

MIL-E-46796A(AT)  
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SUPERSEDING  
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## MILITARY SPECIFICATION

ENGINE, DIESEL: 8 CYLINDER, V-TYPE 390 H.P.

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 one type of 8-cylinder, V-type, liquid-cooled, 2-stroke-cycle, turbo-supercharged, internal-combustion, compression ignition engine for use in military vehicles (see 6.1).

### 2. APPLICABLE DOCUMENTS

#### 2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this specification to the extent specified herein.

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-A-548  | - Antifreeze, Ethylene Glycol, Inhibited.            |
| O-I-490  | - Inhibitor Corrosion, Liquid Cooling System.        |
| P-C-437  | - Cleaning Compound, High Pressure (Steam)<br>Clean. |
| VV-F-800 | - Fuel Oil, Diesel.                                  |

## MILITARY

- |             |  |
|-------------|--|
| MIL-P-514   | - Plates Identification, Instruction and<br>Marking, Blank.                            |
| MIL-L-2104  | - Lubricating Oil, Internal Combustion<br>Engine, Heavy Duty.                          |
| MIL-A-11755 | - Antifreeze, Arctic-Type.   |
| MIL-A-13488 | - Air Cleaner, Engine: Heavy-Duty, Oil-Bath<br>Type (for Internal-Combustion Engines). |
| MIL-L-21260 | - Lubricating Oil, Internal Combustion<br>Engine, Preservative.                        |
| MIL-F-46162 | - Fuel, Diesel, Referee Grade.   |
| MIL-L-46167 | - Lubricating Oil, Internal Combustion<br>Engine, Arctic.                              |
| MIL-A-62048 | - Air Cleaners, Automotive: Heavy Duty,<br>Dry-Type (for Internal-Combustion Engines). |

STANDARDS  
MILITARY

- |               |  |
|---------------|--|
| MIL-STD-105   | - Sampling Procedures and Tables for<br>Inspection by Attributes.  |
| MIL-STD-193   | - Painting Procedures and Marking for<br>Vehicles, Construction Equipment, and<br>Material Handling Equipment. |
| MIL-STD-1184  | - Electrical Components for Automotive<br>Vehicles, Waterproofness Test.                                       |
| MIL-STD-45662 | - Calibration System Requirements.   |

2.1.2 Other Government documents, drawings, and publications. The following documents, drawings, and publications form a part of this specification to the extent specified herein.

DRAWINGS  
ARMY

- |          |                                     |
|----------|-------------------------------------|
| 11669155 | - Engine Assembly (M110A3, M578).   |
| 12260210 | - Engine Assembly (M109A2, M109A3). |

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

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2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable.

## NATO INTERNATIONAL STAFF - DEFENSE SUPPORT DIVISION

AC/225 (Panel II)	NATO Standard Engine Laboratory Test for
D/131 (Part II)	Diesel and Gasoline Engines.
AEP-5	

(Application for copies of NATO publications should be addressed to NATO, Military Agency for Standardization (MAS), 35 Chesham Place, London SW1, England.)

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.

## 3. REQUIREMENTS

3.1 First article. Unless otherwise specified (see 6.2), the contractor shall furnish diesel 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 unit to be furnished to the Government. All subsequent diesel engines delivered to the Government shall conform to these samples in all of their pertinent physical and performance attributes.

3.2 Materials. Materials shall be as specified herein and in referenced specifications, standards, and drawings (see 4.1.1 and 6.4).

3.3 Design and construction. The engine construction and assembly shall be in accordance with Drawings 11669155 or 12260210 (see 4.1.2).

3.3.1 Electrical accessories and equipment. All electrical accessories and equipment, including wiring and electrical connections, shall conform to the applicable requirements of MIL-STD-1184. Unless otherwise specified, all accessories and equipment shall be installed on the engine and properly adjusted (see 4.6.1).

3.3.2 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 without requiring modification (see 4.6.2).

