

MIL-E-62541(AT)  
24 February 1988  
SUPERSEDING  
(see 6.7)

## MILITARY SPECIFICATION

### ENGINE, DIESEL, 6-CYLINDER, V-TYPE, 275 H.P., TURBOCHARGED

This specification is approved for use by US Army Tank-Automotive Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers a commercial, 6-cylinder, V-type, liquid-cooled, 2-stroke-cycle, crosshead-piston, turbocharged, by-pass blower, internal-combustion, compression-ignition (diesel) engine for use in military vehicles M730A2 and M113A3.

#### 2. APPLICABLE DOCUMENTS

##### 2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Tank-Automotive Command, ATTN: AMSTA-GDS, Warren, MI 48397-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

AMSC N/A

FSC 2815

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SPECIFICATIONS  
FEDERAL

- |          |   |
|----------|---|
| O-I-490  | - Inhibitor Corrosion, Liquid Cooling System.       |
| P-C-437  | - Cleaning Compound, High Pressure (Steam) Cleaner. |
| VV-F-800 | - Fuel Oil, Diesel.                                 |

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|-------------|---|
| MIL-P-514   | - Plates; Identification, Transportation-Data, and Blank.   |
| MIL-L-2104  | - Lubricating Oil, Internal-Combustion Engine, Tactical Service.  |
| MIL-B-11188 | - Batteries Storage: Lead-Acid.   |
| MIL-A-11755 | - Antifreeze, Arctic-Type.  |
| MIL-E-13856 | - Electrical Components for Automotive Vehicles; Waterproofness and Resistance to Temperature Cycling Tests, General Requirement for. |
| MIL-L-21260 | - Lubricating Oil, Internal-Combustion Engine, Preservative and Break-In.   |
| MIL-A-46153 | - Antifreeze, Ethylene Glycol, Inhibited.   |
| MIL-F-46162 | - Fuel, Diesel, Referee Grade.  |
| MIL-L-46167 | - Lubricating Oil, Internal-Combustion Engine, Arctic.  |

STANDARDS  
FEDERAL

- |             |   |
|-------------|---|
| FED-STD-791 | - Lubricants, Liquid Fuels and Related Products; Method of Testing. |
|-------------|---|

## MILITARY

- |               |   |
|---------------|---|
| MIL-STD-105   | - Sampling Procedures and Tables for Inspection by Attributes.  |
| MIL-STD-129   | - Marking for Shipment and Storage.   |
| MIL-STD-130   | - Identification Marking of US Military Property.   |
| MIL-STD-193   | - Painting Procedures and Marking for Vehicles, Construction Equipment and Material Handling Equipment. |
| MIL-STD-1184  | - Electrical Components for Automotive Vehicles; Waterproofness Tests.                                  |
| MIL-STD-45662 | - Calibration Systems Requirements.   |

2.1.2 Other Government drawings. The following Government drawings form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

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DRAWINGS  
ARMY

- |          |   |
|----------|---|
| 11650200 | - Engine, Diesel, for the M730A2 Carrier. |
| 11650249 | - Engine, Diesel, for the M113A3 Carrier. |

(Copies of specifications, standards and drawings required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

## SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

- |          |   |
|----------|---|
| SAE J816 | - Engine Power Test Code - Spark Ignition and Diesel. |
|----------|---|

(Information as to the availability of the above standard may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

## 3. REQUIREMENTS

3.1 First article. Unless otherwise specified, the contractor shall furnish engines which shall be subjected to first article inspection (see 4.4 and 6.2). First article inspection samples, properly marked with identifying information, shall be representative of the units to be furnished to the Government. All subsequent engines delivered to the Government shall conform to these first article samples.

3.1.1 Production break-in run. A production break-in run shall be performed on each engine. Fuel conforming to grade 2 of VV-F-800 shall be used. The manufacturer may use lubricating oil of his own selection. Any unsatisfactory operation or conditions which require correction shall be corrected before the engine is presented for acceptance.

