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Our Ref: QCG-9081

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

Subject: Fuel Nozzle Tip 10 CFR Part 21 Final Report

Dear Sir:

The following is a report of activities and corrective action associated with the subject 10CFR21 which have taken place since our initial report of April 5, 1991. We believe that these have provided sufficient information to warrant closure of this issue.

On April 6, 1991, the NRC was notified in writing of a failure involving a standby diesel generator at Houston Light and Power Company's South Texas Project Electric Generating Station. Subsequent investigation revealed that a cracked fuel nozzle tip purchased from Bendix, (a supplier of Cooper-Bessemer), Lot 150006, caused the failure. Affected utilities were notified and a parts recall was initiated.

Subsequent interim reports to the NRC dated July 23, 1991, September 20, 1991, and October 31, 1991 detail the distribution of fuel nozzle tips to the affected utilities and actions taken during this time period.

Since then, additional testing of fuel nozzle tips performed by the Materials Technology Division (MTD) of Houston Light and Power in conjunction with Cooper-Bessemer, the Cooper- Bessemer Owners Group and MPR Associates has been completed, reviewed and recommendations to prevent further failures made. Samples of production lots from utility inventories were submitted to MTD for examination which included visual examination, wet fluorescent magnetic examination (WFMT), internal ligament thickness, effective nitrided case depth, visual nitrided case depth, thickness of the Fe_xN compound layer, and core hardness. Each spray tip sample was visually examined for clogging. Secondly, the sample was transversely cut immediately below the ligament tip for subsequent sectioning by EDM. EDM conical sectioning through the three passage holes allowed WFMT on the fuel hole surfaces. Additional purposes of the EDM sectioning were to ensure precision measurements of the ligament thicknesses between the fuel passage holes and the center bore to make precise metallographic sections through the ligaments. A metallographic section was produced for each lot examined. This section is a radial axial plane that passes through the thinnest part of the ligament between the fuel passage hole and the center bore. The nitrided case depth was determined for each sample by determining the distance from the surface to a depth at which the Knoop hardness equivalent to Rockwell "C" scale 55 was reached.

A045

The effective depth of the case was determined for each metallographic sample at the surface of the fuel passage hole and at the surface of the center bore. In addition to measuring the effective case depth of the nitrided case, the metallographic section was also used to determine the visual case depth, the presence and thickness of the white Fe_xN compound layer, and core hardness.

The results of the metallurgical and dimensional examinations can be found on Table 1 (MTD Report MT-3309 dated July 16, 1991) and Table 1 (MTD Report MT-3822 dated May 4, 1992). A brief summary of the results is as follows:

1. The inner ligament thickness measurements ranged from a low value of .039 inch on lot 150004 to a high value of .063 inch on lot LC001090. The spray tip from Lot 150004 which had failed the Haynes Go-NoGo gage test contained the smallest ligament dimension, had a deep nitride case, and contained cracks on the surface of two of the three fuel passage holes at the ligament between the fuel passage hole and the center hole.

2. The effective nitride case depth in all spray tips examined was lower than the visual nitride case depth.

3. Other than the tip submitted from Lot 150004, none of the remaining lots contained any cracking as determined by visual and WFMT examination.

4. All samples were visually examined for the presence of clogging of the spray holes. The tips of the samples were clean and free of clogging in the as-received condition.

The root cause of this failure of the fuel nozzle tip has been determined to be insufficient ligament thickness (less than 0.048 inch) along with improper nitriding resulting in a too deep case depth (over 45% ratio of case depth to core size).

Revised technical specifications require an effective case depth of .008-.011" and a ratio of visual case depth to core size of 45% maximum measured 1/32" from the ligament tip. This will be verified by destructive examination at the heat treat vendor and again by the Haynes Corporation. Ligament thickness and location of fuel delivery holes will be verified by use of Haynes gauge #44-703039.

Process controls as outlined in our letter to the NRC (our reference QCG-8434 dated 9/20/91) have been revised and are current practice with above stated specifications. Agreement between Cooper-Bessemer and the Cooper-Bessemer Owners Group at the May 1992 meeting and subsequent discussions have resulted in the classification of all fuel nozzle lots as either acceptable or reject.

