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 SAGER, D.A.      Florida Power & Light Co.  
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SUBJECT: Forwards addl info for St Lucie Unit 1 beltline welds 2-203  
 A, B & C USE & final rept CEN-622, "Generic Upper Shelf  
 Values for Linde 1092,124 & 0091 Reactor Vessel Welds," per  
 GL 92-01, Rev 1.

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July 25, 1995

L-95-214  
10 CFR 50.4

U. S. Nuclear Regulatory Commission  
Attn: Document Control Desk  
Washington, D. C. 20555

RE: St. Lucie Unit 1  
Docket No. 50-335  
Generic Letter 92-01 Revision 1  
Belt-line Weld 2-203 Supplemental Information

NRC letter dated May 26, 1994, identified the need for additional data to confirm the USE at end-of-life (EOL) for belt-line weld 2-203, is greater than 50 ft-lb. The additional information was required to support a generic value FPL provided for the unirradiated USE. Your May 26, 1994, letter requested Florida Power and Light Company (FPL) to provide a schedule for providing the required data. On July 1, 1994 FPL provided the requested schedule for the additional data requested on St. Lucie Unit 1 belt-line weld 2-203.

The Combustion Engineering Owners Group (CEOG) performed an analysis of the USE values for a large data set of Linde 1092, 124, and 0091 weld fluxes. The CEOG submitted the results of the analysis in CEN-622, *Generic Upper Shelf Values for Linde 1092, 124, and 0091 Reactor Vessel Welds*, by Owners group letter (CEOG-95-353) dated July 7, 1995. A copy of the report is enclosed for your information. The report concluded through statistical analysis that the USE values grouped by flux type, were independent sets of data and therefore generic values based on these flux types is justified. The supporting information on grouping of data by flux type is attached.

Please contact us if there are any questions about this submittal.

Very truly yours,

D. A. Sager  
Vice President  
St. Lucie Plant

DAS/GRM

Attachments

cc: Stewart D. Ebnetter, Regional Administrator, Region II, USNRC  
Senior Resident Inspector, USNRC, St. Lucie Plant

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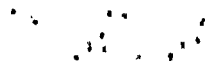
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St. Lucie Unit 1  
Docket No. 50-335  
Generic Letter 92-01 Revision 1  
Belt-line Weld 2-203 Supplemental Information

ATTACHMENT 1



ADDITIONAL INFORMATION FOR THE ST. LUCIE UNIT 1  
BELTLINE WELDS 2-203 A,B & C UPPER SHELF ENERGY

NRC Request - St Lucie 1 (TAC No. M83505)

The NRC issued a letter to Florida Power and Light Company (FPL) on May 26, 1994<sup>1</sup> with their tabulation of the information supplied for Generic Letter (GL) 92-01 concerning the St Lucie Unit 1 & Unit 2 reactor vessels. The letter requested that FPL review this information for accuracy for both units and respond with any inconsistencies. FPL reviewed the data by the NRC and provided a response<sup>2</sup> with a schedule for other requested items to be provided. The other items are described below:

".... For St. Lucie Unit 1, we have determined that additional data is required to confirm that the upper shelf energy (USE) at the end of life (EOL) for one of your beltline materials, weld 2-203 is greater than 50 ft-lb because you have provided a generic mean value for the unirradiated USE. These types of values are unacceptable because they do not consider material variability" (of other weld flux types). "When the unirradiated USE for a particular material has not been determined, you may set the USE equal to the lower tolerance limit calculated for the group of similar materials...."

Response to RAI on Weld 2-203 (St Lucie Unit 1)

In 1993, Florida Power and Light Co. responded to the GL 92-01 RAI<sup>3</sup> and included a generic upper shelf energy (USE) value<sup>4,5</sup> for the St

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<sup>1</sup> Generic Letter (GL) 92-01, Revision 1, *Reactor Vessel Structural Integrity*, St. Lucie Units 1 and 2 (TAC NOS. M83505 and M83506), Letter from NRC to J.H. Goldberg; May 26, 1994.

<sup>2</sup> FPL Letter, L-94-169, St. Lucie Units 1 and 2 Docket No. 50-335 and 50-389, Generic Letter 92-01, Revision 1, *Response to Request for Additional Information*, D. A. Sager to NRC, July 1, 1994.

