



U.S. ARMY ABERDEEN TEST CENTER



ATEC PROJECT NO. 2006-DT-ATC-MK2RB-D2477
TEST RECORD NO. WF-E-83

Jet Propellant (JP)-8 Fuel Evaluation Test

Mk II - Reset (Mk II R) Bridge Erection Boat (BEB)

October 2008



Charlie C. Jones

Support Equipment Division, Warfighter Directorate

Prepared for:

**U.S. Army Tank-automotive and Armaments Command
Warren, MI 48397-5000**

**U.S. Army Developmental Test Command
Aberdeen Proving Ground, MD 21005-5055**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 01 OCT 2008	2. REPORT TYPE N/A	3. DATES COVERED 17 AUG 2006 - 8 AUG 2008	
4. TITLE AND SUBTITLE Jet Propellant (JP)-8 Fuel Evaluation Test Mk II - Reset (Mk II R) Bridge Erection Boat (BEB)		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Charlie C. Jones		5d. PROJECT NUMBER ATEC Project No. 2006-DT-ATC-MK2RB-D2477	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Aberdeen Test Center Aberdeen Proving Ground, Maryland 21005-5059		8. PERFORMING ORGANIZATION REPORT NUMBER Test Record No. WF-E-83	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) TACOM/TARDEC	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) 19500	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited			
13. SUPPLEMENTARY NOTES The original document contains color images.			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	
19a. NAME OF RESPONSIBLE PERSON			

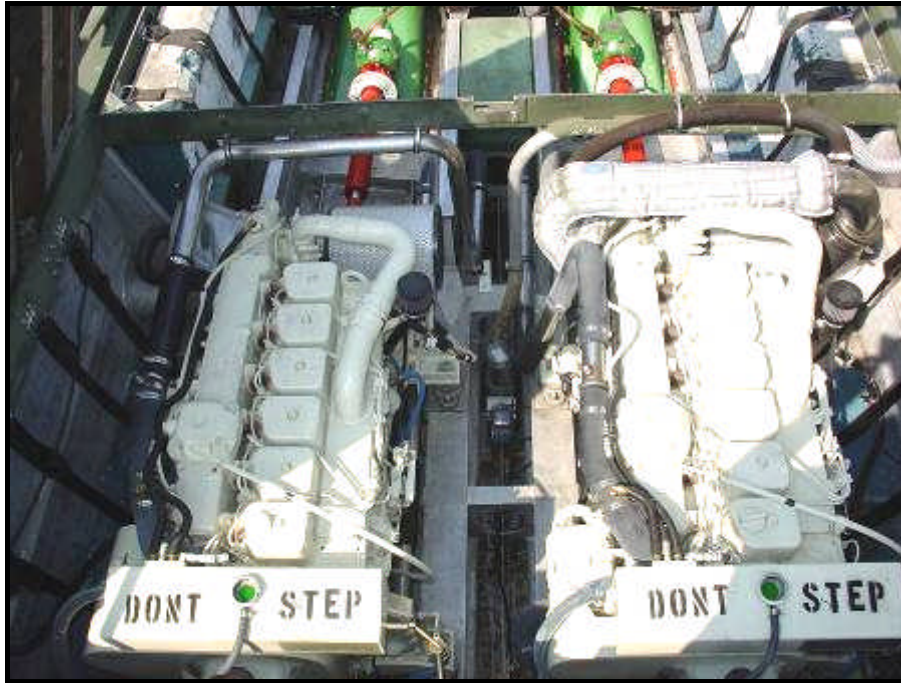


Figure 2. Mk II R, twin Cummins 6BT 5.9-L engines during initial inspection.

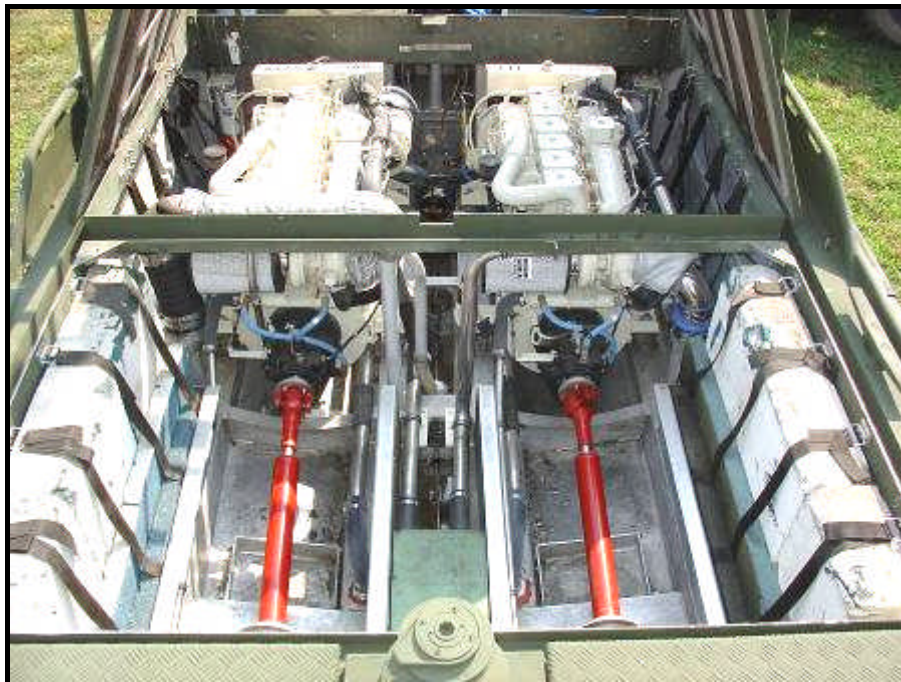


Figure 3. Mk II R, engine compartment, cockpit removed.

