

## **Engine Test Procedure For U.S. Army Bridge Erection Boat (BEB)**

### **Test Scope**

The following dynamometer test cycle has been derived from the Bridge Erection Boat (BEB) mission profile and correlated duty cycle test.

### **Test Setup**

Configuration shall include the engine (after engine break-in period), all fuel system components between the fuel tank and the engine, and all air induction components from the entrance up to the engine. The engine test cell shall be set up in a manner that is representative of the installation in the boat.

### **Test Parameters**

The following general conditions of boat operation are provided:

- ambient air temperature (outside of the boat hull) of up to 120F
- fresh-water temperature (outside of the boat hull) of up to 95F
- solar load (radiation) of up to 104 W/Ft<sup>2</sup> (1120 W/m<sup>2</sup>)

The engine and/or boat manufacturer shall provide to the government, either prior to the test if conducted at a government facility, or in the final report:

- a) Minimum and Maximum engine speeds (known as low and high idle)
- b) Maximum torque (ft-lbs) and at what speed
- c) Maximum allowable coolant temperature
- d) Does the engine have any external cooling requirements that are air cooled, if so the manufacturer will have to provide a water heat exchanger as a replacement.
- e) Fuel supply pressure
- f) Maximum allowable fuel return (spillback) pressure/restriction.
- g) All filtration systems are to be provided by the manufacturers. (Air, Oil, Fuel and if required coolant)
- h) Hoses and connection sizes to be provided in advance of engine delivery.
- i) Size of the induction system, including air flow, the attachment I.D. and O.D. sizes.
- j) Exhaust flange to the turbocharger to be provided by the manufacturer and dimensions of the tubing in advance of engine delivery.
- k) Size of the coolant connections I.D. and O.D. of plumbing connections, in advance of engine delivery.
- l) Drawing of the flywheel or connection point for our prop shaft, MUST be sent in advance.
- m) If available the manufacturer can send engine vibration mounts, disclose if they are coming with the engine and provide drawings of the engine mount points (with or without vibration mounts).

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

| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     | Form Approved<br>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<br><b>11 DEC 2008</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    | 2. REPORT TYPE<br><b>N/A</b>        |                                          | 3. DATES COVERED<br><b>-</b>                             |                                 |
| 4. TITLE AND SUBTITLE<br><b>Engine Test Procedure For U.S. Army Bridge Erection Boat (BEB)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                    |                                     |                                          | 5a. CONTRACT NUMBER                                      |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                          | 5b. GRANT NUMBER                                         |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                          | 5c. PROGRAM ELEMENT NUMBER                               |                                 |
| 6. AUTHOR(S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                          | 5d. PROJECT NUMBER                                       |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                          | 5e. TASK NUMBER                                          |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                          | 5f. WORK UNIT NUMBER                                     |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                    |                                     |                                          | 8. PERFORMING ORGANIZATION REPORT NUMBER<br><b>19503</b> |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                          | 10. SPONSOR/MONITOR'S ACRONYM(S)<br><b>TACOM/TARDEC</b>  |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                          | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)<br><b>19503</b>   |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release, distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |                                          |                                                          |                                 |
| 13. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                          |                                                          |                                 |
| 14. ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                          |                                                          |                                 |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                          |                                                          |                                 |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     | 17. LIMITATION OF ABSTRACT<br><b>SAR</b> | 18. NUMBER OF PAGES<br><b>4</b>                          | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                          |                                                          |                                 |

- n) Any engine that is ECU controlled the manufacture will have to provide wiring harnesses and labeled connection to interface with our data acquisition/control system, all interface leads must be a minimum of 25 feet long.
- o) If the manufacturer wishes to have exhaust port thermocouples, either the manufacturer install them (K range) or provide spare gaskets for the engine so the thermocouples can be installed here. (THIS IS AN OPTION)
- p) Disclose if the engine has performed a break-in period, if not provide the break-in procedures for the engine, this is manufacturer required.

The engine and/or boat manufacturer is expected to determine the specific operating conditions through analysis, simulation, or testing for their particular design, within the limitations of the test facility:

1. Engine space ambient air temp: xxxF +/- xF
2. Air inlet temperature for combustion: xxxF +/- xF
3. Fuel temp entering the high pressure pump: xxxF +/- xF.
4. Inlet air depression: xx +/- x mbar.
5. Exhaust back pressure: xx +/- x mbar.
6. Engine coolant operating temperature: xxxF +/- xF.