<sup>3</sup> St. Lucie Units 1 and 2 - *Request for Additional Information - Generic Letter (GL) 92-01, Revision 1*, (TAC NOS. M83505 and M83506), Letter from NRC to J.H. Goldberg; July 28, 1993.

<sup>4</sup> FPL Letter, L-93-286, St. Lucie Units 1 and 2 Docket No. 50-335 and 50-389, Generic Letter 92-01, Revision 1, *Response to Request for Additional Information (RAI)*, D. A. Sager to NRC, November 15, 1993.

<sup>5</sup> *Upper Shelf Energy Information Pertaining to the St. Lucie Unit 1 and Unit 2 Reactor Vessel Welds*, ABB-Combustion Engineering, F-MECH-93-050/L-MECH-93-015,

Lucie Unit 1 intermediate shell longitudinal welds (2-203 A, B, C). The analysis did not address data from other weld flux types to justify their exclusion from the generic value so more information was requested. The Combustion Engineering Owners Group (CEOG) performed an analysis of USE values for a large data set of Linde 124, 0091, and 1092 weld fluxes<sup>6</sup>. The report concluded through statistical analysis that the USE values, grouped by flux type, were independent sets of data and therefore generic values based on these flux types were justified. This grouping of data by flux type accomplishes the following:

- 1) A reduction of variability for each data set when compared to the overall population of USE data. Using just Linde 124 USE values allows for a tighter data set and the associated standard deviation.
- 2) The determination of a conservative generic USE for our material based on both this statistical data and on specific material test data available for the St Lucie Unit 1 weld seams 2-203 A, B and C.

The St. Lucie Unit 1 weld seams 2-203 A, B & C were all fabricated with a single electrode process using the same weld wires A8746 and 34B009 with Linde 124 flux noted in Table 1. The mean USE value of the Linde 124 flux type data set is 102.3 ft-lbs and is based on the same 68 point data set previously reported<sup>7,8</sup>. The standard deviation for this data set is 9.4 ft-lbs.

The 1/4T end of life (EOL) fluence previously reported in Reference 2 was a conservative vessel maximum. The 1/4T location specific fluence (adjusted for the azimuthal location of the weld seams) for the axial welds 2-203A, B & C is reported in Table 2. Using the Cu, generic mean USE value from Table 1 and the St. Lucie Unit 1 actual azimuthal (EOL) 1/4 T vessel fluence at these longitudinal weld locations, the decrease in USE can be predicted from Figure 2

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September 28, 1993.

<sup>6</sup> *Generic Upper Shelf Values for Linde 1092, 124 and 0091 Reactor Vessel Welds, Task 839, ABB-Combustion Engineering Owners Group, CEN-622, June, 1995.*

<sup>7</sup> *FPL Letter, L-93-286, St. Lucie Units 1 and 2 Docket No. 50-335 and 50-389, Generic Letter 92-01, Revision 1, Response to Request for Additional Information (RAI), D. A. Sager to NRC, November 15, 1993.*

<sup>8</sup> *Upper Shelf Energy Information Pertaining to the St. Lucie Unit 1 and Unit 2 Reactor Vessel Welds, ABB-Combustion Engineering, F-MECH-93-050/L-MECH-93-015, September 28, 1993.*

of Regulatory Guide 1.99 revision 2<sup>9</sup>. The predicted EOL USE for welds 2-203A, B, C welds using the generic mean is reported in line 1 of Table 2 and is not predicted to fall below the 10 CFR 50 Appendix G, 50 ft-lbs limit within the license life.

Since no NRC regulation exists on how to determine a conservative estimate of USE from generic data, the same procedure suggested in RG 1.99 section 1.1 of mean plus one standard deviation for chemistry values will be used. For an USE value the conservative value would be mean minus one standard deviation (mean USE -  $\sigma$ ). This procedure will yield a conservative result because the RG 1.99 USE reduction correlation is based on the lower bound of all data.