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**3.2 Design and construction.**

**3.2.1 Construction.** Construction and assembly shall conform to Drawings 11650200 and 11650249 (see 4.6.2).

**3.2.2 Interchangeability.** Component assemblies and parts of the engine shall be so constructed that any part, except those furnished in matched sets or for which a selective fit is specified, may be installed, replaced, and adjusted with no modification required (see 4.6.1).

**3.2.3 Accessories and equipment.** All electrical accessories and equipment, except the engine starter and air pump wiring harness, shall conform to the applicable requirements of MIL-E-13856. Unless otherwise specified, all accessories and equipment shall be installed on the engine and properly adjusted (see 4.6.1).

**3.2.4 Speed range.** The engine shall be designed to operate satisfactorily under all loads and conditions as specified herein throughout the specified speeds (see 4.6.1).

**3.3 Performance.** Except as otherwise specified herein, engine performance requirements shall be met under the following conditions (see 4.6.3):

- a. Coolant. The engine coolant shall be water and antifreeze compound conforming to MIL-A-46153, arctic type antifreeze compound conforming to MIL-A-11755, or water and corrosion inhibitor compound conforming to O-I-490.
- b. Limiting operating temperatures. The engine temperatures shall not exceed the following limits when operating at full load throughout the speed range under any of the conditions specified herein:

Oil sump    235 degrees Fahrenheit (°F) (measured at the drain plug).

Coolant     190°F (measured at the coolant outlet).

- c. Fuel. Fuel shall be grade 2 or DF-A of VV-F-800.
- d. Oil. Lubricating oil shall conform to MIL-L-2104.
- e. Exhaust. The engine shall operate at all conditions with an exhaust back pressure less than 3.0 inches of mercury (in Hg).

**3.3.1 Idle speed.** The engine shall maintain an idle speed of 650 to 700 revolutions per minute (rpm) (see 4.6.3.1).

**3.3.2 Governor.** The governor shall limit the maximum engine speed as follows (see 4.6.3.2):

Full load operation        - 2775 to 2825 rpm.

No load operation         - 2940 to 2990 rpm.

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3.3.3 Dynamometer performance. The bare engine (see 6.3.1), at the full rack setting, shall meet the performance specified below when corrected to standard conditions as follows (reference SAE J816) (see 4.6.3.3 and 6.6):

- a. Air density (dry) - 0.070 pound (lb) per cubic foot.
- b. Air inlet temperature - 85°F.
- c. Fuel temperature - 90°F.
- d. Fuel specific gravity - 0.853 at 60°F.

3.3.3.1 Torque. Developed torque at the engine flywheel shall be not less than 595 pound-feet (lb-ft) at an engine speed of 1600 rpm (see 4.6.3.3).

3.3.3.2 Brake horsepower. The engine shall develop at least 264 gross brake horsepower (bhp) at a speed of 2800 rpm (see 4.6.3.3).

3.3.3.3 Fuel consumption. The fuel consumption shall not exceed the limits of table I (see 4.6.3.3).

TABLE I. Maximum observed fuel consumption.

RPM	Lb per bhp-hr
2200	0.365
2800	0.381

3.3.4 Exhaust smoke density. Exhaust smoke density at full rack position, through the speed range of 2000 to 2800 rpm when measured within 3 feet of the turbocharger outlet, shall not exceed a number 3 (light gray) smoke condition as defined in 4.6.3.4.

3.3.5 Oil consumption. After 25 hours of operation, the engine shall have consumed not more than 0.0035 lb of lubricating oil per brake horsepower-hour, when operating at full rack throughout the power check phase with an oil sump temperature of 200 to 230°F measured at the oil cooler outlet of the main gallery (see 4.6.3.5).

3.3.6 Oil pressure. Under all performance conditions specified herein (including a 1 quart low sump condition), with an oil sump temperature range from 200 to 230°F, gallery oil pressure shall not be more than 80 pounds per square inch (psi) and not less than 40 psi, when the engine is operating at 2800 rpm. Gallery oil pressure shall not be less than 5 psi when the engine is idling as specified in 3.3.1, with the oil sump temperature range from 180 to 230°F (see 4.6.3.6).