Acceptable Lots are those with no known failures or found to meet technical requirements. These lots are identified as the early unnumbered or unrecorded lots (most before 1979), 001110, LC001059, LC001090, LC001091, 20[illegible]40, 150001, 150002, 150003, 150005, 150010, 150013, LCH1, LCH19, and all later LCH series which are now confirmed with Quality Assurance efforts at Haynes Corporation and Cooper-Bessemer.

Lot 150003 will have dimensional inspections imposed as fuel nozzle assemblies are reconditioned as one sample did not pass inspection with the new Haynes hole angle gauge, but in the direction of greater ligament thickness.

Reject Lots are those with known failures or failing to meet technical criteria of ligament thickness and nitride case depth as a result of destructive examination at MTD. The previously recalled lots in 1988 and 1991 as a result of 10CFR Part 21 notification to the NRC are 1124 (includes 1135), 150006, and 150008. In addition, Cooper-Bessemer is adding to this recall list lots 150004, 150009, and D870001. These fuel nozzle tips should be replaced at the next scheduled plant refueling outage and tips in warehouse stores should not be installed in a diesel engine.

The attached listing shows the serial numbers, lot numbers, quantity and location of all reject lot fuel nozzle tips.

In conclusion, Cooper-Bessemer, in agreement with the Cooper-Bessemer Owners Group, and MPR Associates believe that the corrective actions taken by Haynes Corporation (current manufacturer of nozzle tips), Cooper-Bessemer and the utilities are sufficient to preclude this failure from recurring and that this incident should be closed. If you have any questions, please contact J. R. Schneider, Quality Assurance Manager, or J. M. Horne, Manager of Nuclear Engineering at 412-458-8000.

Sincerely,

H. A. LaBrun
Vice President and
General Manager

HAL/kll

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TABLE 1. SUMMARY OF BL&P EXAMINATIONS OF DIESEL FUEL INJECTOR SPRAY TIPS

SAMPLE DESCRIPTION				NONDESTRUCTIVE TESTING		DIMENSIONAL & METALLURGICAL EVALUATION						
MT #	LOT #	SERVICE HOURS	HOLE #	EDDY CURRENT TESTING	WFMT	INNER LIGAMENT THICKNESS (INCHES)	NOMINAL LIGAMENT AREA (SQ. IN.)	EFFECTIVE CASE DEPTH (INCHES)	VISUAL CASE DEPTH (INCHES)	% VISUAL CASE DEPTH	WHITE LAYER DEPTH (INCHES)	CORE HARDNESS (HRc)
3259-1	150010	357	1	ND	ACC	0.048	0.224	0.012	0.016	52	NONE	41
			2		REJ	0.052	0.221					
			3		REJ	0.049	0.212					
3309-1	150006	382	1	REJ	REJ	0.011	0.157	0.015	0.016	100	0.0007	40.5
			2		REJ	0.013	0.159					
			3		REJ	0.012	0.158					
3309-2	150010	357	1	ACC	ACC	0.056	0.245	0.018	0.020	54	0.001	42.5
			2		ACC	0.051	0.243					
			3		ACC	0.049	0.241					
3309-3	LC1091	217	1	ACC	ACC	0.052	0.233	0.013	0.012	32	NONE	48
			2		ACC	0.045	0.233					
			3		ACC	0.040	0.228					
3309-4	150006	324	1	REJ	REJ	0.012	0.174	ND	ND	ND	ND	ND
			2		REJ	0.013	0.175					
			3		ACC	0.013	0.175					
3309-5	150006	432	1	REJ	ACC	0.012	0.174	0.011	0.017	100	0.0005	45.5
			2		REJ	0.017	0.173					
			3		REJ	0.018	0.174					
3309-6	150010	ND	1	ACC	ACC	0.055	0.261	ND	ND	ND	ND	ND
			2		ACC	0.054	0.252					
			3		ACC	0.054	0.252					
3309-7	150010	357	1	ACC	ACC	0.055	0.244	0.011	0.016	50	0.0005	42.0
			2		ACC	0.055	0.250					
			3		ACC	0.051	0.246					
3309-8	LCH19	NEW	1	ACC	ACC	0.05	0.226	0.008	0.006	30	0.001	41.5
			2		ACC	0.05	0.228					
			3		ACC	0.053	0.228					
3309-9	LCH19	NEW	1	ACC	ACC	0.052	0.231	ND	ND	ND	ND	ND
			2		ACC	0.053	0.230					
			3		ACC	0.051	0.236					
3309-10	150009	100	1	ACC	REJ	0.047	0.215	0.012	0.019	63	0.0005	41.0
			2		REJ	0.047	0.215					
			3		REJ	0.046	0.215					
3309-11	150006	324	1	ACC	REJ	0.019	0.176	0.013	0.018	100	0.0005	42.0
			2		REJ	0.021	0.182					
			3		REJ	0.021	0.181					
3309-12	LCH1	NEW	1	ACC	ACC	0.056	0.238	0.010	0.010	23	NONE	41.5
			2		ACC	0.056	0.238					
			3		ACC	0.056	0.234					