Using a conservative estimate of USE (mean USE -  $\sigma$ ) of 92.9 ft-lbs, welds 2-203A, B, and C will not fall below the 10 CFR 50 Appendix G, 50 ft-lbs limit at EOL. Taking an extremely conservative approach and repeating the same EOL 1/4T USE calculation using the mean USE -  $2\sigma$  as a lower bound USE value of 83.5 ft-lbs, welds 2-203A, B, and C will not fall below the 10 CFR 50 Appendix G, 50 ft-lbs limit at EOL. These EOL 1/4T USE values are show in Table 2 lines 2 and 3 respectively.

The lower bound USE value of mean USE- $2\sigma$  is very conservative for the 2-203 A, B and C welds when available Charpy data is considered. Charpy 10°F data compared to actual USE supplies a strong inference that the actual upper shelf is higher than the low bound. Actual Charpy data for the 2-203 A, B and C welds at 10°F provided average results 70 ft-lbs<sup>10</sup>.

Examination of EPRI Report NP-2428, Irradiated Nuclear Pressure Vessel Steel Data Base<sup>11</sup>, for Linde 80, 124, 1092 and 0091 weld data indicates that the 10°F results are typically in the mid-transition region of the Charpy curve and well below the upper shelf in energy value. A summary of data from 20 welds including 10°F energy, USE, a ratio of the two and a difference between the two energy values is presented in Table 3 and listed in ascending order of 10°F Charpy energy. The ratio of USE to 10°F energy ranged from 1.34 to 2.52 for this data set with an average delta between USE and 10°F energy of 43.1 ft-lbs.

Another source of full Charpy curves is the CE response to the NRC I&E bulletin 78-12<sup>12</sup>. A summary of data from 18 Linde 124 flux

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<sup>9</sup> US NRC Regulatory Guide 1.99, *Radiation Embrittlement of Reactor Vessel Materials*, Revision 2, May 1988.

<sup>10</sup> FPL Letter, L-77-308, *St. Lucie Unit 1 Reactor Vessel Material Information*, R. E. Uhrig to D. K. Davis, NRC, September 30, 1977.

<sup>11</sup> *Irradiated Nuclear Pressure Vessel Steel Data Base*, EPRI Report NP-2428, June 1982.

<sup>12</sup> *Atypical Weld Material In Reactor Pressure Vessel Welds*, CE Response to I&E Bulletin 78-12, June 8, 1979.



welds including 10°F energy, USE, a ratio of the two and a difference between the two energy values is presented in Table 4 and listed in ascending order of 10°F Charpy energy. Although this 18 point data set is not as large as the 68 data points that determined the generic mean <sup>13</sup>, the lowest USE (82.7 ft-lbs) of the data set is included and both the average USE value and the generic USE mean are almost identical. The ratio of USE to 10°F energy ranged from 1.15 to 1.75 for this data Linde 124 only data set. This data set also showed the 10°F was in the mid transition region of the Charpy curve. Also included is a ratio of the actual 10°F data for the St. Lucie Unit 1 welds 2-203 compared to the generic mean USE value minus 1 and 2 standard deviations of 1.33 and 1.19 respectively. The average delta between USE and 10°F energy for this Linde 124 only data set is 27.6 ft-lbs.

All the full Charpy curves for the welds in Table 3 and 4, had an upper shelf that did not start until beyond 100°F. When both data sets are considered no Linde flux welds with a 10°F Charpy energy of greater than 66 ft-lbs had a USE of < 92.9 ft-lbs (the proposed generic mean USE - 1σ applicable for the St. Lucie Unit 1 welds 2-203). Applying this same ratio to the proposed generic mean USE - 1σ (92.9 ft-lbs) for the St. Lucie welds 2-203 A, B and C provides a ratio of 1.33. Comparing this ratio of 1.33 to the 18 Linde 124 flux welds in Table 4 shows that although this ratio is not the lowest, the only data with a lower ratio have an USE value higher than that proposed for the St Lucie Unit 1 welds 2-203 of 92.9 ft-lbs. Of the 5 data points with a ratio below 1.33, all but one have an USE >102.3 ft-lbs (Linde 124 generic mean USE in reference 6) and non have a USE below the proposed generic mean USE - 1σ (92.9 ft-lbs) for the St. Lucie Unit 1 welds 2-203 A, B and C demonstrating the excessive conservatism associated with the mean - 2σ value.