3.3.7 Endurance (NATO 400-hour test). The engine shall operate as specified in 4.6.3.7 for a period of 400 hours. During the test, the engine shall require only minor repairs, such as replacement of belts and filters. At the conclusion of this test, the engine shall conform to the performance requirements specified in 3.3.1 to 3.3.5, with the exception that the engine

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shall develop not less than 90 percent (%) of its initial power output with a maximum exhaust smoke density as specified in 3.3.4 without adjustments to the engine and shall develop 95% of full rated power after an authorized tune-up procedure. There shall be no evidence of abnormal wear such as scuffing or galling of cylinder bores, pistons, piston rings, piston pins, bearings, bearing journals, gear teeth, cam surfaces, valves, tappets, or other parts; burning of valves or pistons; sticking of valves or piston rings; leakage of gaskets or seals; imminent failure of a component; or other malfunction.

3.3.8 Extreme temperature starting conditions. The bare engine (see 6.3.1) shall start within 2 minutes under any of the following conditions or possible combination of conditions:

- a. With integral cold starting aid, without external aids after being cold-soaked for a 24-hour period, without benefit of solar radiation, in an ambient temperature of -25°F, and with the engine cranking speed not less than 120 rpm and the voltage to the air pump at 16 volts (see 4.6.3.8).
- b. Without external aids, and when operated at the following temperature with exposure to maximum solar radiation (see 4.6.3.8):

Ambient air temperature	125°F
Intake air temperature (at air cleaner inlet)	125°F
Coolant outlet temperature	230°F
Oil sump temperature	Maximum temperature attainable up to 275°F

3.3.9 Low-pressure conditions. At an atmospheric pressure equivalent to 8000 feet, the observed power output of the engine shall be not less than 90% of rated power (see 4.6.3.9).

3.3.10 Humidity conditions. The engine shall perform as specified herein under relative humidity conditions as low as 5% at a temperature of 125°F and as high as 100% at all temperatures from -25 to 85°F (see 4.6.3.10).

3.3.11 Steam and water jet cleaning. The engine and all its components shall withstand cleaning with high-pressure steam cleaner conforming to P-C-437 and water jet without deterioration of seals or hose, water leakage past seals or gaskets, or other defects. Paint removal shall not be considered a deficiency (see 4.6.3.11).

3.4 Exterior surface treatment. All exposed exterior surfaces of the engine and its components shall be cleaned, and painted or treated for corrosion resistance as specified on the applicable drawings, or if not so specified, in accordance with applicable provisions of MIL-STD-193 (see 4.6.1 and 4.6.2).

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3.5 Identification marking. Identification marking shall be in accordance with MIL-STD-129 and MIL-STD-130 and the specific product drawings (see 4.6.2).

3.5.1 Nameplates. Unless otherwise specified on applicable drawings (see 6.2), the nameplate, data and instruction plates shall conform to MIL-P-514 (see 4.6.2).

3.6 Workmanship. The workmanship shall be such quality as to assure that engines procured under contract meet all requirements specified herein. The engines produced shall be free of any defects or safety hazards which affect its performance or serviceability (see 4.6.2).

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform or witness any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 Inspection equipment. Unless otherwise specified in the contract (see 6.2), the contractor is responsible for the provision and maintenance of all inspection equipment necessary to assure that supplies and services conform to contract requirements. Inspection equipment must be capable of repetitive measurements to an accuracy of 10% of the measurement tolerance. Calibration of inspection equipment shall be in accordance with MIL-STD-45662.

4.1.3 Government verification. All quality assurance operations performed by the contractor will be subject to Government verification at unscheduled intervals. Verification will consist of (a) surveillance of the operation to determine that practices, methods, and procedures of the written quality assurance system plan are being properly applied, and (b) Government product inspection to measure the quality of the product offered for acceptance. Deviation from the prescribed or agreed upon procedure, or

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instances of poor practices which might have an adverse effect upon quality of the product, will be called to the attention of the contractor. Failure of the contractor to promptly correct deficiencies shall be cause for suspension of acceptance until corrective action has been made, or until the conformance of the product to prescribed criteria has been demonstrated.