SUPPORTING FACILITY

Facility:

Spesutie Narrows Waterway, U.S. Army Aberdeen Test Center (ATC), Aberdeen Proving Ground (APG), Maryland.

DETAILS OF TEST

a. Testing was performed from 17 August 2006 through 8 August 2008. This test was a follow-on effort to U.S. Army Test and Evaluation Command (ATEC) Project No. 2006-DT-ATC-BEBSX-D1897. In theater, the Mk II R BEBs suffered numerous engine reliability issues when they were fueled with jet propellant (JP)-8. The U.S. Army Tank-automotive and Armaments Command (TACOM) directed ATC to conduct a comparison test with three Mk II R boats using JP-8 fuel. The JP-8 fuel evaluation test was accomplished in accordance with the test outline for the Compatibility Customer Test (CT) of the Mk II R JP-8 Fuel and Fire Extinguisher, September 2006. The objectives of the test were to validate the engine kit installation configuration and the Cummins engine operating procedures, demonstrate that the engines could run for 50 hr without fuel- or hardware-induced failures when the FS20000 lubricity filter was used, show that rotary fuel injection pump life was shortened without lubricity additive, and validate the improved fuel system plumbing. In addition, the original Halon fire suppression system, which was prohibited by the Environmental Protection Agency (EPA) and unsupported, was replaced. ATC was asked to install and demonstrate a new FM200 automatic-activation fire suppression system. The system presented no safety or human factors issues.

b. Initial Inspection and Test Preparation. Three BEBs (table 1) were equipped with the Cummins model 6BTA 5.9-L M2, 210-hp engine having the Delphi rotary fuel injection pump. Major component serial numbers are listed in Table 2. The lubricity filter was installed in the fuel stream of BEB R-1. The BEB R-2 lubricity filter was removed from the fuel stream. A summary of the initial inspection and test preparation performed on each BEB is presented in Tables 3 through 5.

TABLE 1. TEST ITEM
IDENTIFICATION

BEB	SERIAL NO.
R-1	00070
R-2	00079
R-3	554

TABLE 2. MK II R SYSTEM MAJOR COMPONENT
SERIAL NUMBERS

COMPONENT	BEB SERIAL NO.		
	R-1	R-2	R-3
Engine: Port	46455824	46453120	46453154
Starboard	46455839	46452989	46455805
Hydrojet: Port	228721062	228721074	439732581
Starboard	15862929	138721113	No data plate
Transmission: Port	31661	Illegible	31653
Starboard	31656	31659	31655
Alternator: Port	200451	200442	1268650M
Starboard	No data plate	200447	Illegible
Fuel injection pump: Port	07830-KXG	07835-KXG	07822-KXG
Starboard	12971-KXG	07829-KXG	06241-MXG

TABLE 3. R-1 INITIAL INSPECTION AND SERVICING SUMMARY

DATE, 06	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
17 Aug	2.6	2.4	001	Initial Inspection. BEB R-1 was inspected in accordance with Technical Manuals (TMs) 5-190-277-10C3 and 5-1940-277-20C2. There was no damage on the hull, push knees, rub rails, or tow hook. The steering wheel and all instruments worked to full capacity. The engine and transmissions were checked for damages, leaks, and proper fluid levels. The fuel tanks were drained of the diesel fuel and refilled with JP-8 fuel.
22 Aug	2.6	2.4	003	Master Battery Switch Inoperative. The master battery switch would not lock into place. The switch was disassembled and corrosion and debris were noted inside the switch. After battery cleaner was used to clean the switch, the switch was fully functional.
17 Aug	2.6	2.4	006	Masthead Navigation Light Lens Broken. The lens on the mast lower forward navigational light was broken. The upper portion of the lens was broken off flush with the rest of the lens. No action was taken due to the lack of a replacement part.
22 Aug	2.6	2.4	009	Class I Hydraulic Leak at Starboard Jet Drive Reservoir. There was a Class I hydraulic oil leak at the hose fitting at the starboard jet drive hydraulic reservoir. The hose clamp was loose and was tightened.
			010 and 011	Port and Starboard Windshield Wiper Motors Inoperative. The windshield wiper motors were inoperative. The wires for the wipers were not connected at the cab connection. The wires were properly connected and the wipers functioned normally.
29 Aug	2.7	2.5	016	Aft Bilge Pump Air Duct Hose Cracked. There were several cracks in the aft bilge pump air hose. The hose was replaced.
24 Aug	2.7	2.5	017	Port and Starboard Coolant Header Tanks Empty. The port and starboard coolant header tanks were empty. Both tanks were filled with 2 qt of antifreeze and 2 qt of water.
			018	Port and Starboard Coolant Overflow Tanks Empty. The port and starboard coolant overflow tanks were empty. Both tanks were filled with 1 qt of antifreeze and 1 qt of water.
			019	Port Air Filter Touches Exhaust Elbow. The port air cleaner was touching the exhaust hose, making access difficult. No action was taken.
30 Aug	2.8	2.6	020	Battery Voltage Low. Due to an incident on BEB R-2 (TIR No. K2-D000008), the batteries on BEB R-1 were tested for voltage. Each battery showed a reading of 10 V with 700 cold cranking amps (CCA). The four original batteries were replaced with serviceable batteries from an XM20 BEB.