Comparison of the deltas between USE and 10°F energies for the Linde 124 data set in Table 4 and the St Lucie Unit 1 weld material shows that the delta for the generic mean - 1σ (92.9 ft-lbs) is 22.9 ft-lbs and is below the average delta for the data set. Of the six data points with deltas < 22.9 ft-lbs only one has a USE lower than the proposed 92.9 ft -lbs. Additionally no data has a delta between USE and 10°F energy that is below the 13.5 ft-lbs observed for mean - 2σ (83.5 ft-lbs) demonstrating the excessive conservatism associated with the mean - 2σ value.

Therefore a USE value mean - 1σ (92.9 ft-lbs) is a conservative estimate of USE for the St. Lucie Unit 1 welds 2-203 A, B and C.

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<sup>13</sup> *Generic Upper Shelf Values for Linde 1092, 124 and 0091 Reactor Vessel Welds, Task 839, ABB-Combustion Engineering Owners Group, CEN-622, June, 1995.*

### Summary

A generic mean value of USE for the St. Lucie Unit 1 Welds 2-203 has been determined to be 102.3 ft-lbs based on the mean of 68 similar flux type welds. A conservative value of USE (mean USE -  $1\sigma$ ) of 92.9 ft-lbs as applicable for the St. Lucie Unit 1 weld 2-203 A, B and C. Using a conservative value of USE (mean USE -  $1\sigma$ ) of 92.9 ft-lbs for the calculation of predicted EOL irradiated USE, welds 2-203A, B, and C will not fall below the 10CFR50 Appendix G, 50 ft-lbs limit at EOL. The conservative generic USE value of mean USE -  $1\sigma$  (92.9 ft-lbs) is justified when considering weld specific average 10°F data at 70 ft-lbs.

TABLE 1

ST. LUCIE UNIT 1 REACTOR VESSEL  
BELTLINE WELD MATERIAL

WELD LOCATION	HEAT #	FLUX TYPE	FLUX LOT	% Cu	% Ni	DROP WEIGHT (°F)	RT <sub>INDT</sub> (°F)	CHARPY USE (FT-LB)
Intermediate Shell Long Seam (2-203 A, B, C)	A8746/34B009	Linde 124	3878/3688	0.19 (b)	0.10 (b)	NA	-56 (a)	102.3 <sup>14</sup>

NA - Not Available

a - Generic data for CE submerged arc welds using Linde 0091, 1092 and 124 Flux per 10CFR50.61

b - Best estimated Cu and Ni content (low nickel type wire)<sup>15</sup>

TABLE 2

ST. LUCIE UNIT 1 REACTOR VESSEL  
BELTLINE WELD 2-203 EOL USE PROJECTION

Material	Initial USE ft-lb (Transverse)	% Cu (Ref. 4)	EOL 1/4 T Fluence (n/cm <sup>2</sup> )	Reg Guide 1.99 rev .2 (% reduction)	EOL USE (ft-lb)
Intermediate shell long welds (2-203 A, B, C)	102.3 (mean value)	0.19	1.43 x 10 <sup>19</sup>	36 %	65.5
Intermediate shell long welds (2-203 A, B, C)	92.9 (Conservative Estimate, mean - 1σ)	0.19	1.43 x 10 <sup>19</sup>	36 %	59.5
Intermediate shell long welds (2-203 A, B, C)	83.5 (lower bound, mean - 2σ)	0.19	1.43 x 10 <sup>19</sup>	36 %	53.4

<sup>14</sup> Generic Upper Shelf Values for Linde 1092, 124 and 0091 Reactor Vessel Welds, Task 839, ABB-Combustion Engineering Owners Group, CEN-622, June, 1995.

<sup>15</sup> FPL Letter, L-93-286, St. Lucie Units 1 and 2 Docket No. 50-335 and 50-389, Generic Letter 92-01, Revision 1, Response to Request for Additional Information (RAI), D. A. Sager to NRC, November 15, 1993.