4.1.4 Quality assurance provisions. In the conduct of inspection, the contractor shall adhere to Quality Assurance Provisions (QAP) and General Quality Assurance Provision (STA Form 458) as applicable and as required by the documents forming part of this specification.

4.1.5 Certification. Where certification (see 4.6.1) is required to verify material or component conformance to a specification, the contractor shall furnish such certification along with documented test results and performance and analytical data, as applicable.

4.1.6 Classification of inspections:

- a. First article inspection (see 4.2).
  - (1) Preproduction inspection (see 4.2.1).
  - (2) Initial production inspection (see 4.2.2).
  - (3) Teardown inspection (see 4.2.3).
- b. Quality conformance inspections (see 4.3).
  - (1) Examination (see 4.3.2).
  - (2) Tests (see 4.3.3).
- c. Control tests (see 4.4).

4.1.7 Inspection conditions. Unless otherwise specified (see 6.2), all inspections shall be conducted under the environmental conditions specified in 3.3.8 through 3.3.11.

4.2 First article inspection. First article inspection shall be performed on preproduction or initial production samples, and teardown samples as specified herein. Approval of the first article samples by the Government shall not relieve the contractor of the obligation to supply engines that are fully representative of those inspected as first article samples. Any changes or deviation of the production units from the first article samples shall be subject to the approval of the contracting officer.

4.2.1 Preproduction inspection. When specified (see 6.2), the preproduction sample shall consist of two engines. Preproduction inspection shall consist of inspection as specified in table II.

4.2.2 Initial production inspection. Unless otherwise specified (see 6.2), the Government shall select 2 from the first 10 engines produced under the production contract for initial production inspection. Initial production units shall be inspected as specified in table II.



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4.2.3 Teardown inspection. Final inspection after first article inspection shall include teardown of the engine for detailed investigation. The Government shall randomly select 10 engines out of the first production lot. The contractor, in the presence of the Government, shall disassemble and inspect these 10 engines. Disassembly shall be accomplished to the extent required to perform inspections for the following:

- a. Oil contamination (spectro analysis).
- b. Dirt, chips, or foreign matter in the engine block and oil pan (visual).
- c. Main bearing bolt torque.
- d. Connecting rod bolt torque.
- e. Cylinder bore scuffing, scoring, galling, etc. (visual).
- f. Piston scuffing and burning (visual).

4.2.4 First article inspection failure. Test item deficiencies during, or as a result of, first article inspection shall be cause for rejection of the items until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiency. Any deficiency found during, or as a result of, first article inspection shall be evidence that all items already produced prior to completion of first article inspection are similarly deficient unless evidence satisfactory to the contracting officer is furnished by the contractor that they are not similarly deficient. Such deficiencies on all items shall be corrected by the contractor. The Government shall not accept products until first article inspection is completed and accepted by the Government representative.

TABLE II. Classification of inspections.

Title	Requirement	Inspection	First article	Quality conformance		Control
				Examination	Tests	
Materials and construction	3.2.1 thru 3.2.4 and 3.4	4.6.1	X			
Defects (see table III)	3.2.1 and 3.4 thru 3.6	4.6.2	X	X		X
Coolant	3.3.a	4.6.3	X			
Limiting operating temperatures	3.3.b	4.6.3	X			X
Fuel	3.3.c	4.6.3	X			
Oil	3.3.d	4.6.3	X			
Exhaust	3.3.e	4.6.3	X			
Idle speed	3.3.1	4.6.3.1	X		X	X
Governor	3.3.2	4.6.3.2	X		X	X
Dynamometer performance	3.3.3	4.6.3.3	X			X
Torque	3.3.3.3	4.6.3.1	X		X	X
Brake horsepower	3.3.3.3	4.6.3.2	X		X	X
Fuel consumption	3.3.3.3	4.6.3.3	X			X

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TABLE II. Classification of inspections - Continued.