TABLE 3 (Cont)

DATE, 06	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
25 Aug	2.8	2.6	021	FM200 Installation. The FM200 automatic fire suppression system was installed. The cylinder mounting plate was installed after the proper holes were drilled. The cylinder bracket was then removed from the cylinder using a flat tip screwdriver, and was installed using the supplied hardware. The FM200 cylinder was then positioned on the bracket and secured using the adjustable strap. The electrical system was then installed. The relay/pressure switch and the bridge rectifier were mounted, and the appropriate wires were connected.
31 Aug	3.0	2.8	022	Extra Parts for Fire Suppression Kit. After completing installation of the fire suppression kit (TIR No. K2-000021), the following parts were left over: one hour meter bracket, five No. 10 washers, six 1/4-in. washers, three Phillips head machine screws, two 1/4-in. 20 Nyloc nuts, and two hex head machine screws.
31 Aug	3.0	2.8	023	Electrical Short Hour Meter Wiring Damaged. During a check of the FM200 kit (TIR No. K2-D00021), the system failed to function. There was no power at the inspection light socket with the master switch on. Two wires were disconnected from the port engine hour meter and were connected to the FM200 power cable, and the master switch was turned on. Within seconds, smoke was visible from the wire bundle. Four wires in the starboard battery compartment were damaged. The wires were disconnected from the diode.
31 Aug	3.0	2.8	024	No Voltage at Inspection Light Receptacle. During installation of the fire suppression kit, there was no voltage at the inspection light receptacle. Troubleshooting revealed that the No. 2 and 10 wires in the circuit breaker were not connected to the correct lug. The wires were moved to the correct positions.
7 Sep	3.0	2.8	025	Electrical Issues. There were three wires (No. 26, 27, 28) on the port charging diode in the wrong position; the wires were repositioned correctly. The port engine wiring had a misplaced wire (No. 28) from the starter relay to the starter solenoid; the wire was repositioned correctly. Wire No. 29 at the starboard charging diode had too large of an eyelet and was not connected properly; the eyelet was replaced. Two wires (No. 2 and 10) in junction box No. 1 were positioned incorrectly; the wires were repositioned. Five of the six wires at the windshield wiper motor were disconnected. The wires were connected to the proper terminals.
7 Sep	3.0	2.8	026	Aft Bilge Pump Float Switch Malfunctioning. During unscheduled maintenance, an inspection of the aft bilge pump revealed that the float switch was malfunctioning. The light illuminated when the float was low instead of the proper function of illuminating when the float was high. The float switch was replaced.

TABLE 3 (Cont)

DATE, 06	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
12 Sep	3.4	3.2	028	Fuel Tank Pipe Plugs Incorrectly Installed. The two pipe plugs on the top of the fuel tank were installed in the incorrect holes. The plugs were in the forward hole and the fuel return elbow was in the aft hole on both sides of the tank. The plug and elbow were switched to the correct position fore and aft.
4 Oct	3.2	3.2	030 and 031	Manufacturer Inspection and Measurements. Two Cummins' representatives and one TACOM representative observed an inspection of the port and starboard engine fuel systems. Temporary diagnostic instrumentation was connected. The fuel pressure between the fuel inlet line and lift pump was measured along with temperature. The engine was operated at various speeds, unloaded, and then tested with load while pushing against a fixed pole. None of the test data were shared with the data collector. The lubricity filter for the starboard engine was changed at this time due to the unknown condition of the installed filter.
16 Oct	5.5	5.6	037	Vendor Fuel Quality Test. A fuel quality test was conducted on the BEB. Samples were taken from the tank, the line returning to the tank, and the fuel that was discharged into the injection pump. All samples were taken to Cummins for analysis.
17 Oct	6.4	6.6	038	Starboard Engine Serpentine Belt Damaged. During operations, there was a loud noise coming from the starboard engine. A visual inspection revealed that the serpentine belt had begun to come off the pulleys and one of the ribs of the belt was missing. After the mechanic removed the damaged belt, it was noted that four ribs were missing. A new belt was installed upon receipt.
19 Oct	7.0	7.2	039	Port Engine Serpentine Belt Walking Off Pulley. During unrelated maintenance, it was noted that the port serpentine belt was walking off the back of the pulley. The belt was removed and no damage was found. The belt was then reinstalled.
19 Oct	7.1	7.2	040	Starboard Engine Incorrect Idle revolutions per minute (rpm). During an engine idle speed check, it was noted that the starboard engine was idling at 624 rpm in neutral instead of the correct 750 rpm. The idle adjustment screw was adjusted one turn and the engine idled at 746 rpm.
			041	Port Engine Incorrect Idle rpm. During an engine idle speed check, it was noted that the port engine was idling at 706 rpm in neutral instead of the correct 750 rpm. The idle adjustment screw was adjusted one turn and the engine idled at 739 rpm.