3.3.3 Air cleaner. The air cleaner required for use with the engine, shall be either dry or oil-bath type of approved design and capacity. They shall conform to MIL-A-62048 or MIL-A-13488 respectively (see 4.6.3).

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3.3.4 Oil. The lubricating oil required for the engine to perform as specified herein shall be in accordance with the seasonal requirements of MIL-L-2104 from minus 10 to plus 115 degrees Fahrenheit (°F) and MIL-L-46167 from minus 65°F to 0°F. The manufacturer may use oil of his own selection during engine build up and the break-in run. Oil conforming to grade 30 of MIL-L-21260 may also be used during the build up and break-in run. Reference grade oil used during the endurance test (see 4.7.12) shall be designated as specified (see 4.6.4).

3.4 Performance.

3.4.1 Engine break-in run. An engine break-in run shall be performed by the contractor. The break-in run schedule shall be established by the contractor to ensure that the engine, as offered for delivery, is suitable for immediate operation. All the required checks or tests, complete and in sequence of performance and endurance, shall be performed with no loss in engine life expectancy (see 4.7.1, 4.7.1.1 and 4.7.1.2).

3.4.2 Speed range. The engine shall operate satisfactorily under all loads and conditions as specified herein through a speed range of 1150 to 2600 revolutions per minute (rpm) (see 4.7.2).

3.4.2.1 Idle speed. The engine shall maintain a satisfactory idle speed of 550 to 600 rpm when using diesel fuel conforming to grade DF-2 of VV-F-800 (see 4.7.2.1).

3.4.3 Governor. The governor shall limit the engine speed as follows during vehicle operations:

Full Load .....	2275 to 2325 rpm
No Load .....	2450 to 2500 rpm (minimum)

When engine is equipped with a two speed governor, speed during winching operations shall be as follows:

Full Load .....	1150 rpm (min)
No Load .....	1350 rpm (max)

In each case, the engine speed with no load on the engine shall stabilize within three seconds after full rack position is reached (see 4.7.3).

3.4.4 Brake horsepower (BHP). The bare engine at a full rack setting, upon the completion of the break-in run, shall develop not less than 374 observed bhp at 2300 rpm using diesel fuel conforming to grade DF-2 of VV-F-800 (see 4.7.4).

3.4.4.1 Operating conditions. The engine horsepower rating shall be corrected to the following conditions (see 4.7.4):

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Dry air barometer	28.33 inches of mercury (Hg)
Inlet air temperature	90°F
Fuel (specific gravity .853 at 60°F)	100°F
Dry air density	.0684 lbs./cu.ft.

3.4.5 Torque. The observed torque at the engine flywheel, upon completion of the break-in run with the full rack setting, shall be not less than 885 pounds feet (lbs. ft) at 1700 rpm using diesel fuel conforming to grade DF-2 of VV-F-800 (see 4.7.5).

3.4.6 Exhaust smoke density. The exhaust smoke density, at full rack position, shall be not more than the conditions as listed in table I or table II using diesel fuel conforming to grade DF-2 of VV-F-800 (see 4.7.6).

TABLE I. Exhaust smoke density.

Engine speed (rpm)	Meter number	Visual number
1000	6	3
1400	5	3
2600	4	1

TABLE II. Visual exhaust smoke density classification.

Exhaust smoke description	Visual number
Clear	1
Haze	2
Light gray	3
Medium gray	4
Dark gray to black	5

NOTE: The meter reading number shall take precedence over the visual reading.

3.4.7 Fuel consumption. The fuel consumption of the base engine shall not exceed the limits specified in table III when operating at the full rack setting as specified in 3.4.4 using diesel fuel conforming to grade DF-2 of VV-F-800 (see 4.7.7).

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TABLE III. Maximum observed brake specific fuel consumption.

Engine speed (rpm)	Fuel consumption (lbs per bhp hour)
1400	.44
2300	.43

3.4.8 Oil consumption. The engine oil consumption shall be not more than 0.007 lbs of lubricating oil per observed bhp hour after 25 hours of operation at full rack throughout the engine power check phase (see 4.5.3.2.1) with oil sump temperatures of 180 to 260°F, using oil as specified (see 4.7.8).