Title	Requirement	Inspection	First article	Quality conformance		Control
				Examination	Tests	
Exhaust smoke density	3.3.4	4.6.3.4	X		X	
Oil consumption	3.3.5	4.6.3.5	X			X
Oil pressure	3.3.6	4.6.3.6	X		X	
Endurance						
NATO 400-hour test	3.3.7	4.6.3.7.1	X			
Control test	3.3.7	4.6.3.7.2				X
Extreme temperature starting conditions	3.3.8	4.6.3.8	X			X
Low pressure conditions	3.3.9	4.6.3.9	X			
Humidity conditions	3.3.10	4.6.3.10	X			
Steam and water jet cleaning	3.3.11	4.6.3.11	X			X

4.3 Quality conformance inspections.4.3.1 Sampling.

4.3.1.1 Lot formation. An inspection lot shall consist of all the engines of one type and part number, from an identifiable production period, from one manufacturer, submitted at one time for acceptance.

4.3.1.2 Sampling for examination. Samples for the quality conformance examination shall be selected in accordance with general inspection level II of MIL-STD-105.

4.3.2 Examination.

4.3.2.1 Acceptable quality level. Each sample selected in accordance with 4.3.1.2 shall be examined to determine conformance to the following acceptable quality levels (AQL) on the basis of % defective.

<u>Classification</u>	<u>AQL</u>
Major	1.0
Minor	2.5

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4.3.2.2 Classification of defects. For examination purposes, defects shall be classified as listed in table III.

TABLE III. Classification of defects.

Category	Defect	Method of examination
Critical	None	
<u>Major</u>	<u>AQL 1.0% Defective</u>	
101	Incomplete assembly (see 3.2.1).	Visual and functional
102	Valve tappet clearance (each valve), improperly adjusted (see 3.2.1).	Gage
103	Improper torque on cylinder head bolts (see 3.2.1).	Torque wrench
104	Crankshaft, excessive or restrictive endplay (see 3.2.1).	Gage and functional
105	Dimensions affecting interchangeability, out of tolerance (see 3.2.1).	SIE 1/
106	Linkage, improperly adjusted (see 3.2.1).	Visual
107	Fuel, oil, and coolant leakage (see 3.3).	Visual
108	Fuel system, malfunction, damage, leaks, etc. (see 3.3).	Visual and functional
109	Fuel injection system timing and components: malfunction, improper adjustment (see 3.3).	Gage
110	Governor, malfunction (see 3.3.2).	Visual and functional
111	Identification marking, improper (see 3.5).	Visual
112	Faulty workmanship affecting performance (see 3.6).	Visual and functional
113	Dirt, chips, and foreign material in oil sump (see 4.2.3).	Visual and functional
<u>Minor</u>	<u>AQL 2.5% Defective</u>	
201	Dimensions not affecting interchangeability, out of tolerance (see 3.2.1).	SIE
202	Air box pressure, excessive (see 3.3).	Gage
203	Crankcase pressure, excessive (see 3.3).	Gage
204	Painting, improper (see 3.4).	Visual
205	Faulty workmanship not affecting performance (see 3.6).	Visual

1/ SIE = Standard Inspection Equipment.

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4.3.3 Tests. Each engine shall be subjected to the tests specified in table II.

4.4 Control tests. Control tests shall be conducted on 1 engine per month when production is 100 units per month or less, and on 2 per month when production is greater than 100 units per month. The engines shall be subjected to the control tests specified in table II.

4.5 Failure. Failure of any engine to pass any of the specified inspections shall be cause for the Government to refuse acceptance of the production quantity represented, until action taken by the contractor to correct defects is presented to and approved by the Government.

4.6 Methods of inspection.

4.6.1 Materials and construction. Conformance to 3.2.1 through 3.2.4 and 3.4 shall be determined by inspection of contractor records providing proof or certification that design, construction, processing, and materials conform to requirements. Applicable records shall include drawings, specifications, design data, receiving inspection records, processing and quality control standards, vendor catalogs and certifications, industry standards, test reports, and rating data.

4.6.2 Defects. Conformance to 3.2.1 and 3.4 through 3.6 shall be determined by examination for the defects listed in table III. Examination shall be visual, tactile, or by measurement with SIE.

4.6.3 Performance. Performance tests specified herein shall be performed on a dynamometer under the conditions listed in 3.3.a through 3.3.e.

4.6.3.1 Idle speed. To determine conformance to 3.3.1, the engine shall be observed for steady idling between 650 to 700 rpm.