TABLE 4. R-2 INITIAL INSPECTION SUMMARY

DATE, 06	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
22 Aug	1.4	1.3	002	Initial Inspection. BEB R-2 was inspected in accordance with TMs 5-190-277-10C3 and 5-1940-277-20C2. There was no damage on the hull, push knees, rub rails, or tow hook. The steering wheel and all instruments worked to full capacity. The engine and transmissions were checked for damages, leaks, and proper fluid levels. The fuel tanks were drained of the diesel fuel and refilled with JP-8 fuel.
22 Aug	1.4	1.3	004	Starboard Battery Ground Disconnected. The ground cable on the starboard battery was disconnected. The cable was reconnected.
23 Aug	1.4	1.3	005	Port Air Cleaner Touching Exhaust Hose. The port air cleaner was touching the exhaust hose, making access difficult. No action was taken.
25 Aug	1.4	1.3	007	Port and Starboard Coolant Header Tanks Empty. The port and starboard coolant overflow tanks were empty. Both tanks were filled with 2 qt of antifreeze and 2 qt of water.
29 Aug	2.1	1.7	008	Starboard Engine Cranked but Would Not Start. An in-water operational check was performed. The port engine started, but while cranking the starboard engine, the port engine died. The port engine was restarted, and the starboard engine was slave started off of it. Voltage readings were taken, and a collective voltage of 18 V was found. The batteries were deemed unserviceable and were replaced.
28 Aug	1.4	1.3	012	FM200 Automatic Fire Suppression System. The FM200 automatic fire suppression system was installed. The cylinder mounting plate was installed after the proper holes had been drilled. The cylinder bracket was then removed from the cylinder using a flat-tip screwdriver, and was installed using the supplied hardware. The FM200 cylinder was then positioned on the bracket and secured using the adjustable strap. The electrical system was then installed. The relay/pressure switch and the bridge rectifier were mounted and the appropriate wires connected.
29 Aug	2.4	2.1	013	Starboard Engine Incorrect Idle rpm. During the initial inspection water function check, the starboard engine was not reaching the specified 700-rpm idle speed. The engine idled at 500 rpm. The idle adjustment screw was adjusted three turns. The engine tachometer then read 700 rpm.
29 Aug	2.4	2.1	014	Port Engine Exhaust Clamp Loose. During the initial inspection water function check, water was leaking from the rear upper exhaust clamp area on the port engine. The clamp was tightened and there was no further leaking.
31 Aug	2.5	2.2	015	Automatic Fire Suppression Installation Kit Extra Parts. After completing installation of the fire suppression kit (TIR No. K2-D000012), the following parts were left over: one hour meter bracket, three 10-32 Nyloc nuts, six 1/4-in. washers, three Phillips head machine screws, two 1/4-in. 20 Nyloc nuts, and two hex head machine screws.

TABLE 4 (Cont)

DATE, 06	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
12 Sep	2.5	2.2	027	Fuel Tank Pipe Plugs Incorrectly Installed. A visual inspection revealed that the two pipe plugs on the top of the fuel tank were installed in the incorrect holes. The plugs were in the forward hole, and the fuel return elbow was in the aft hole on both sides of the tank. The plug and elbow were switched to the correct position fore and aft.
4 Oct	3.4	3.4	029	Starboard Fuel/Water Separator Filter Base Unknown Substance. Sediment, including an unknown jelly-like substance, was found after draining the fuel/water separator of 1 pint of JP-8 fuel.
16 Oct	3.4	3.4	032	Port Engine Failed to Start. The port engine failed to start. The bleeder screw on the injector pump was loosened, and the manual priming pump was used to verify that fuel was at the injector pump. The bleeder screw was tightened and the No. 1 fuel injector was opened to vent any air while the engine was cranked. This process was repeated for all injectors. The engine was then successfully started.
16 Oct	3.6	3.4	033	Starboard Engine Failed to Start. The starboard engine failed to start. The bleeder screw on the injector pump was loosened, and the manual priming pump was used to verify that fuel was at the injector pump. The bleeder screw was tightened and the No. 1 fuel injector was opened to vent any air while the engine was cranked. This process was repeated for all injectors. The engine was then successfully started.
19 Oct	4.1	4.3	034	Port Engine Not Reach Idle rpm. During an idle speed check, the port engine was idling at 690 rpm in neutral instead of the correct 750 rpm. The idle adjustment screw was adjusted approximately one turn and the engine idled at 739 rpm.
			035	Starboard Engine Not Reach Idle rpm. During an idle speed check, the starboard engine was idling at 690 rpm in neutral instead of the correct 750 rpm. The idle adjustment screw was adjusted approximately one turn and the engine idled at 739 rpm.
19 Oct	4.8	4.6	036	Starboard Engine Idle Adjustment Screw Loose. During adjustment of the idle adjustment screw (TIR No. D2-D000035), the jam nut would not tighten and had vibrated loose. A replacement idle screw and jam nut were installed.
30 Oct	5.8	5.7	042	Fuel Heater Installed. A fuel heater was temporarily installed prior to extreme cold conditions. All brackets were securely bolted down and the fuel lines from the fuel/water separator were disconnected and connected to the fuel heater with an additional line closing the loop. The lines were then bled of air. The engine was started and operated for 2 min with no fuel leaks observed.