3.4.8.1 Oil pressure. With the engine operating at 2300 rpm, the gallery oil pressure shall be not more than 80 pounds per square inch (psi) nor less than 35 psi, measured at the pressure sending unit, under all operating conditions specified herein, including a one quart low oil sump condition, with an oil sump temperature of not less than 180°F. The oil shall be as specified in 3.3.4 and shall be not less than five psi when engine is idling as specified in 3.4.2.1 (see 4.7.9).

3.4.9 Coolant. The engine shall perform as specified herein using water and antifreeze compound conforming to O-A-548, arctic-type antifreeze compound conforming to MIL-C-11755, or water and corrosion inhibitor compound conforming to O-I-490 (see 4.7.9).

3.4.10 Limiting operating temperature. The engine shall not exceed the following limiting temperatures when operating at full load throughout the speed range of the engine under any of the conditions specified herein (see 4.7.10):

- a. Oil sump ... 275°F (measured at the drain plug).
- b. Coolant .... 230°F (measured at coolant outlet).

3.4.11 Supercharger. The turbo supercharger shall develop an intake manifold pressure of not less than 55 inches mercury (Hg) absolute when operating at full load and 2300 rpm, using fuel conforming to grade DF-2 of VV-F-800 (see 4.7.11).

3.4.12 Endurance. The engine shall be capable of passing AEP-5 (June 1980) NATO standard engine 400 hour endurance laboratory test for diesel engines (part II) using reference fuels, lubricants and coolants. Unless otherwise specified the reference test fuel shall conform to MIL-F-46162. The 400 hour test is divided into ten hour schedules as defined in the AEP-5 document (see 4.7.12).

3.5 Environment. The engine shall start within two minutes and shall demonstrate the performance characteristics specified herein under any of the following conditions or possible combination of conditions (see 4.8).

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3.5.1 Temperature start conditions.

3.5.1.1 Low temperature start with aids. With integral cold starting aid and without external aids after being cold soaked, without benefit of solar radiation, to an ambient temperature of minus 25°F (see 4.8.1.1).

3.5.1.2 High temperature start without aids. Without external aids, with cooling fan installed, and a fuel pressure of five psi at the inlet to the fuel injector supply pumps, when operated at the following temperatures with exposure to maximum solar radiation (see 4.8.1.2):

Ambient air temperature	115°F
Intake air temperature (at air cleaner inlet)	115°F
Coolant outlet temperature	230°F
Oil sump temperature	Maximum temperature attainable up to 275°F

3.5.2 Elevation conditions. The engine shall have adequate torque and power requirements at any elevation from sea level to 8000 feet, except that the power requirements of the engine shall be reduced proportional to the elevation. At 8000 feet elevation, the observed power output of the engine shall be not less than 90 percent of rated power (see 4.8.2).

3.5.3 Humidity conditions. The engine shall perform under relative humidity conditions as low as five percent at temperature of 115°F and as high as 100 percent at all temperatures from minus 25°F to plus 85°F (see 4.8.3).

3.6 Grades and slopes. The engine shall start and demonstrate the performance characteristics specified herein when operated throughout the speed range of the engine. For not less than 30 minutes in each direction, with full and one quart low oil level conditions in the sump, on longitudinal grades or lateral slopes up to 60 percent in all directions, and, as a result of said operation, no evidence of faulty lubrication, cooling, fuel supply, leakage, or other malfunction shall be found (see 4.9).

3.7 Submersion. The engine, with intake and exhaust ducted to the atmosphere, and with the applicable crankcase fording kit installed, shall operate for a period of 30 minutes while completely submerged in either fresh or salt water, and while still submerged shall restart after being stopped for three minutes and then operated for an additional 15 minutes. At the conclusion of operation a maximum of one percent water contamination in the lubricating oil is permissible (see 4.10).

