examination results. The performance characteristics of an ultrasonic system are determined by the system's electronics and search unit parameters.

Appendix VIII defines the system electronics i.e., pulsers, receivers, cables and search unit parameters as "essential variables" and permits the substitution of these essential variables only under strictly limited conditions.

A comparison of the subject equipment's ability to detect and size flaws under controlled conditions provides a better means for the comparison of examination results.

1.1 Pre-exam Performance Checks

a. The design of the GERIS 2000 does not provide any pulse shape or noise suppression controls.

b. RF Waveform

RF Waveforms from reference reflectors are not obtained as part of the qualified procedure.

The GERIS 2000 records every RF waveform for each search unit position during the examination. This data is available and can be processed to obtain the frequency amplitude information at the time of flaw detection.

1.2 Field Performance Checks

a. The design of the GERIS 2000 does not provide any pulse shape or noise suppression controls.

b. Instrument Sensitivity during Linearity Checks

The GERIS 2000's sensitivity is not dependent on any gain settings normally available to the system's operator. Due to the design characteristics of the GERIS 2000 the linearity checks specified by the Code do not verify any portion of the ultrasonic system's electronics or displays.

c. RF Waveform

RF Waveforms from reference reflectors are not obtained as part of the qualified procedure.

The GERIS 2000 records every RF waveform for each search unit position during the examination. This data is available and can be processed to obtain the frequency amplitude information at the time of flaw detection.

d. Screen Height Linearity

Due to the design characteristics of the GERIS 2000 the screen height linearity checks specified by the Code do not verify any portion of the ultrasonic system's electronics or displays.

e. Amplitude Control Linearity

Due to the design characteristics of the GERIS 2000 the amplitude control linearity checks specified by the Code do not verify any portion of the ultrasonic system's electronics or displays.

f. Angle Beam Profile Characterization

Beam profile measurements are not obtained as part of the qualified procedure.

Angle beam profile data is required for amplitude based sizing techniques using beam spread correction. Amplitude based sizing is not used by the GERIS 2000 Invessel system.

The flaw sizing methods used by the GERIS 2000 Invessel system are tip diffraction based and have been qualified by performance demonstration.

2. CALIBRATION

Ultrasonic calibrations are performed on the GERIS 2000 Invessel system only for the purpose of providing a reference for comparison of detected flaws with previous and future data.

The establishment of the DAC curve and sweep calibration complies with Article 4, Section V and Appendix I of Section XI.

The ultrasonic calibration is performed using the Code calibration blocks specified in the Owners examination plan, both prior to and after a series of examinations.

2.2 Calibration for Mechanized Scanning

a. Not applicable.

b. Not applicable.

c. Not applicable.

d. The ultrasonic calibrations are performed staticaly and a comparison of static versus dynamic performance has been performed. No correction factor was indicated.

2.3 Calibration Confirmation

The GERIS 2000 does not rely on any characteristic of the basic calibration block for flaw detection or sizing and as such no intermediate calibration verifications are performed.

Electronic simulators are not used for calibration confirmation.

2.4 Calibration Blocks

The ultrasonic calibration is performed using the Code calibration blocks specified in the Owners examination plan. These blocks should comply with the requirements of Appendix I, Section XI or Article 4, Section V as applicable..

3. EXAMINATION

The scope and extent of ultrasonic examinations comply with IWA-2000, Section XI.

The gates specified by the qualified procedure include the entire thickness of the required examination volume.

The scan overlap specified by the qualified procedure is greater than the minimum 25 percent requirement.

3.1 Internal Surface

The GERIS 2000 Invessel system has successfully demonstrated the ability to detect, length size and thruwall size flaws located at the clad / base material interface (Supplement 4).

a. Not applicable.

b. The qualified procedure does not rely on any characteristic of the basic calibration block for flaw detection or sizing and the use of an alternate reflector is not indicated.

c. The qualified procedure effectively examines the entire thickness of the required examination volume.

3.2 Scanning Weld-Metal Interface

The GERIS 2000 Invessel system has successfully demonstrated the ability to detect, length size and thruwall size flaws located in the base material other than at the clad / base material interface (Supplement 6). This demonstration included unfavorably oriented planar flaws i.e. oriented perpendicular to the examination surface.

4. BEAM PROFILE (DELETED)

5. SCANNING WELD-METAL INTERFACE (DELETED)

6. RECORDING AND SIZING

The GERIS 2000 Invessel system has successfully demonstrated the ability to detect, length size and thruwall size flaws to the requirements of ASME Appendix VIII, Supplements 4 and 6.

These demonstrations were administered in November of 1994 by representatives of the PDI. The performance demonstrations were in accordance with the PDI-RPV Protocol document implementing the requirements of ASME Section XI, Appendix VIII, 1992 Edition with the 1993 Addenda.

The demonstrated recording and sizing techniques are those used for examination.

6.1 Geometric Indications

Geometric indications are recorded and the nature of the geometry is described.

6.2 Indications with Changing Metal Path

a. All indications with apparent thruwall dimensions are recorded regardless of amplitude.

b. All relevant indications exceeding 50% of DAC are recorded and characterized using demonstrated techniques.

c. All relevant indications exceeding 20% of DAC are recorded and characterized using demonstrated techniques.

6.3 Indications without Changing Metal Path

a. All relevant indications are recorded and characterized using demonstrated techniques

b. All relevant indications are recorded and characterized using demonstrated techniques

c. The GERIS 2000 displays are not subject to this effect.

6.4 Additional Recording Criteria

a. Indications are recorded every 0.25 inch.

b. Indication metal path and search unit position is recorded at 20%, 50% and 100% DAC and at the maximum amplitude of the signal. This information is for reference only and is not utilized for flaw sizing.

c. The GERIS 2000 Invessel system does not use the automated detection and recording system described in this paragraph.

7. REPORTING OF RESULTS

The Final Report documenting the examinations performed by the GERIS 2000 Invessel system is provided to the Owner. Maintenance of this document is the Owners responsibility.

Relevant indications sized by the demonstrated flaw sizing techniques are characterized in accordance with the rules of IWA-3000 and evaluated to the acceptance standards of IWB-3000. Indications exceeding the acceptance standards of IWB-3000 are reported to the Owner. The Owner is responsible for the final disposition and subsequent reporting of these indications.

a. The flaw sizing procedure has successfully completed a performance demonstration in accordance with ASME Section XI, Appendix VIII, Supplements 4 and 6 as implemented by the PDI.

The flaw sizing tolerances are within the acceptance criteria of Appendix VIII as implemented by the PDI. The actual error band established by the performance demonstration is not currently available to General Electric. This information is available on request by PDI member utilities and the USNRC from the PDI.

b. The examination procedure has successfully completed a performance demonstration in accordance with ASME Section XI, Appendix VIII, Supplements 4 and 6 as implemented by the PDI.

c. This estimate and supporting drawings or descriptions are provided to the Owner as part of the Final Report documenting the examination.

d. These drawings are provided to the Owner as part of the Final Report documenting the examination.

e. Not applicable.