TABLE 5. R-3 INITIAL INSPECTION SUMMARY

DATE, 07	ENGINE HOURS		TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD		
23 Jan	9.7	9.0	065	Initial Inspection. BEB R-3 was inspected in accordance with TMs 5-190-277-10C3 and 5-1940-277-20C2. There was no damage on the hull, push knees, rub rails, or tow hook. The steering wheel and all instruments worked to full capacity. The engine and transmissions were checked for damages, leaks, and proper fluid levels. The engines were checked for proper idle speed. The port engine was idling at 771 rpm. The idle adjustment screw was turned until the engine slowed to 749 rpm. The starboard engine speed was 749 rpm and needed no adjustment. Full throttle engine speeds were also measured. The starboard engine speed at neutral was 3011 rpm and under load was 2573 rpm. The port engine speed at neutral was 2804 rpm and under load was 2466 rpm.

c. Fire Suppression System. In accordance with the Program Executive Office (PEO) Combat Systems, Combat Systems Support installation instructions for the Mk II R BEB automatic fire suppression system (encl 1), the existing Halon canisters were removed from the engine compartment hatches. The port side engine compartment buoyancy blocks were removed and the port engine hour meter was relocated within the compartment. The FM200 fire suppression kit, which included the hull attachment bracket, FM200 cylinder, alarm module, and electrical connection cables, were installed in each BEB.

SUMMARY OF RESULTS

a. System Operations. Detailed Test Incident Reports (TIRs) were issued for all test preparation, inspection, and incident occurrences. Performance testing commenced on 31 October 2006 with BEBs R-1 and R-2. On 24 January 2007, at the request of the Project Manager (PM) BEB, an additional BEB (R-3) was included into performance testing. A total of 177 hr of test operations were accrued (table 6).

TABLE 6. TEST DURATION

SYSTEM	HOURS
R-1	91.2
R-2	52.7
R-3	33.4
Total	177.3

Note: The hours were averaged between port and starboard engines.

The BEB engines experienced original and original equipment manufacturer (OEM) replacement rotary fuel injection pump failures. These failures were characterized by either engine stall at idle speed or hot start failures. During operations as throttle position was reduced from full to idle, the engine would stall with little or no warning. Another indication of rotary fuel injection pump failure was difficulty starting a hot engine or a no start of a hot engine. On numerous occasions after refueling, operators had to engage the engine starter for up to 30 sec prior to engine start. In the case of a no start, operators waited 2 min for the engine starter to cool down and then repeated the process. In the event the engine would not start after three attempts, maintenance was notified. BEB R-1 operated for 36.9 hr prior to a port engine stall while returning to the dock. As a result, both engines fuel injection pumps were removed for wear analysis. New OEM rotary fuel injection pumps of matching part numbers were installed in BEB R-1. After 54.3 hr of operation, the starboard OEM replacement pump experienced hard starting issues when the engine was hot and would only start after a 12 hr or greater nonoperational period indicating a failure of the rotary fuel injection pump. Engine stall occurred while in the process of reducing from full throttle or mid throttle to idle. This was a consistent preliminary indication of rotary fuel injection pump failure.

BEB R-2 operated for 41.9 hr to prior removal of both port and starboard rotary fuel injection pumps for baseline wear analysis. The original pumps were replaced with OEM replacement rotary injection pumps which were operated for 3 hr prior to removal for wear analysis. Additional OEM replacement rotary injection pumps were installed and operated for 8 hr when the starboard engine failed to start when hot. No further action was taken as testing was suspended.

BEB R-3 operated for 20.9 hr when the port rotary fuel injection pump was removed by Cummins due to an insufficient amount of fuel emitting from the high pressure side of the injection pump. The Cummins inspection of the pump revealed debris in the inlet injection pump filter. The filter was cleaned with compressed air and the injector was reinstalled. The port engine started; however, water testing was accomplished and the Cummins representative found the injection pump was inoperative. Cummins accomplished a repair of the pump and re-installed it, but the pump was again removed for wear analysis at the direction of the PM. New OEM rotary fuel injection pumps of matching part numbers were installed on the port and starboard engines. These pumps operated for 12.4 hr until testing was suspended.

Preventive maintenance checks and services (PMCS) and diagnostics, in addition to the fuel injection wear analysis were conducted during the test period by boat crews and mechanics from Cummins Power Systems and ATC. Visual inspection of the fuel system piping, lubricity filter replacement, lift pump replacement, eliminating the fuel system of air leaks, fuel line connection physical checks, RACOR fuel water separators installations and checks, idle adjustment verification and maintenance, injection pump surface temperature measurements, and injection pump timing adjustments were conducted. The operational duration of the original rotary fuel injection pumps is listed in Table 7.