3.8 Steam and water jet cleaning. The engine and all its components shall withstand cleaning with high pressure steam using cleaner compound conforming to P-C-437 and water jet, without deterioration of seals or hoses, water leakage past seals or gaskets, or other defects. Paint removal shall not be considered a deficiency (see 4.11).

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3.9 Exterior surface treatment. All exposed exterior surfaces of the engine and its components shall be cleaned, 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 4.12).

3.10 Engine nameplate. The engine nameplate, data, and instruction plates shall conform to MIL-P-514, unless otherwise shown on the applicable drawings (see 4.13).

3.11 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 4.14).

#### 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 Materials. The contractor records shall be reviewed to determine conformance to 3.2.

4.1.2 Design and construction. To determine conformance to 3.3, parts, components and assemblies shall be inspected in accordance with applicable drawings and specifications.

4.1.3 Inspection equipment. Unless otherwise specified in the contract (see 6.2), the supplier is responsible for the provision and maintenance of all inspection equipment necessary to assure that supplies and services conform to contract requirements. Commercial, modified commercial, or supplier designed inspection equipment or measuring set-ups must be capable of repetitive measurements to an accuracy of 10 percent of the component tolerance. Calibration of inspection equipment shall be in accordance with MIL-STD-45662.

4.1.4 Physical characteristics. Conformance to 3.2 and 3.3, shall be determined by visual and tactile examination, and measurement with standard inspection equipment.



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4.2 Classification of inspection:

- a. First article inspection (see 4.4).
- b. Quality conformance inspections (see 4.5).
  - 1. Examination (see 4.5.2).
  - 2. Acceptance tests (see 4.5.3.1).
  - 3. Control tests (see 4.5.3.2).

4.3 Inspection conditions. Unless otherwise specified (see 6.2), all inspections shall be conducted under the following conditions:

- a. Air temperature  $73 \pm 18^{\circ}\text{F}$
- b. Barometric pressure  $28.5 \pm 2.0$  in Hg  
- 3.0
- c. Relative humidity  $50 \pm 30$  percent

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

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

4.4.2 Initial production inspection. Unless otherwise specified (see 6.2), the Government shall select two units, from the first ten engines produced under the production contract for initial production inspection. Initial production units shall be inspected as specified in table IV.

4.4.3 First article inspection failure. Test item deficiencies during, or as a result of, the first article test, 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 the first article test, shall be prima facie evidence that all items already produced prior to completion of the first article test 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 at no cost to the Government. The Government shall not final accept products until first article testing is completed to the satisfaction of the Government.

NOTE: Assemblies subjected to first article endurance tests shall not be delivered to the Government, but will be retained and indelibly marked, DO NOT USE.

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4.5 Quality conformance inspection.4.5.1 Sampling.

4.5.1.1 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.

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

TABLE IV. Classification of inspections.

Title	Requirement	Inspection	First article	Quality conformance	
				Acceptance (100%)	Control
Materials, design and construction	3.2 thru 3.3	4.1.1 thru 4.1.2	X		X
Engine break-in run	3.4.1	4.7.1 thru 4.7.1.2	X	X	X
Speed range	3.4.2	4.7.2	X	X	X
Idle speed	3.4.2.1	4.7.2.1	X		
Governor	3.4.3	4.7.3	X	X	X
Brake horsepower	3.4.4	4.7.4	X	X	X
Operating conditions	3.4.4.1	4.7.4	X		
Torque	3.4.5	4.7.5	X	X	X
Exhaust smoke density	3.4.6	4.7.6	X	X	X
Fuel consumption	3.4.7	4.7.7	X		X
Oil consumption	3.4.8	4.7.8	X		X
Oil pressure	3.4.8.1	4.7.8.1	X	X	X
Coolant	3.4.9	4.7.9	X		
Limiting operating temperatures	3.4.10	4.7.10	X		X
Supercharger	3.4.11	4.7.11	X		X
Endurance	3.4.12	4.7.12	X		
Environment	3.5	4.8	X		
Low temperature start with aids	3.5.1.1	4.8.1.1	X		
High temperature start without aids	3.5.1.2	4.8.1.2	X		
Elevation	3.5.2	4.8.2	X		
Humidity	3.5.3	4.8.3	X		
Grades and slopes	3.6	4.9	X		

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TABLE IV. Classification of inspections - Continued.

