Review of Mihama Unit 1

Surveillance Program Weld Metal Data

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NON-PROPRIETARY

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CE Engineering Technology
Component Integrity
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REV. NO.	DATE	PAGES AFFECTED	PREPARED BY:	APPROVED BY:
00	10/23/00	All	C. L. Hoffmann	S. T. Byrne B. Hinton

BACKGROUND

In Reference 1 relevant surveillance data were reviewed in order to evaluate the Fort Calhoun reactor pressure vessel (RPV) beltline materials with the purpose of demonstrating that the RPV materials will not exceed the pressurized thermal shock (PTS) screening criteria (Reference 2). Included in the surveillance data for evaluation of the Fort Calhoun RPV were unirradiated baseline data and irradiated data from three surveillance capsules from Mihama Unit 1. Mihama Unit 1 is a 320 MWe Westinghouse PWR operated by Kansai Electric Power Co. in Japan. The weld material in the Mihama Unit 1 surveillance program was fabricated by Combustion Engineering (CE) using a tandem submerged arc weld deposited with weld wire heats 12008 and 27204. This combination of weld wire heats corresponds to one of the same combinations also used by CE in the fabrication of the Fort Calhoun RPV beltline lower shell course axial weld seams 3-410-A thru C. This weld wire heat combination was identified as the controlling weld seam chemistry for the Fort Calhoun RPV. Mihama Unit 1 has been identified as the only known plant containing the 12008 and 27204 weld wire heat combination in any surveillance program of a CE fabricated RPV. Because of the importance of this particular weld wire heat combination to the Fort Calhoun RPV PTS evaluation, data from the Mihama Unit 1 surveillance program were obtained from Kansai Electric Power Co. This report provides a review and summary of the Mihama Unit 1 surveillance program weld metal data and its applicability to the Fort Calhoun RPV.

SURVEILLANCE DATA

Surveillance capsule test data provided by Kansai Electric Power Co., Inc. for the Mihama Unit 1 surveillance weld metal (Ref. 3) are summarized in the following Table 1.

Unirradiated baseline Charpy data for the surveillance weld were reported in Reference 4. Kansai Electric Power Co., Inc. provided the irradiated Charpy data for the three surveillance capsules (Reference 5). The data from Mihama Unit 1 surveillance program were obtained through a proprietary agreement between Kansai Electric Power Co. and the Omaha Public Power District. Complete details of all of the surveillance capsule testing were not obtained from Kansai Electric Power Co. Therefore, the purpose of this evaluation is to demonstrate that the reported values are reasonable and consistent with the expected behavior for this type of C-E fabricated weld metal rather than to demonstrate that the reported values can be reproduced exactly by alternate analysis. .

The individual unirradiated Charpy test data (Reference 4) are provided in Table 2. Surveillance capsule weld metal Charpy test specimen data for the three reported sets of capsule results are provided in Table 3. The unirradiated and irradiated Charpy data for this weld metal were evaluated to establish that the weld metal surveillance data from the Mihama Unit 1 reactor vessel are applicable to the Fort Calhoun RPV:

TABLE 1
Surveillance Program Weld Metal Test Results for Mihama Unit 1

Surveillance Capsule Test	Neutron Irradiation	Initial RT_{NDT} + Shift		USE	
	($x10^{19}$ n/cm^2)	(°C)	(°F)	(J)	(ft-lb)
Initial	0	-50	-58	133	97.8
1st Monitoring	0.6 (Approx. 7 EFPY at 1/4t)	54	129.2	93	68.4
2nd Monitoring	1.2 (Approx. 15 EFPY at 1/4t)	64	147.2	83	61.0
3rd Monitoring	2.1 (Approx. 25 EFPY at 1/4t)	76	168.8	83	61.0

TABLE 2
Unirradiated Baseline Charpy Impact Data
for Mihama Unit 1 Surveillance Weld Metal

Neutron Fluence	Spec. I.D.	Test Temperature		Impact Energy		Lateral Expansion		Fracture Appearance
($x10^{19}$ n/cm^2)		(°C)	(°F)	(kg-m)	(ft-lb)	(mm)	(mils)	(%)
[								]

TABLE 3
Irradiated Baseline Charpy Impact Data
for Mihama Unit 1 Surveillance Weld Metal

Neutron Fluence	Spec. I.D.	Test Temperature		Impact Energy		Lateral Expansion		Fracture Appearance
($x10^{19}$ n/cm^2)		(°C)	(°F)	(kg-m)	(ft-lb)	(mm)	(mils)	(%)
[ ]								

DATA EVALUATION

The individual Charpy specimen data for the unirradiated tandem weld wire heat 12008/27204 were used to establish the unirradiated Charpy curve. The data from Table 2 are plotted in Figure 1 along with hyperbolic tangent curve fits to both the Charpy energy and the lateral expansion values reported in Reference 1.