TABLE 7. ORIGINAL ROTARY FUEL INJECTION PUMP TEST DURATION

BEB	PORT		STARBOARD	
	SERIAL NO.	OPERATIONAL HOURS	SERIAL NO.	OPERATIONAL HOURS
R-1	07830-KXG	^a 36.9	12971-KXG	^b 38.4
R-2	07835-KXG	^b 41.9	07829-KXG	^b 41.9
R-3	07822-KXG	^a 20.9	06241-MXG	^b 21.4

^aIndicates the fuel injection pump was removed due to a failure of the engine to operate.

^bIndicates removal for wear analysis

The BEB engines did not demonstrate the objective of 50 hr of operation without a fuel induced hardware failure due to the multiple suspected failures of the original equipped Delphi rotary fuel injection pumps. During operations, suspected failures of the rotary fuel injection pumps were characterized by difficulty starting the engine when hot or a failure of the engine to idle particularly when full throttle position was reduced to idle. The removal of any rotary fuel injection pumps from the BEB engines was a result of either the engine stalling and or failure to start when hot or removal for analysis at the direction of the PM BEB based on fleet operational issues. The sole source use of JP-8 fuel in BEB engines equipped with Delphi rotary fuel injection pumps would cause operational issues which would lead to engine operational and reliability issues. A summary of BEB test incidents and servicing which characterize test operation and BEB reliability issues are listed in Tables 8 through 10.

TABLE 8. R-1 PERFORMANCE TEST INCIDENT AND SERVICING SUMMARY

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
31 Oct 06	9.2	9.2	0	043	Performance Testing Initiated. Performance Testing Initiated. Engine hours recorded upon initial inspection. Lubricity filters were installed per test plan.
7 Nov 06	22.1	22.1	12.9	048	Low Fuel Warning Light Inoperative. During baseline testing, both the port and starboard engines shut down. The fuel tanks were empty, and the low fuel warning light was not illuminated. Refueled.
21 Dec 06	46.1	46.1	36.9	054	Port Engine Stalled During Operations. The port engine stalled while returning to dock after cycle 15 of the intentional stall tests. A check of the fuel flow identified fuel into the injection pump, but was not flowing normally from the pump. The engine would continue to stall during troubleshooting and eventually would not start. There was no water in the fuel/water separator. The fuel injectors and fuel advance on the injection pump were bled. Voltage was verified at the shutoff solenoid. Solenoid resistance was checked to verify correct switch operation. The governor housing check valve inspection revealed that the metering valve was closed. The valve was manipulated manually. New lubricity filters (part No. 3966406) were installed. The engine was then operated for two minutes without incident. On 8 January 2007, after 1 hour of operation, the boat was conducting cycle No. 16 when the port engine stalled. The engine was restarted and after shifting to idle the engine stalled and could not be restarted.
16 Jan 07	48.1	47.6	38.6	057	Starboard Fuel Injection Pump Replaced. The original fuel injection pump (part No. 4020108, serial No. 12971-KXG,) was removed at the request of the Product Manager, and was replaced with a new pump (serial No. 68837-KZB) to baseline the boat. The pump was submitted to its manufacturer for an inspection.
				058	Port Fuel Injection Pump Replaced. The original fuel injection pump (serial No. 07830-KXG) was removed at the request of the Product Manager, and was replaced with a new unit (serial No. 43865-FZB) to baseline the boat. The pump was submitted to its manufacturer for an inspection.
18 Jan 07	48.1	47.6	38.6	063	Fuel System Modification. A fuel system plumbing modification kit was installed by the Cummins Diesel representative on both engines. New fuel/water separators (900 MA Racor) were installed and the fuel systems were primed. Audio and visual water sensing gauges were installed and the sensing alarm was tested.
30 Jan 07	56.8	56.3	47.4	068	Port and Starboard Fuel Injection Pump Timing Adjustments. The port and starboard fuel injection pump timing was adjusted by the Cummins representative. The three nuts securing the pumps to the gear housing were removed, allowing the pump to be realigned slightly. The nuts were then reinstalled and the pump bled of air.
				069	
30 Jan 07	56.8	56.4	47.4	070	Port and Starboard Engines Not Achieving Idle rpm. During a water functional check, the port engine idle speed was registered as 716 rpm. The idle adjustment screw was turned approximately one and a half turns. The engine idle then registered as 752 rpm. The starboard engine idle speed was registered as 715 rpm. The idle adjustment screw was turned approximately one and a half turns. The engine idle then registered as 754 rpm.
				071	

TABLE 8 (Cont)