Title	Requirement	Inspection	First article	Quality conformance	
				Acceptance (100%)	Control
Submersion	3.7	4.10	X		
Steam and waterjet cleaning	3.8	4.11	X		
Exterior surface treatment	3.9	4.12	X		
Engine nameplate	3.10	4.13	X	X	
Workmanship	3.11	4.14	X		

4.5.2 Quality conformance examinations.

4.5.2.1 Acceptable quality level. Each sample selected in accordance with 4.5.1.2 shall be examined to determine conformance to the following acceptable quality levels (AQL) on the basis of percent defective (see 6.3).

<u>Classification</u>	<u>AQL</u>
Major	6.5
Minor	25.0

4.5.2.2 Classification of defects. For examination purposes, defects shall be classified as listed in table V.

TABLE V. Classification of defects.

Category	Defect	Method of examination
Critical	None	
<u>Major</u>	<u>AQL 6.5% Defective</u>	
101	Improper adjustment of valve tappet clearance, each valve: Intake and exhaust (see 3.3).	Gage
102	Dirt and foreign particles, in the oil sump, fuel, air, and oil filters (see 3.4.1).	Visual and functional
9 103	Leakage of fuel, oil and coolant (see 3.11).	Visual
104	Damage to fuel line (see 3.11).	Visual and functional
105	Malfunction, of governor (see 3.4.3).	Visual and functional
106	Improper torque on cylinder head bolts, intake and exhaust manifold flange bolts and vibration damper (see 3.3).	Torque wrench
107	Excessive or restrictive end play of the crankshaft (see 3.11).	Gage and functional

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TABLE V. Classification of defects - Continued.

Category	Defect	Method of examination
108	Malfunction, of engine (see 3.11).	Functional
109	Malfunction, damage or leakage of fuel system components (see 3.11).	Visual and functional
110	Malfunction and improper adjustment of fuel injection system timing and components (see 3.11).	Visual and functional
<u>Minor</u>	<u>AQL 25.0% Defective</u>	
201	Improper linkage adjustment (see 3.3).	Visual
202	Omitted minor assemblies (see 3.3).	Visual
203	Improper adjustment or installation of components (see 3.3).	Visual and functional
204	Improper assembly or installation of fuel lines, hoses, vents and shut-off valve (see 3.3).	Visual
205	Improper application of paint (see 3.9).	Visual
206	Missing engine nameplate (see 3.10).	Visual
207	Faulty workmanship, improper installation or adjustment of components (see 3.11).	Visual

4.5.3 Quality conformance tests.

4.5.3.1 Acceptance tests (100 percent). Each engine submitted shall be subjected to the tests specified in table IV.

4.5.3.2 Control tests (50 hour). A 50 hour control test shall be conducted on one engine selected at random from each lot of 100 engines produced. However, not more than two engines shall be tested in any 30 day period. If production is less than 100 engines per month or on curtailed production, one engine in every 60 day period shall be tested. The engines shall be subjected to the tests as specified in table VI after being examined for deficiencies specified in table V and shall conform to performance requirements listed in table IV. The engine shall be operated for 50 hours as near continuously as possible.

4.5.3.2.1 Power check test. The engine shall be operated according to the schedule as listed for period seven in table VI. The performance characteristics for the power check test shall be as listed under control test in table IV.

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TABLE VI. Control test schedule (50 hour).

Period	Time (hrs)	Speed (rpm)	Rack position (% of full rack)	Fuel (grade)
1 Run-in (see 4.7.1)				DF-2
2	5	1400	50	do
3	5	1800	75	do
4	5	2300	75	do
5	5	2100	100	do
6	30	2300	100	do
7 Power check (see 4.5.3.2.1)				
1		1200	100	do
2		1400	100	do
3		1800	100	do
4		2100	100	do
5		2300	100	do

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

1/ The "do" stands for "ditto".