4.6.3.2 Governor. To determine conformance to 3.3.2, the engine maximum speed shall be measured.

4.6.3.3 Dynamometer performance. Torque (see 3.3.3.1) and brake horsepower (see 3.3.3.2) shall be determined by dynamometer performance, and corrected to standard conditions. Fuel consumption (see 3.3.3.3) shall be determined from observed bhp and observed fuel rate.

4.6.3.4 Exhaust smoke density. To determine conformance to 3.3.4, exhaust smoke density shall be determined with a Bosch model EFAW 68 smoke meter or equivalent (as approved by the responsible engineering activity),

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and model DFAW 65 sampling pump or equivalent (as approved by the responsible engineering activity). The following table may be used to visually define the degree of exhaust smoke density in lieu of the smoke meter:

<u>Description of exhaust smoke</u>	<u>Classification</u>
Clear	1
Haze	2
Light Gray	3
Medium Gray	4
Dark Gray to Black	5

NOTE: Observation of exhaust smoke shall be made against a white background within 3 feet of the turbocharger outlet.

4.6.3.5 Oil consumption. To determine conformance to 3.3.5, the engine shall be operated on the dynamometer for 25 hours at full rack.

4.6.3.6 Oil pressure. To determine conformance to 3.3.6, the engine shall be operated at 2800 rpm, with oil sump temperature range from 230 to 250°F. The engine shall be idled as specified in 3.3.1, with an oil sump temperature range from 180 to 230°F.

4.6.3.7 Endurance. To determine conformance to 3.3.7, an applicable test shall be performed, as follows.

4.6.3.7.1 NATO 400-hour test.

4.6.3.7.1.1 Test conditions.

4.6.3.7.1.1.1 Test hours. Running time less than 30 minutes unless specified in table IV shall not be counted toward fulfillment of the 400 endurance hours.

4.6.3.7.1.1.2 Temperature. Inlet air temperatures shall be not less than 70°F or more than 100°F unless otherwise specified (see 4.6.3.7.1.3.2). The lubricating oil temperature shall not exceed 230°F at the sump.

4.6.3.7.1.1.3 Fuel. During the 400-hour endurance test, diesel fuel conforming to MIL-F-46162 shall be used.

NOTE: The use of additives of any kind to produce a clean fuel, or the use of a solvent to treat the fuel, is not permitted.

4.6.3.7.1.2 Test procedure.

4.6.3.7.1.2.1 Test. The endurance test shall be 400 hours, consisting of four periods of 100 hours each. Each 100-hour period shall be made of ten 10-hour cycles. Each 10-hour cycle shall be in accordance with the program specified in table IV.

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TABLE IV. Ten-hour cycle.

Period	% rated speed	% Load	Duration hours
1	Idle	0	1/2
2	100	100	2
3	Governed speed	0	1/2
4	75	100	1
5	Idle _____ 100	0 _____ 100 4 min.      6 min.	2
6	60	100	1/2
7	Idle	0	1/2
8	Governed speed	70	1/2
9	Max. torque speed	100	2
10	60	50	1/2
Total duration			10

4.6.3.7.1.2.2 Power check. Full rack characteristics of the engine shall be measured according to the following schedule before the endurance test and after each 100-hour operating period:

<u>Period</u>	<u>Engine speed (rpm)</u>	<u>Rack position</u>
1	1800	Full rack
2	2000	Full rack
3	2400	Full rack
4	2600	Full rack
5	2800	Full rack

4.6.3.7.1.2.3 Teardown. Final inspection after the NATO 400-hour endurance test shall include teardown of the engine for detailed investigation to the extent stipulated in 4.2.3.

4.6.3.7.1.3 Acceptable NATO 400-hour endurance performance. During the 400-hour test, the engine shall be observed for compliance with the following performance requirements during power check tests (see 4.6.3.7.1.2.2). The power checks shall be made at the beginning of the endurance run and at the end of each 100-hour period.

a. Idle speed	3.3.1.
b. Governed speeds	3.3.2.
c. Torque	3.3.3.1.
d. Brake horsepower	3.3.3.2.
e. Fuel consumption	3.3.3.3.
f. Exhaust smoke density	3.3.4.
g. Oil consumption	3.3.5.
h. Oil pressure	3.3.6.