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
13 Mar 07	88.1	87.4	78.5	091	Fuel Pickup Tube Inspection. The fuel supply and return pickup tubes were inspected to verify if the tubes were equipped with screens and to verify the length of the tubes. No screens were present. The supply and return pickup tubes were measured as 15-1/4 in. and the depth of the fuel tank was measured as 17-1/2 in.
16 May 07	90.1	89.4	80.6	099	Racor 900MA Fuel/Water Separators. The Racor 900MA fuel/water separators were removed from the BEB in preparation for the future installation of the Racor 500MA fuel/water separator.
21 May 07	90.2	89.5	80.3	100	Fuel Return Flow Test on Starboard Engine. A fuel return flow test was conducted to verify the fuel flow return rate on the starboard engine. A fuel burette scale was added to the fuel system. The fuel level of the burette was noted after five minutes during each test. The boat was operated in free boat patrol mode at 1800 rpm (260 mL fuel), high speed boat patrol mode at 2400 rpm (250 mL fuel), idling in gear at 900 rpm (370 mL fuel), connected to a two bay raft at 1800 rpm (250 mL fuel), the two bay raft at full throttle (375 mL), and in neutral at 1800 rpm while pushing the two bay raft (300 mL fuel).
				101	
5 Jul 07	93.6	92.7	83.9	116	Starboard Engine Would Not Start. While performing the water functional inspection (TIR No. K2-D000113), the starboard engine would not restart. The engine was run for 1 hr, then allowed to cool for 5 min. The engine was cranked for 30 sec without starting. After cooling an additional 2 min, the throttle was set at half throttle and the engine was cranked for 30 sec without starting. The engine was cooled another 5 min, then cranked for 30 sec at half throttle and did not start.
8 Aug 07	97.2	96.3	87.5	121	Port and Starboard Fuel Injector Pop-Off Test. The manufacturer's representative decided that all fuel injectors were to be removed and pressure tested using a pop-off tester. The engine fuel injectors test results ranged from 3800 to 4200 psi. All of the injectors appeared to be fully functional.

Note: The operational hours were averaged between port and starboard engine.

TABLE 9. R-2 PERFORMANCE TEST INCIDENT AND SERVICING SUMMARY

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
31 Oct 06	5.9	5.7	0	044	Performance Testing Initiated. Engine hours recorded upon initial inspection. Lubricity filters were bypassed per test plan.
7 Nov 06	18.7	18.5	12.8	047	Low Fuel Warning Light Inoperative. During baseline testing, the port and starboard engines shut down. The fuel tanks were empty and the low fuel warning light was not illuminated. The fuel tanks were refueled.
16 Jan 07	48.0	47.4	41.9	059	Port Fuel Injection Pump Replaced. The original fuel injection pump (part No. 4020108, serial No. 07835-KXG) was removed at the request of the PM, and was replaced with a new unit (serial No. 43865-FZB).
				060	Starboard Fuel Injection Pump Replaced. The original fuel injection pump (serial No. 07829-KXG) was removed at the request of the PM, and was replaced with a new unit (serial No. 58197-HZB).
18 Jan 07	48.0	47.4	41.9	061 and 062	Port and Starboard Lubricity Filters Replaced. The lubricity filters (part No. 3966406) were replaced by the Cummins representative for the three-month scheduled change.
22 Feb 07	48.0	47.4	41.9	081	Fuel System Modification. The Cummins Diesel representative installed a fuel system plumbing modification kit on both engines. New fuel/water separators (900 MA Racor) were installed and the fuel systems were primed. Audio and visual water sensing gauges were installed and the sensing alarm was tested.
13 Mar 07	51.0	50.4	44.9	092	Fuel Pickup Tube Inspection. The fuel supply and return pickup tubes were inspected to verify that the tubes were equipped with screens and to verify the length of the tubes. No screens were present. The supply and return pickup tubes were 15-1/4 in. and the depth of the fuel tank was 17-1/2 in.
16 May 07	51.0	50.5	44.9	097	Racor 900MA Fuel/Water Separators. The Racor 900MA fuel/water separators were removed from the BEB in preparation for the future installation of the Racor 500MA fuel/water separator.
24 May 07	51.0	50.4	44.9	102	Starboard Fuel Pump and Injectors Replaced. Per the PM, the original starboard fuel injection pump (serial No. 58197HZB) and fuel injectors (part No. 4089254) were replaced. New gaskets (part No. 3909356) were installed on the injector nozzles. The new pump (serial No. 08813K7B) and gasket were installed.
				103	Port Fuel Pump and Injectors Replaced. At the request of the PM, the original starboard fuel injection pump (serial No. 43865FZB) and fuel injectors (part No. 4089254) were replaced. New gaskets (part No. 3909356) were installed on the injector nozzles. The new pump (serial No. 59640HZB) and gasket were installed.
31 May 07	51.5	50.5	44.9	104	Racor 500MA Fuel/Water Separators. The port and starboard Racor 500MA fuel/water separators were installed on the BEB using the supplied brackets and mounting bolts. The fuel system was then primed until clean fuel without air came through the separator.

TABLE 9 (Cont)

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
25 Jul 07	51.1	50.5	44.9	112	Port Fuel Injector Class I Leak. During the water functional inspection, a Class I fuel leak was found at the No. 2 fuel injector. The clamp was checked and noted to be tight on the fuel line. The leak was monitored.
7 Aug 07	58.5	58.5	52.7	120	Starboard Engine Failed - Injectors Tested. During operations, the starboard engine failed to start after several attempts. The six fuel injectors were removed and pressure tested using a pop-off tester. All six showed satisfactory values (4000 to 4150 psi) and were reinstalled. The port engine injectors were also removed and tested (4000 to 4200 psi). The original starboard fuel injection pump was removed (serial No. 68813KZB) and a new fuel injection pump (serial No. 68035JZB) was installed.