No unirradiated drop weight test results were reported for the baseline testing of the Mihama Unit 1 surveillance weld metal. The Mihama Unit 1 baseline report (Ref. 4) was issued in January 1970 prior to the definition of the requirements for determining initial RT_{NDT} properties introduced in the Summer 1972 addenda to Section III of the ASME Boiler & Pressure Vessel Code. The unirradiated Charpy data support the initial RT_{NDT} value of -58°F (-50°C) reported for the 12008/27204 weld metal. Interpolation of the minimum values at the –50°F and +10°F test temperatures, as suggested for certain materials in NB-2331(d) produces a T_{Cv50} of approximately [ ] Initial RT_{NDT} is determined in part by the temperature at which a minimum of 50 ft-lb and 35 mils lateral expansion is achieved. This initial RT_{NDT} value is also consistent with the -56°F (-49°C) generic mean value for Linde 1092 flux welds (Reference 2).

The unirradiated T_{Cv30} temperature is overestimated somewhat by the hyperbolic tangent curve fit shown in Figure 1. The three test results at the test temperature of -100°F [ ] have an average value of [ ] Therefore the T_{Cv30} temperature for the weld metal based on the Charpy test results was concluded to be approximately [ ]

The individual irradiated Charpy specimen data for the three surveillance capsule fluences from Table 3 are plotted in Figure 2. Hyperbolic tangent curve fits were made to the data set from each set of capsule data. The resulting curves are also shown in Figure 2.

The Mihama Unit 1 data were originally reported as values of Initial RT_{NDT} plus shift. The corresponding shift values obtained by subtracting out the initial RT_{NDT} value of -58°F (-50°C) are shown in Table 4. The T_{Cv30} temperatures were determined from the curve fits for each data set shown in Figure 2. These values and the corresponding ΔT_{Cv30} shifts for each set of surveillance capsule data are summarized in Table 4. Comparison of the reported shift values to those determined from the hyperbolic tangent curve fits of the data show good agreement. The maximum difference between the reported values and the estimated shifts from curve fits to the data is [ ] variation between the reported and estimated shifts for the highest fluence surveillance capsule. [ ] This difference is insignificant relative to the total shift and may be attributed to differences in curve fitting procedures, estimate of initial

properties and rounding of values. The minor difference is also explained in part due to not having complete detailed reports detailing how each calculated value was determined.

TABLE 4
Evaluation of Surveillance Program Weld Metal Test Results for Mihama Unit 1

		Mihama Values		Tanh Curve Fits to Data	
Surveillance Capsule Test	Neutron Irradiation	Initial RT_{NDT} + Shift	Shift ΔT_{Cv30}	T_{Cv30} Temperature	Shift ΔT_{Cv30}
	($x10^{19}$ n/cm^2)	(°F)	(°F)	(°F)	(°F)
Initial	0	-58	0	[ ]	0
1st Monitoring	0.6	129.2	187.2	[ ]	[ ]
2nd Monitoring	1.2	147.2	205.2	[ ]	[ ]
3rd Monitoring	2.1	168.8	226.8	[ ]	[ ]

SUMMARY & CONCLUSIONS

Based on the review of the Mihama Unit 1 weld metal surveillance data, the initial and irradiated properties reported by Kansai Electric Power Co. are considered to be reasonable and consistent with the expected behavior for this type of weld metal used in fabrication of reactor pressure vessels by C-E's Chattanooga facility. The reported initial RT_{NDT} value is supported by the Charpy data and is consistent with the generic value for this type of material.

The irradiated Charpy impact data were evaluated and compared to the unirradiated data. Charpy shifts determined from this evaluation were consistent with shift values reported for each of the three surveillance capsules. Based on this evaluation, the Mihama Unit 1 surveillance program data is considered to be applicable to the same combination of weld wire heats used to fabricate the axial weld seams of the lower shell course in the Fort Calhoun RPV.

REFERENCES

1) "Evaluation of Reactor Vessel Surveillance Data Pertinent to the Fort Calhoun Reactor Vessel Beltline Materials: Basis for Prediction of RT_{PTS} for the Fort Calhoun RPV," CEN-636, Rev. 02, July 2000.

2) 10 CFR 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events," Federal Register, Vol. 60, No. 243, December 19, 1995.

3) Communication from Y. Nishida (Kansai Electric Power Co.) to J. K. Gasper (OPPD), "Mihama Unit No. 1 Reactor Vessel Material Information," dated December 7, 1999.

4) S. E. Yanichko, "Kansai Electric Power Co. Mihama Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-7374, Westinghouse Electric Corp., Pittsburgh, PA, January 1970.

5) Letter from K. Shigemune (Kansai Electric Power Co.) to J. K. Gasper (OPPD), "Reactor Vessel Data of Mihama Unit 1," dated April 17, 2000.