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4.6.3.7.1.3.1 Servicing. Prior to each power check test, the lubricating oil shall be changed, all filters serviced, and valve clearances and injector rack settings checked and adjusted to applicable requirements.

4.6.3.7.1.3.2 High temperature. The last 100 hours of the 400-hour endurance test shall be conducted with the air inlet temperature not greater than  $125 \pm 5^{\circ}\text{F}$ , in accordance with 3.3.8.b. The power check tests shall be made at room temperature (see 3.3.3).

4.6.3.7.1.3.3 Teardown. At teardown the engine shall be observed for compliance with 4.6.3.7.1.2.3.

4.6.3.7.2 Control test. The control test for endurance shall be 50 hours duration.

4.6.3.7.2.1 Test conditions.

4.6.3.7.2.1.1 Temperature. The coolant temperature shall be maintained at  $180 \pm 5^{\circ}\text{F}$ .

4.6.3.7.2.2 Test procedure. The 50-hour control test shall be conducted as specified herein for the purpose of determining the continued quality of the engine. The test is required at the rate specified in 4.4. The engine shall be identified as to production period and shall have completed break-in (see 3.1.1), tests (as specified in table II), and examination for defects (as specified in table III) prior to the control test specified in table V.

TABLE V. 50-hour control test.

Period	Time (hrs)	Speed (rpm)	% of full rack position	Fuel
1	(Run-in schedule)			Fuel conforming VV-F-800 shall be used during the entire run.
2	5	1800	50	
3	5	2300	75	
4	5	2800	75	
5	5	2500	100	
6	30	2800	100	
7	Power check test (see 4.6.3.7.1.2.2)			

4.6.3.7.2.2.1 Teardown. Upon completion of the 50-hour control test, the engine shall be disassembled to the extent stipulated in 4.2.3 for inspection. Evidence of component or parts damage indicated by this inspection shall require such further disassembly of the engine as necessary to determine the cause of failure.

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4.6.3.7.2.3 Data. The following recordings are required during the control test:

- a. Engine speed, rpm.
- b. Observed brake horsepower, bhp.
- c. Observed torque, lb-ft.
- d. Air box pressure (in Hg).
- e. Fuel pressure after secondary filter, psi.
- f. Lubricating oil pressure, psi.
- g. Lubricating oil temperature in oil sump, °F.
- h. Fuel temperature after secondary filter, °F.
- i. Coolant temperature - engine outlet, °F.
- j. Air temperature at turbocharger, °F.
- k. Cell ambient air temperature, °F.
- l. Exhaust temperature (after turbocharger).
- m. Fuel flow, lb/hr.
- n. Brake specific fuel consumption, lb per bhp-hr.
- o. Specific oil consumption, lb per bhp-hr.
- p. Exhaust smoke density.
- q. Barometer pressure during power check test.

NOTE: All data shall be obtained under stabilized operating conditions, with the engine coupled to a dynamometer. At each start, the engine shall be warmed up until torque, speed, and temperatures have been stabilized for a period of not less than 1 minute. All applicable temperatures shall be recorded at the conclusion of each warm-up period. Starting, warm-up, and stopping times shall be recorded; however, warm-up time and running time of less than 30 minutes, unless specified in table V, shall not be charged to the test run hours. Prior to start of test, all applicable settings and adjustments shall be reset to specification requirements.

4.6.3.8 Extreme temperature starting conditions:

- a. To determine conformance to 3.3.8.a, the bare engine, with integral winterization aids, shall be cold started at -25°F on fuel specified in 3.3.d. Prior to the cold start, the engine shall be cold soaked in an ambient temperature of -25°F for a period of 24 hours. After starting, the engine shall operate for sufficient time to stabilize engine operation.
- b. To determine conformance to 3.3.8.b, the bare engine shall be placed in a high-temperature chamber maintained at a temperature of 125°F and operated at full load until all temperatures are stabilized within the limits specified in 3.3.b. The engine shall then be shut down, hot soaked, and restarted when the fuel temperature at the inlet to the fuel transfer pump reaches a temperature of 170°F. Fuel shall be supplied to the engine mounted fuel transfer pump at a pressure of 5 psi. The fuel pressure shall be shut off during the hot-soak period. The starting time shall not exceed 2 minutes.