### **Baseline Torque Curve**

Prior to running the sixty two cycles, but after a manufacturer's recommended engine break-in cycle, full load torque (performed on JP-8 only) should be measured at 25%, 50%, 75%, 85%, and 100% of rated speed in order to establish the installed engine's power curve.

At the conclusion of the test cycles, the measurements should be taken at the same points for comparison to the original.

### **Duty Cycle**

The table below shall be conducted sixty two times using JP-8 fuel for a total running time of 403 hours. The table below specifies the load, as a percent of full load, at which each test point will be run. The load will be based on the maximum achievable boat thrust. The boat manufacturer will determine the engine speed for each step based on an analysis of the engine torque curve and the propeller torque demand curve (along with knowledge of any proposed gear reduction). The engine torque curve, propeller demand torque curve, and specifications of any gear reduction units shall be supplied by the boat manufacturer prior to the test.

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

| <b>Load</b>                                               | <b>Cumulative Engine<br/>Run time (minutes)</b> |
|-----------------------------------------------------------|-------------------------------------------------|
| 1. 0% (idle), 10 mins                                     | 10                                              |
| 2. 100%, 37 mins                                          | 47                                              |
| 3. *0%, 110% Engine Rated Speed, 30 mins                  | 77                                              |
| 4. Run highlighted section 8 times                        | 129                                             |
| A) 100% load, 5 mins                                      |                                                 |
| B) 0% (idle), 30 secs                                     |                                                 |
| C) 100% load, 30 secs                                     |                                                 |
| D) 0% (idle), 30 secs                                     |                                                 |
| 5. 50%, 11 mins                                           | 140                                             |
| 6. 0% (idle), 10 mins                                     | 150                                             |
| 7. 100%, 25 mins                                          | 175                                             |
| 8. 0% (idle), 10 mins                                     | 185                                             |
| 9. 100%, 42 mins                                          | 227                                             |
| 10. Run highlighted section 8 times, 52 mins              | 279                                             |
| 11. 50%, 14 mins                                          | 293                                             |
| 12. 0% (idle), 10 mins                                    | 303                                             |
| 13. 100%, 42 mins                                         | 345                                             |
| 14. 0% (idle), 10 mins                                    | 355                                             |
| 15. *0%, 110% Engine Rated Speed, 25 mins                 | 380                                             |
| 16. 0% (idle), 5 mins (or manufacturer's time if greater) | 385                                             |
| 17. Shutdown & immediate re-start (30 secs or less)       | 385                                             |
| 18. Shutdown & wait 5 mins engine off, then Re-start      | <u>390</u>                                      |
|                                                           | 6.5 hours                                       |

Note: When shutting the engine down for operator break time or longer duration, perform proper shut-down procedure, to include the necessary idle time.

\*Steps 3 and 15 will not be performed when the engine is in a boat conducting missions.

### **Failure(s)**

A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the engine or that brings about a loss of power which cannot be rectified to give at least 95% of initial measured power, within the scope of normal maintenance and adjustment (items that the manufacturer recommends in the course of normal preventative maintenance).

A minor failure is a failure which leads to a loss of power or degradation which can be rectified to give at least 95% of initial measured power of the operation of the engine, and which it is possible to remedy within the scope of normal maintenance and adjustment (items that the manufacturer recommends in the course of normal preventative maintenance).

Any failures, and the measures taken to overcome them, must be included in the test report.

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

**Instrumentation**

For the duration of the test, the following parameters should be recorded at least once near the end of each sub-cycle that is longer than 30 seconds:

- Engine speed
- Torque
- Ambient air temperature
- Barometric pressure
- Humidity
- Inlet air temperature (before and after the turbo and charge air cooler, if so equipped)
- Inlet air pressure (before and after the turbo and charge air cooler, if so equipped)
- Exhaust temperature
- Exhaust back pressure
- Oil temperature
- Oil pressure in the main gallery
- Coolant temperatures entering and exiting the engine
- Fuel temperature (at the injection pump inlet and the return line)
- Fuel pressure at injection pump inlet
- Fuel pump skin temperature near the pumping element
- Fuel consumption
- Smoke density
- Engine blow-by

**Maintenance**

Oil consumption should be recorded for the duration of the test. Normal preventive maintenance is permitted (i.e. engine oil and filter change) every 104hr (16 cycles) of engine run time, or as required by the manufacturer. If the test will be performed at a government facility, the contractor is to provide all planned or expected maintenance replacement items.

**Conclusion of Test**

At the completion of the test, the engine will be torn down and the engine condition assessed. A final report should include at a minimum pictures of setup and tear down, calculations, test parameters, failures, and all performed maintenance actions.

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