FIGURE 1 – Unirradiated Baseline Charpy Data for Mihama Unit 1 Surveillance Weld Metal (Reference 4)

FIGURE 2 – Irradiated Charpy Data for Mihama Unit 1
Surveillance Weld Metal (Reference 5)

Quality Assurance and Surveillance Program Supplemental Information for License Amendment Request dated August 3, 2000 (LIC-00-0064)

QA of Mihama 1 Data:

- *Standard for calibration of Charpy test machine, temperature, measurement of equipment.*

  Charpy testing of the Mihama 1 surveillance materials was conducted using ASTM E 23 (Standard Test Methods for Notched Bar Impact Testing of Metallic Materials). Section 10 (Verification of Charpy Machines) describes how this verification is performed. Because Kansai Electric used the same standard as in the U.S., results from their surveillance program are compatible with those from domestic programs.

- *Method of determining chemical composition (% Cu, % Ni) of surveillance test specimens.*

  Kansai Electric notified OPPD that Westinghouse provided the chemical analysis information. Westinghouse staff involved in the evaluations confirmed that they used the same chemical analysis testing techniques and standards that they used for the U.S. plant surveillance programs.

- *Accuracy of measurements of above 2 items.*

  With respect to the Charpy measurements, the accuracy meets the requirements of ASTM E 23, as do the domestic programs.

  With respect to chemical composition measurements, the accuracy meets the requirements of domestic programs of the Mihama 1 plant's vintage.

- *If Japanese standards are different than American standards, compare the standards.*

  As noted above, both Kansai and U.S. surveillance programs use ASTM E 23 for Charpy measurements. For the chemical composition analysis, the measurements were conducted in the U.S. by Westinghouse using standard chemical analysis techniques typical of the same vintage of domestic plants.

Surveillance Programs of Sister Vessels:

For the limiting Fort Calhoun Station reactor vessel welds, the surveillance programs of Mihama 1 (12008/27204), Diablo Canyon 1 (27204), Palisades Supplemental (27204), and Fort Calhoun W-275 Supplemental (27204 & 12008/13253) were reviewed to determine when further data would be available for use in the Fort Calhoun Station Reactor Vessel Integrity Program. This information is summarized below:

- Weld Wire Heat 12008/27204

  The data from Capsules 1-3 were used in CEN-636, Rev. 02. The removal schedule for the remaining **Mihama 1** capsules is:

  (1) Capsule 4 is scheduled for removal in 2001; results are expected in 2002.
  (2) Capsule 5 is scheduled for removal in 2010; results are expected in 2011.
  (3) Capsule 6 is currently considered standby with no scheduled removal.

- Weld Wire Heat 27204/27204:

  The status of the **Palisades** capsules is:

  (1) Capsule SA-60-1 was pulled and evaluation data are found in internal report ATI-99-006-002 (8/4/99). The capsule report will likely be submitted to the NRC this year. The data were used in CEN-636, Rev. 02.
  (2) Capsule SA-240-1 was pulled and is at Framatome for evaluation. The report is scheduled for submittal to the NRC in 2001.

  The removal schedule for the **Diablo Canyon Unit 1** capsules and status of results reporting to the NRC are:

  (1) Capsule DC1-S data are in WCAP-11567 (December 1987). The data were used in CEN-636, Rev. 02.
  (2) Capsule DC1-Y data are in WCAP-13750 (July 1993). The data were used in CEN-636, Rev. 02.
  (3) Capsule DC1-V is scheduled for May 2002 removal, with an expected May 2003 report submittal. This is the last of the 3 original capsules containing 27204 weld material.
  (4) Capsule DC1-C (supplemental) is scheduled for October 2005 removal, with an expected October 2006 report submittal. This supplemental capsule uses reconstituted Charpy specimens from Capsule DC1-Y.
  (5) Three supplemental capsules (A, B, and D) containing FCS 27204 weld material were installed in Cycle 5.

Fort Calhoun Station has Capsule W-275S, containing FCS 1-410 nozzle dropout weld material (27204) [and Maine Yankee nozzle dropout weld material (12008/13253)]. Due to the low lead factor at 275 degrees F, this capsule should be removed no earlier than March 2025 at 40 EFPY. Fluence= 1.0×10^{19} n/cm^2.

- Weld Wire Heat 12008/13253:

Fort Calhoun Station has Capsule W-275S, containing Maine Yankee nozzle dropout weld material (12008/13253) [and FCS 1-410 nozzle dropout weld material (27204)]. Due to the low lead factor at 275 degrees F, this capsule should be removed no earlier than March 2025 at 40 EFPY. Fluence= 1.0×10^{19} n/cm^2.

- Weld Wire Heat 13253

This material is non-limiting and need not be reported.

LIC-00-0096
Attachment 3

Westinghouse - CE Nuclear Power report CENPSD-1204-P, Revision 00,
Review of Mihama Unit 1 Surveillance Program Weld Metal Data
(PROPRIETARY VERSION)