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4.6.3.9 Low-pressure conditions. To determine conformance to 3.3.9, the engine shall be placed in a simulated environmental condition of 8000 feet elevation as follows, and its general performance characteristics observed:

<u>Elevation</u>	<u>Standard pressure</u>	<u>Temperature</u>
8000 feet	22.2 in Hg	90°F

NOTE: Pressure is measured at turbocharger inlet and exhaust outlet.

4.6.3.10 Humidity conditions. To determine conformance to 3.3.10, the engine shall be verified to meet all performance requirements when subjected to relative humidity conditions as low as 5% at temperature of 115°F and as high as 100% at all temperatures from minus 25°F to plus 85°F.

4.6.3.11 Steam and water jet cleaning. To determine conformance to 3.3.11, steam and water jet cleaning shall be performed as follows. The jet shall be applied perpendicular to the surface being cleaned at a distance of not more than 1 foot from the surface for steam cleaning and not more than 5 feet from the surface for water jet cleaning, and it shall be cleaned at a rate of 1 square foot per minute. The jet pressure shall not be less than 100 psi, and not more than 110 psi. Prior to cleaning, the air intake opening, flywheel, exhaust, and all other openings that might be affected shall be covered.

4.6.3.11.1 Post-cleaning test. The engine shall start and operate at idle speed without misfiring within 2 minutes immediately after the completion of both the steam and water jet cleaning operations.

## 5. PACKAGING

5.1 Preservation, packaging, packing, and marking. Preservation, packaging, packing, and marking for the desired level of protection shall be in accordance with the applicable packaging requirements specified by the contracting authority (see 6.2).

## 6. NOTES

6.1 Intended use. The engines covered by this specification are intended for production use, as spares, or as replacements for military tactical vehicles.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. Title, number, and date of applicable drawings.
- c. If first article samples are not required (see 3.1).
- d. If nameplates shall be other than as specified (see 3.5.1).
- e. If responsibility for inspection shall be other than as specified (see 4.1).
- f. If responsibility for inspection equipment shall be other than as specified (see 4.1.2).

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- g. If inspection conditions shall be other than as specified (see 4.1.7).
- h. If preproduction inspection is required (see 4.2.1).
- i. If initial production inspection is not required (see 4.2.2).
- j. Selection of applicable level and packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Bare engine. Bare engine (see 3.3.d, 3.3.3, and 3.3.8) is defined as an engine depicted on Drawings 11650200 and 11650249.

6.3.2 Brake horsepower. Brake horsepower is defined as the horsepower output of the bare engine at the flywheel.

6.4 Subject term (key word) listing.

Commercial  
 Compression-ignition  
 Diesel  
 Engine  
 Internal-combustion  
 Liquid-cooled  
 6-cylinder  
 Turbocharged  
 2-stroke-cycle  
 V-type

6.5 Reference grade oil. The following designations apply for the various grades (see 3.3.d):

<u>Grade</u>	<u>Government designation</u>
10	MC-2877
30	MC-2879
15W-40	MC-2777

6.6 Correction factors. Observed dynamometer performance may be corrected to standard conditions by application of correction factors as follows:

- a. Air inlet temperature: Add 2.1 bhp for each 10°F difference above 85°F. Subtract 2.1 bhp for each 10°F difference below 85°F.
- b. Fuel temperature: Add 0.90 bhp for each 4°F difference above 90°F. Subtract 0.90 bhp for each 4°F difference below 90°F.
- c. Fuel specific gravity: Add 0.60 bhp for each 0.001 difference less than 0.853 specific gravity measured at 60°F. Subtract 0.60 bhp for each 0.001 difference greater than 0.853 specific gravity measured at 60°F.

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6.7 Supersession. This specification supersedes purchase description ATPD 2105, dated 21 March 1986.

Custodian:  
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