Note: The operational hours were averaged between port and starboard engine.

TABLE 10. R-3 PERFORMANCE TEST INCIDENT AND SERVICING SUMMARY

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
24 Jan 07	9.7	9.0	0	066	Performance Testing initialed. Lubricity filters were installed per test plan.
30 Jan 07	20	19.2	10.2	067	Vendor Fuel Quality Test. Fuel quality samples were taken by the Cummins Diesel representative. Samples were taken after the engine was run for one minute. Samples were taken from the lubricity filter and fuel injection pump on both engines.
21 Feb 07	24.1	23.6	14.6	080	Starboard Engine Stalling. During intentional stall testing, the starboard engine would repeatedly stall out. Inspection of the engine showed that the jam nut on the idle adjustment screw was loose. The idle adjustment screw was adjusted until the engine idled at 752 rpm and the jam nut was tightened. No fuel leaks were found.
8 Mar 07	30.6	29.6	20.8	090	Port Engine Stalling. During full throttle performance testing, the operator idled the engines to begin to flush ice out of the water jets. While doing this, the port engine stalled four times. The operator was unable to get the engine restarted after the fourth stall. The mechanic found that the amount of fuel coming from the injectors was insufficient to start the engine. On 9 Mar 07, an inspection by the Cummins representative revealed debris in the inlet injection pump filter. The filter was cleaned with compressed air and reinstalled. The port engine started. Water testing was accomplished and the injector pump was found to be inoperative by the Cummins representative. The original injection pump (serial No. 07822-KXG) was removed and repaired by Cummins off-site. The original pump was reinstalled on 14 Mar 07. The original fuel injectors were removed and new injectors installed.

TABLE 10 (Cont)

DATE	ENGINE HOURS		OPERATIONAL HOURS	TIR NO. K2-D000	INCIDENT DESCRIPTION AND ACTION TAKEN
	PORT	STARBOARD			
13 Mar 07	30.9	29.6	20.8	093	Fuel Pickup Tube Inspection. The fuel supply and return pickup tubes were inspected to verify if the tubes were equipped with screens and to verify the length of the tubes. No screens were present. The supply and return pickup tubes were measured as 15-1/4 in. and the depth of the fuel tank was measured as 17-1/2 in.
2 Apr 07	31.2	29.8	21.2	094	Excessive Amount of Sediment in Fuel Filter Bowls. While draining the fuel from the BEB, an excessive amount of sediment was found in the starboard and port fuel filter bowls. Both bowls were removed, cleaned, and reassembled.
16 May 07	31.2	29.8	21.2	098	Racor 900MA Fuel/Water Separators. The Racor 900MA fuel/water separators were removed from the BEB in preparation for the future installation of the Racor 500MA fuel/water separator.
31 May 07	31.2	29.8	21.2	105	Starboard Fuel Injectors and Pump Replaced. The original fuel injection pump (part No. 4020108, serial No. 06241-MXG) was removed at the request of the Product Manager, and was replaced with a new unit (serial No. 59136-HZB). The starboard fuel injectors (part No. 3802328) were replaced.
				106	Port Fuel Injectors and Pump Replaced. The original fuel injection pump was removed at the request of the Product Manager, and was replaced with a new unit (serial No. 59116-HZB). The port fuel injectors (part No. 3802328) were replaced.
1 Jun 07	31.2	29.8	21.2	107	Racor 500MA Fuel/Water Separators. The port and starboard Racor 500MA fuel/water separators were installed on the BEB using the supplied brackets and mounting bolts. The fuel system was then primed until clean fuel without air came through the separator.
19 Jun 07	32.4	30.8	22.3	109	Baseline Fuel Inspection. A baseline fuel inspection was performed to ensure the system was in good working condition prior to testing. Using a digital thermal scanner, the temperatures of the fuel pumps (starboard 138 °F, port 128 °F), governors (starboard 135 °F, port 135 °F), pump inlet (185 °F), and fuel ambient (82 °F) temperatures were taken while the BEB was operating at full throttle. No problems were observed during operations.
2 Aug 07	36.6	34.8	26.4	115	Low Fuel Warning Light Inoperative. BEB operated until it ran out of fuel. The boat was towed to the dock and refueled with 60.1 gal. of JP-8 fuel. The engines did not restart after the boat was refueled. The fuel lines were bled of air and the engines were successfully started.
8 Aug 07	43.6	41.8	33.4	118	Starboard Fuel Injectors Removed. The fuel injectors on the starboard engine were removed and tested per the test director. The pressures ranged from 3900 to 4200 psi.
				119	Port Fuel Injectors Removed. The fuel injectors on the port engine were removed and tested per the test officer. The pressures ranged from 4000 to 4100 psi.

SUBMITTED BY:

Signed //s//

CHARLIE JONES
Test Officer

REVIEWED BY:

//signed//

NANCY T. CASTALDO
Chief, Bridging, Watercraft and PAWS Team

2 Encls

1. Fire Suppression Installation Instructions
2. Distribution List

FOR THE COMMANDER:

Signed //s//

DENNIS C. GRAHAM
Chief, Support Equipment Division