**Table 3:  
Selected Weld Charpy Data from EPRI Report NP-2428<sup>16</sup>**

EPRI Report NP2428 On initial USE of RV Surveillance welds							
Vessel Vendor	Page #	Flux Type	10°F ft lb	10°F Measure Actual/Estimate	USE (ft-lb)	Ratio of USE to 10°F ft-lb	USE Minus 10°F energy (ft-lb)
B&W	2-92	L80	25	no-est	63	2.52	38
B&W	2-72	L80	30	no-est	68	2.27	38
B&W	2-110	L80	31.3	yes-act	65	2.08	33.7
B&W	1-139	L80	31.7	yes-act	63.6	2.01	31.9
CB&I	1-105	L124	33	20°F data	77.3	2.34	44.3
B&W	2-165	L80	34.7	yes-act	66.3	1.91	31.6
B&W	1-170	L80	38.3	yes-act	69.5	1.81	31.2
B&W	1-152	L80	39.3	yes-act	70	1.78	30.7
B&W	1-109	L80	40.6	30°F data	71.4	1.76	30.8
B&W	2-57	L80	43.7	yes-act	76.3	1.75	32.6
CE	1-205	L1092	48	no-est	112	2.33	64
CE	1-122	L1092	49.7	yes-act	106.7	2.15	57
CE	1-118	L1092	52	yes-act	118.3	2.28	66.3
CE	1-220	L1092	55	no-est	111.3	2.02	56.3
CE	1-231	L124	61.3	yes-act	93.7	1.53	32.4
CE	2-19	L1092	62.7	yes-act	125.7	2.00	63
CE	3-101	L1092	68.7	yes-act	112.7	1.64	44
CE	1-100	L1092	78.7	yes-act	111	1.41	32.3
CE	1-96	L1092	81.7	yes-act	149	1.82	67.3
CE	1-195	L0091	109	yes-act	146.3	1.34	37.3
AVERAGE			50.7		93.9	1.94	43.1

<sup>16</sup> Irradiated Nuclear Pressure Vessel Steel Data Base, EPRI Report NP-2428, June 1982.



Table 4:

Linde 124 Weld Charpy Data from CE Response to  
NRC I&E Bulletin 78-12<sup>17</sup> with St. Lucie Unit 1  
Data for Comparison.

"Atypical Weld Material in RPV Welds" - CE, June 8, 1979							
Information Requested By NRC I&E Bulletin No. 78-12							
Wire Ht	Report Section VIII Page #	Flux Type	10°F ft lb	10°F Measure Actual/ Estimate	USE (ft-lb)	Ratio of USE to 10°F ft-lb	USE Minus 10°F energy (ft-lb)
E56906	195	L124	52	no-est	89.3	1.72	37.3
90144	221	L124	53	yes-act	93	1.75	40
90211 **	RVG1391	L124	55	no-est	82.7	1.50	27.7
91762	203	L124	58	yes-act	88	1.52	30
89833	218	L124	64	no-est	95.7	1.50	31.7
69025	215	L124	66	no-est	88.6	1.34	22.6
3P7317	192	L124	68	no-est	103	1.51	35
3P7313	198	L124	70	no-est	102.7	1.47	32.7
651A708	231	L124	70	no-est	96.3	1.38	26.3
4P7869	209	L124	72	no-est	97.3	1.35	25.3
5P8866	212	L124	75	no-est	107.7	1.44	32.7
3P8013	237	L124	75	no-est	93.7	1.25	18.7
89408	186	L124	81	no-est	110.7	1.37	29.7
4P7927	206	L124	83.7	yes-act	115.7	1.38	32
3P7802	224	L124	87	no-est	109.7	1.26	22.7
3P7246	189	L124	88	no-est	108	1.23	20
LP5P9744	242	L124	91	no-est	109	1.20	18
4P8632	234	L124	95	no-est	109.3	1.15	14.3
AVERAGE			72.4		100.0	1.41	27.6
Plant	Weld #	Flux Type	10°F ft-lb	10°F Measure Actual	Mean - 1 std dev.	Ratio of USE to 10°F ft-lb	USE Minus 10°F energy (ft-lb)
St Lucie 1	Weld 2-203A,B,C	L124	70	yes-act	92.9	1.33	22.9
					Mean - 2 std dev.		
St Lucie 1	Weld 2-203A,B,C	L124	70	yes-act	83.5	1.19	13.5
** Data From CE RVG Task (lowest USE in Linde 124 Data Set)							

<sup>17</sup> Atypical Weld Material In Reactor Pressure Vessel Welds, CE Response to I&E Bulletin 78-12, June 8, 1979.