ND = NOT DETERMINED.

TABLE 1. SUMMARY OF HI&P EXAMINATIONS OF DIESEL FUEL INJECTOR SPRAY TIPS

Sample Description					Dimensions & Metallurgical Evaluation					
Sample Identification Number	Lot #	Utility	Hole #	WPMT Results	Inner Ligament Thickness (inches)	Effective Case Depth (inches)	Visual Case Depth (inches)	% Visual Case Depth	Core Hardness (HRC)	White Layer Depth (inches)
3822-1	LC001059	PP&L	1 2 3	ACC ACC ACC	0.056 0.053 0.048	0.007	0.013	40.4	42.7	None
3822-2	LC001090	APS	1 2 3	ACC ACC ACC	0.042 0.044 0.063	0.008	0.012	47.1	45.2	None
3822-3	001110	PP&L	1 2 3	ACC ACC ACC	0.041 0.041 0.050	0.007	0.011	50.2	43.3	None
3822-4	150004 (Tag 4E1616)	PP&L	1 2 3	ACC ACC ACC	0.045 0.047 0.051	0.008	0.015	64.6	45.2	0.0002
3822-5	150004 (Tag 4E1607	PP&L	1 2 3	REJ REJ ACC	0.040 0.041 0.039	0.010	0.018	77.6	45.5	0.0002
3822-6	150013	APS	1 2 3	ACC ACC ACC	0.055 0.057 0.059	0.008	0.014	45.5	45.8	0.0006
3822-7	200440	PP&L	1 2 3	ACC ACC ACC	0.042 0.043 0.044	0.007	0.010	38.6	45.7	None
3822-8	087001	APS	1 2 3	ACC ACC ACC	0.043 0.041 0.042	0.012	0.016	72.5	44.7	None

REJECT LOTS 2-50F-003-023 FUEL INJECTOR TIP				
DATE	CES S/N	LOT #	QTY	CUSTOMER
1/23/89	9A2401-16	150009	16	
	9A2401-04			CECO/BYRON
	9A2405-08			CECO/BRAIDWOOD
	9A2409, 11, 14-16			CECO/BYRON
	9A2412, 13			APS
9/26/79	9K2001-02	001124	2	
	9K2002			NI-MO
1/10/86	6B1001-29	D37001	29	
	6B1001, 02, 05, 07,09, 15, 21, 24, 29			HL&P
	6B1003, 06, 10-13, 17-19, 23			APS
	6B1008, 14, 16, 20, 22, 25-28			CECO/BYRON
10/26/86	6L1701-12	150004	12	
10/31/86	6L1901-29	150004	29	
	6L1901-06, 08-13, 15, 29			HL&P
	6L1907, 14, 18, 19, 21, 25, 27, 28			PP&L
	6L1920, 23, 26			APS
	6L1916			HL&P
10/28/88	9A0401-02	150009	2	
	9A0401			CECO/BRAIDWOOD