4.5.3.3 Failure. Failure of any engine to pass any of the specified tests shall be cause for the Government to refuse acceptance of the production quantity represented, until action taken by the contractor to correct the defects and prevent recurrence has been approved by the Government.

NOTE: Any engine assembly subjected to control tests shall not be delivered to the Government as an end item of the contract until the engine has been disassembled and examined for wear and damage. Wear limits shall not exceed those specified for overhaul by the manufacturer. Scuffing, galling, or burning of parts or surfaces shall not be permitted. Subsequent to the inspection, performed above, the engine may be reassembled using all parts that meet new part drawing requirements, or replacing worn or damaged parts with new parts. Following reassembly the engine shall pass the break-in run and acceptance tests as specified herein.

#### 4.6 Methods of inspection.

4.6.1 Electrical accessories and equipment. To determine conformance to 3.3.1, verify that electrical accessories and equipment conform to the applicable engine drawings and that the manufacturer has a certificate attesting conformance of electrical components to MIL-STD-1184.

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4.6.2 Interchangeability. To determine conformance to 3.3.2, the manufacturer shall provide a certificate attesting that all parts except assemblies requiring individual select fitting components, may be installed in a like engine without modification.

4.6.3 Air cleaner. To determine conformance to 3.3.3, verify that the air cleaner capacity and design for this engine conforms to MIL-A-62048 for dry types or MIL-A-13488 for oil bath type air cleaners.

4.6.4 Oil. To determine conformance to 3.3.4, verify that the engine shall operate without damage during all testing specified herein using oil as specified. Reference grade oil required for the endurance test (see 3.4.12) shall be designated as follows:

Grade	Government designation
10	MC-1065
30	MC-1066
40	MC-1115

4.6.5 Preservation, packaging, packing and marking. To determine conformance to 5.1, preservation, packaging, packing, and marking shall be inspected in accordance with 4.1.1 and 4.1.2.

4.7 Performance. Unless otherwise specified all tests specified herein shall be conducted on an engine dynamometer.

4.7.1 Engine break-in run. In conformance with 3.4.1, each engine shall be operated through the break-in run schedule developed by the contractor. The break-in run shall be conducted on all engines prior to further testing. Any unsatisfactory operations or conditions which require correction shall be corrected by the contractor before the engine is presented for further testing.

4.7.1.1 Engine break-in run inspection. To determine conformance to 3.4.1, when specified (see 6.2) at the conclusion of the break-in run the first 10 engines, and every second engine of the next 10 of any contract, except overlapping contracts shall be disassembled and inspected by the contractor in the presence of the Government inspector. Disassembly shall be accomplished to the extent required to perform the following inspection:

- a. Oil contamination.
- b. Dirt chips or foreign matter in the engine block, oil pan, filters and accessory drive case.
- c. Main bearing bolt torque.
- d. Connecting rod bolt torque.
- e. Cylinder bore scuffing, scoring and galling.
- f. Piston scuffing and burning.

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4.7.1.2 Corrections and reassembly. To determine conformance to 3.4.1, evidence of any condition of engine or parts requiring correction, such correction shall be made by the contractor prior to reassembly of the engine and resubmission to the break-in run. In addition, the contractor shall submit objective evidence to the Government that corrective action has been taken in production to eliminate any deficiency disclosed. Failure of the contractor to submit such evidence shall be cause for refusal by the Government to continue acceptance of subsequent engines. Any engine requiring replacement parts shall be reassembled and subjected to the break-in run (see 4.7.1) and acceptance power check test (see 4.5.3.1). Any engine not requiring replacement parts shall be reassembled and subjected to the acceptance power check test only.

4.7.2 Speed range. To determine conformance to 3.4.2, verify that the engine operates satisfactorily within the speed range of 1150 to 2600 rpm, under all loads and conditions specified in 4.5.3.1.

