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NRC Contract 04-75-202

Progress for October, 1978

Total funds expended during October are estimated to be $16K, including G&A, IR&D and fee.

Cold Worked Study

The EPR results for Types 304 and 304L samples cold-worked 0 - 20% (including low temperature sensitization at 500°C/24h after cold working) were reported previously (GEAP - 10207-43). Additional testing was completed on ten of these cold worked (non-sensitized) samples after aging at 300°C(572°F) for 800 hours to assess any changes in degree of sensitization resulting from BWR service temperature. The results are given in Table 1, where it appears that there is little change in the levels of sensitization after the brief aging period. With one exception (1% cold worked) the Pa values actually decrease, however, these low values could reflect normal measurement variability.

Type 316/316L Studies

The EPR data for welded Types 316 and 316L stainless steels were presented last period. Those data were obtained using the test parameters for Type 304, and, as reported, the values for Types 316/316L were quite low compared to Type 304 stainless steel. Consequently, the EPR tests were repeated for Types 316/316L stainless steels using a reactivation scan rate of 3V/h instead of the usual 6V/h rate. These data are given in Table 2 where it is apparent that the slower scan rate significantly increases the current response. This slower scan rate is necessary to sufficiently attack the chromium-depleted zone adjacent to the grain boundaries in Types 316/316L, where, the width is a factor of 10 narrower than Type 304 stainless steel given comparable thermal treatment. Future EPR measurement of Types 316/316L stainless steel will probably be accomplished using the slower scan rate; the additional change of increasing the KSCN content of the electrolyte has yet to be investigated.

Additional Pipe Weldment Testing

As a continuing study, EPR measurements are taken in the weld heat affected zones of Type 304 piping samples which fracture by IGSCC in the Pipe Test Laboratory. To date, measurements have been obtained from 18 weldments representing four heats of material. These data are given in Table 3. Here, the Pa values vary considerably within a single heat of material. This variation is due in part to the lack of sufficient weld heat affected zones of the samples received. The pipes are sectioned for detailed analysis after fracture, and the resulting multiple slicing often obliterates a portion of the heat affected zone. Also, many of the fracture sections have intergranular cracks propagated through the sample, such that the removal of a satisfactory EPR sample is difficult. The IGSCC-fractured pipe sections where suitable samples such that the removal of a satisfactory EPR sample is difficult. The IGSCC-fractured pipe sections where suitable samples* could be removed all revealed Pa values of 4 C/cm^2 or greater. The remaining samples all ranged between 2-4 C/cm^2, with the lowest value in which IGSCC was noted occurring in a heat 181190 (0.06 w/o C) weldment (Pa = 2.00 C/cm^2).

Table 1. Effect of Cold Working on the EPR Determined Sensitization Response of Types 304 and 304L Stainless Steels ($0.5\underline{M}$ H_2SO_4 + $0.01\underline{M}$ KSCN at 30°C)
(Pa, C/cm^2)

Alloy	Cold Work %	Cold Worked Only	Cold Worked + 300°C/800h
304	0	0.024	$\leq 10^{-3}$
	1	0.025	0.194
	5	0.269	0.229
	10	0.249	0.130
	20	0.173	0.047
304L	0	$\overline{<} 10^{-3}$	$\overline{<} 10^{-3}$
	1	$\overline{<} 10^{-3}$	$\overline{<} 10^{-3}$
	5	$\overline{<} 10^{-3}$	$\overline{<} 10^{-3}$
	10	$\overline{<} 10^{-3}$	$\overline{<} 10^{-3}$
	20	$\overline{<} 10^{-3}$	$\overline{<} 10^{-3}$

Table 2. EPR Results for Types 316 and 316L Stainless Steel Weldments Test at 30°C in 0.5M H_2SO_4 + 0.01M KSCN($Pa,C/cm^2$)[a]

Alloy	Heat	Weldment	6V/h Scan Rate AW	AW+LTS	3V/H Scan Rate AW	AW+LTS
316	037049	A-A	0.55	1.36	15.1	25.6
	037050	A-A	1.87	1.00	21.9	13.6
	M6985	A-A	0.20	0.44	4.6	7.1
316L	00630	A-A	$\leq 10^{-3}$	$\leq 10^{-3}$	$\leq 10^{-3}$	$\leq 10^{-3}$
	037041	B-B	↕	↕	↕	↕
	037040	A-A				
	063104	B-B				1.0

a AW = As Welded

LTS = Low Temperature Sensitized (500°C/24h)

Table 3. EPR Results for Type 304 Pipe Weld Heat Affected Zones in which IGSCC Caused Fracture in the PTL ($0.5\underline{M}$ H_2SO_4 + $0.01\underline{M}$ KSCN at 30°C and 6V/h)

Heat	Pa, C/cm^2
181190	4.6
	2.8
	2.2
	10.5
	7.1
	2.0
	10.5
	15.3
	10.0
454970	34.5
497816	2.8
	3.5
	25.8
51416	4.4
	10.7
	6.8
	2.5
	5.1