REJECT LOTS 2-50F-003-023 FUEL INJECTOR TIP				
DATE	CES S/N	LOT #	QTY	CUSTOMER
	9A0402			
11/11/85	5L2001-11	D87001	11	
	5L2001, 08, 11			APS
	5L2007			CECO/BYRON
	5L2010			CECO/BYRON
	5L2002-06, 09			CECO/BYRON
11/11/85	5L2101-07	D87001	7	APS
11/11/85	5M1301-15	D87001	15	APS
4/12/88	8D1301-24	150009	24	
	8D1301, 03, 04, 06, 09, 11, 15, 16, 18, 21			CECO/BRAIDWOOD
	8D1302, 05, 07, 12, 13, 17			HL&P
	8D1308, 10, 14, 22			CECO/BRAIDWOOD
1/28/88	8A2801-20	150008	20	
	3A2801, 02, 04, 06-08, 10-13, 15			APS
	8A2819, 20			CECO
3/3/88	7M1801-47	150008	47	
	7M1801-27			HL&P
	7M1828-47			APS

REJECT LOTS
2-50F-003-023
FUEL INJECTOR TIP

DATE	CES S/N	LOT #	QTY	CUSTOMER
7/22/87	7H0701-14	150006	14	
	7H0701-07, 09-14			HL&P
	7H0708			APS
7/20/87	7G2901-06	150006	6	HL&P
6/29/79	9G2301-04	001124	4	
	9G2304			HL&P
9/26/79	9K1701-14	001124	14	
	9K1701			CECO/BRAIDWOOD
	9K1706, 09			APS
4/10/89	9F2601-07	150009	7	APS

REJECT LOTS KSV-13-2A#4 FUEL INJECTOR ASSEMBLY				
DATE	CES S/N	LOT #	QTY	CUSTOMER
3/17/88	8D0201-50	150008 (T) JS0008 (A)	50	
	8D0201-06, 08-12, 27-29, 31-38			CECO/BYRON
	8D0207, 13, 14, 18-26, 43, 45, 46-48			CECO/BRAIDWOOD
	8D0203			SCARP #03962 5/90
4/22/87	7E1101-04	150004 (T) JS0005 (A)	4	HL&P
1/30/87	7B1801-09	150004 (T) JS0005 (A)	9	
	7B1801, 03, 04, 06			HL&P
	7B1802, 05, 09			CECO/BRAIDWOOD
	7B1807, 08			CECO/BYRON
7/31/87	7H0501-36	150006 (T) JS0006 (A)	36	
	7H0501,02,07,09,10,12,13,14,16,17,18,20,24,28,29			APS
	7H0503, 08, 11, 30, 31-36			HL&P
	7H0504-06			HL&P
	7H0515, 21, 23, 26			CECO/BRAIDWOOD
	7H0519, 22, 25, 27			HL&P
7/3/87	7H1801-02	150006 (T) JS0006 (A)	2	CECO/BRAIDWOOD
12/15/86	7B0901-30	150004 (T) OR 150005 (T) JS0004 (A) OR JS0005 (A)	30	
	7B0901			CECO/BRAIDWOOD
	7B0902-06, 08, 10, 12-15, 26-28, 30, 21			CECO/BYRON

A = Assembly Serial No.
T = Original Tip Serial No.

REJECT LOTS
KSV-13-2A#4
FUEL INJECTOR ASSEMBL

DATE	CES S/N	LOT #	QTY	CUSTOMER
	7B0907, 11, 16-19, 22-25, 29			CECO/BRAIDWOOD
	7B0909, 20			HL&P
7/26/88	8M0601-10 8M0701-30	150009 (T) JS0009 (A)	40	
	8M0601-10 8M0701-10			CECO/BRAIDWOOD
	8M0711-19, 26-28			HL&P
	8M0720-25, 29, 30			HL&P SENT TO APS
9/26/88	8M0501-10	150009 (T) JS0009 (A)	10	CECO/BRAIDWOOD
10/31/86	6L1801-15	150003 (T) OR 150004 (T) JS0003 (A)	15	
	6L1801-10			APS
	6L1811-15			HL&P
11/24/86	6L2606-10	150004 (T) JS0003 (A)	5	HL&P
11/24/86	6L2611-20	150004 (T) JS0004 (7)(A) 150003 (T) JS0003 (3) (A)	10	CECO/ZION
11/24/86	6L2601-05	150003 (T) JS0004 (A)	5	
	6L2601			LP&L
	6L2602-05			NI-MO

A = Assembly Serial No.
T = Original Tip Serial No.