4.7.2.1 Idle speed. To determine conformance to 3.4.2.1, verify that the range idle speed of 550 to 600 rpm is maintained using diesel fuel conforming to grade DF-2 of VV-F-800.

4.7.3 Governor. To determine conformance to 3.4.3, verify that the full load engine speed is 2275 to 2325 rpm and the no load engine speed is not less than 2450 to 2500 rpm. When a two speed governor is installed on an engine, the governor speeds during winching operations shall be not less than 1150 rpm for full load and not more than 1350 for no load. Verify in each no load case that the engine speed stabilizes within three seconds after a full rack position is reached.

4.7.4 Brake horsepower. To determine conformance to 3.4.4 and 3.4.4.1, verify that the observed brake horsepower is not less than 374 at 2300 rpm when corrected to specified operating conditions, upon completion of the engine break-in run (see 3.4.1).

4.7.5 Torque. To determine conformance to 3.4.5, verify that the observed torque measured at the engine flywheel, upon completion of the break-in run, is not less than 885 lb. ft at 1700 rpm with a full rack setting.

4.7.6 Exhaust smoke density. To determine conformance to 3.4.6, verify that the exhaust smoke density measured with a smoke meter and sampling pump or visually against a white background, within three feet of the turbocharger outlet, shall meet the conditions listed in table I or table II respectively.

4.7.7 Fuel consumption. To determine conformance to 3.4.7, verify that the fuel consumption does not exceed the limits specified in table II when operating at the specified full rack setting.

4.7.8 Oil consumption. To determine conformance to 3.4.8, verify that the oil consumption does not exceed 0.007 lbs per observed bhp hour after 25 hours of full rack operation at conditions as specified in 3.4.4 and 3.4.4.1.

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4.7.8.1 Oil pressure. To determine conformance to 3.4.8.1, verify that the engine gallery oil pressure, measured at the oil pressure sending unit, does not exceed 80 psi nor is less than 35 psi when the engine is operating at 2300 rpm with an oil sump temperature of not less than 180°F. The oil pressure when the engine is idling at 550 to 600 rpm shall be not less than five psi.

4.7.9 Coolant. To determine conformance to 3.4.9, verify that the engine meets all performance and operating temperatures (see 3.4.10) requirements when using coolants and additives that conform to O-A-548, MIL-A-11755 and O-I-490.

4.7.10 Limiting operating temperatures. To determine conformance to 3.4.10, measure engine oil sump temperature at the drain plug and the coolant temperature at the coolant outlet to verify limiting operating temperatures are not exceeded when operating at full load throughout the speed range of the engine.

4.7.11 Supercharger. To determine conformance to 3.4.11, verify that the turbo supercharger intake manifold pressure is not less than 55 inches Hg absolute when operating at full load and 2300 rpm.

4.7.12 Endurance. Verify that the engine has passed the AEP-5, NATO standard 400 hour endurance laboratory test as specified in 3.4.12.

4.8 Environment. To determine conformance to 3.5, with the engine mounted on a dynamometer, the engine shall start within two minutes and meet the performance requirements of this specification under all of the following conditions or combination of conditions.

4.8.1 Temperature start conditions.

4.8.1.1 Low temperature start with aids. To determine conformance to 3.5.1.1, the base engine with integral winterization aids shall be cold started at minus 25°F using diesel fuel in accordance with grade DF-2 of VV-F-800. Prior to start, the engines shall be cold-soaked in an ambient temperature of minus 25°F for a period of 24 hours. After each start the engine must operate for a sufficient amount of time to stabilize engine operation.

4.8.1.2 High temperature start without aids. To determine conformance to 3.5.1.2, the bare engine, without aids, shall be placed in a high temperature chamber maintained at a temperature of 115°F, and operated at full load until all temperatures are stabilized within the limits specified in 3.4.10. The engine shall then be shut down, hot soaked, and restarted when the fuel temperature at the inlet to the inspection pump reaches its maximum value. Fuel shall be supplied to the engine mounted fuel pump at a pressure of five psi. The fuel pressure shall be shut off during the hot soak period. The starting time shall not exceed two minutes.