REJECT LOTS KSV-13-2A#4 FUEL INJECTOR ASSEMBLY				
DATE	CES S/N	LOT #	QTY	CUSTOMER
3/5/86	6C1201-10	D87001 (T) JS0001 (1)(A) JS0002 (9)(A)	10	
	6C1201-07			LP&L
11/11/85	5L2101-60	D87001 (T) JS0001 (A)	60	
	5L2123, 42, 48, 50, 58			CECO/BYRON
	5L2145, 46, 47, 49, 57			CECO/BRAIDWOOD
	5L2124, 43, 44, 56			APS
	5L2125, 27, 28, 36, 37, 41,			NEBRASKA
	5L2126, 31			LP&L
	5L2129, 30, 32-35, 38, 39, 52, 54, 55, 59			CECO/BYRON
	5L2140, 51, 53, 60			NI-MO
	5L2101-22			CECO/BYRON
11/11/85	5L2501-56	D87001 (T) JS0001 (A)	56	
	5L2501-19, 21, 22, 24, 25, 28-36, 38-47, 49, 51, 53-56			PP&L
	5L2520, 23, 26, 27, 37, 48, 50, 52			CECO/BYRON
11/25/85	5M1101-03	D87001 (T) JS0001 (A)	3	LP&L
11/25/85	5L2601-10	D87001 (T) JS0001 (A)	10	
	5L2602			CECO/ZION
	5L2101, 03-10			LP&L
12/1/86	6M1101-07	150004 (T) JS0003 (A)	7	NI-MO

A = Assembly Serial No.
T = Original Tip Serial No.

REJECT LOTS KSV-13-2A#4 FUEL INJECTOR ASSEMBLY				
DATE	CES S/N	LOT #	QTY	CUSTOMER
12/11/86	6M1718-20	150004 (T) JS0004 (A)	3	NI-MO
12/11/86	6M1701-17	150004 (T) JS0005 (A)	17	
	6M1701-05, 11-14, 16			CECO/BYRON
	6M1706, 08			APS
	6M1707			LP&L
3/1/88 DRO 967	7H0167, 7J1501-03, 7D2003, 7D2006, 2C3286, 1D1416, 8K0902	150008 (T) JS0008 (A)	9	CECO/ZION
6/3/92 DRO 704	5L2604, 5L2608, 6C1201, 6M1707	150004 (1) D87001 (3)	26	LP&L
4/1/92 DRO 717	6M1103, 6M1104, 6M1720	150004 (3)	11	NI-MO
6/13/92 RCM 1492		150009	6	CECO/BRAIDWOOD
6/23/91 RCM 1493		150008	1	CECO/BRAIDWOOD

A = Assembly Serial No.
T = Original Tip Serial No.

REJECT LOTS
KSV-13-2A#6
FUEL INJECTOR TIP

DATE	CES S/N	LOT #	QTY	CUSTOMER
5/19/92 DRO 695	2E1503, 2E1504	150004	7	CECO/ZION

REJECT LOTS
KSV-13-5A#1
FUEL INJECTION TIP

DATE	CES S/N	LOT #	QTY	CUSTOMER
8/21/92 DRO 780	9206046	D87001 (1)	40	HL&P
9/15/92 DRO 813	9208020, 21, 26, 27, 30, 42, 43	150004 (7)	50	CECO/BYRON
	9208025, 28	D87001 (2)		
	9208037, 38	150009 (2)		
	9208024, 29, 35, 39, 40	001124 (5)		

A = Assembly Serial No.
T = Original Tip Serial No.