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4.8.2 Elevation conditions. To determine conformance to 3.5.2, the engine shall be placed in a simulated environmental condition of 8000 feet elevation with a pressure of 22.2 inches Hg measured at the air cleaner outlet and exhaust outlet at a temperature of 90°F, and its general performance characteristics observed.

4.8.3 Humidity conditions. To determine conformance to 3.5.3, verify that the engine meets all performance requirements when subjected to relative humidity conditions as low as five percent at temperature of 115°F and as high as 100 percent at all temperatures from minus 25°F to plus 85°F.

4.9 Grades and slopes. To determine conformance to 3.6, the engine shall start and operate on the longitudinal grades or lateral slopes up to 60 percent in all directions for not less than 30 minutes. Verify that there is no evidence of inadequate lubrication, cooling, fuel supply, leakage or other malfunction.

4.10 Submersion. To determine conformance to 3.7, the engine shall be submerged in a tank or container of either fresh or salt water and operated for a period of 30 minutes. The air intake and exhaust systems shall be ducted to the atmosphere with an applicable crankcase fording kit. After 30 minutes of operation, and while still submerged, the engine shall be stopped for a three minute period and then restarted and operated for an additional 15 minutes. There shall be not more than one percent water contamination by volume evident in the lubricating oil at the conclusion of the test.

4.11 Steam and water jet cleaning. To determine conformance to 3.8, the engine assembly shall be steam and water jet cleaned as follows: The jet is applied perpendicular to the surface being cleaned at a distance not more than one foot from the surface for steam cleaning, and not more than five feet from the surface for water jet cleaning, and cleaned at a rate of one square foot per minute (sq. ft/min). The jet pressure shall be not less than 100 psi and not more than 110 psi. Subsequent to the cleaning operation, the engine and components shall be disassembled to the extent necessary to determine if any deterioration to seals, hose, gaskets, or driving belts exists, and to determine if any entry of water has occurred into the engine or any component. Any evidence of seals, hose gasket, or driving belt deterioration, or any sign of water entry resulting from above testing, shall be cause for rejection.

4.12 Exterior surface treatment. To determine conformance to 3.9, the engine assembly shall be examined to assure that there are no exposed bare metal surfaces, except for mating mounting surfaces. Cleaning, priming, and painting shall conform to the requirements of MIL-STD-193.

4.13 Engine nameplate. As required by 3.10, verify that nameplates, data and instruction plates shall conform to MIL-P-514.

4.14 Workmanship. The engine assembly shall be visually examined to verify that the workmanship at all phases of fabrication, assembly and test meet all specified requirements (see 3.11).

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## 5. PACKAGING

5.1 Preservation, packaging, packing, and marking. Preservation, packaging, packing, and marking for the desired level shall be in accordance with the applicable packaging standard or packaging data sheet 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 replacements for military combat and tactical vehicles.

6.2 Ordering data. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. If preproduction samples shall be furnished (see 4.4.1).
- c. If initial production units shall not be furnished (see 4.4.2).
- d. If engine break-in inspection is required.
- e. Selection of applicable levels of preservation, packaging, packing and marking (see 5.1).

6.3 Process average. Sampling may be initiated if the process average value for the first twenty engines inspected is less than the AQL specified in the classification of defects for major and minor defects.

$$\text{Process average} = \frac{\text{Number of defects}}{\text{Number of engines inspected}} \times 100$$

If the computed process average exceeds the specified AQL, 100 percent inspection shall be performed and continued until such time that the process average for twenty consecutive engines is less than the specified AQL (see 4.5.2.2).

6.4 Recycled materials. The use of recycled materials which meet the requirements of the applicable material specifications without jeopardizing the intended use of the item shall be encouraged (see 3.2).

6.5 Subject term (key word) listing.

Diesel, engine V-type 390 H.P., 8 cylinder

6.6 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:  
Army - AT

Preparing activity:  
Army - AT

(Project No. 2815-A166)