MIL-E-62290(AT)
31 August 1977
SUPERSEDING
MIL-E-62168(AT)
21 March 1973

MILITARY SPECIFICATION

ENGINE, DIESEL: 12-CYLINDER, 90 V-TYPE, 750 H.P. AVDS1790-2, AVDS1790-2A, AVDS1790-2C, AVDS1790-2D AND AVDS1790-2DR (OVERHAUL)

This specification is approved by US Army Tank-Automotive Materiel Readiness 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 establishes the performance and acceptance for five types of overhauled 12-cylinder, 90° V-type, air-cooled, 4-stroke-cycle, turbo-supercharged, internal combustion, compression-ignition (diesel) engines for use in military vehicles (see 1.2).

1.2 Classification. The five engine configurations are as follows:

Type I - AVDS1790-2 (Army No. 8725265) supplied with air-cooled generator and associated accessory drive.
Type II - AVDS1790-2A (Army No. 10912450) supplied with air-cooled generator and associated accessory drive.
Type III - AVDS1790-2C (Army No. 11682700) supplied with oil-cooled alternator and associated accessory drive.
Type IV - AVDS1790-2D (Army No. 11684000) supplied with air-cooled generator and associated accessory drive.
Type V - AVDS1790-2DR (Army No. 11684150) supplied with air-cooled generator and associated accessory drive and an auxiliary power take-off drive.

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 Materiel Readiness Command, ATTN: DRSTA-GSS, Warren, MI 48090, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

FSC 2815

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

VV-F-800	- Fuel Oil, Diesel.

MILITARY

MIL-P-514	- Plate, Identification, Instruction and Marking, Blank.
MIL-L-2104	- Lubricating Oil, Internal Combustion Engine, Tactical Service.
MIL-G-3545	- Grease, Aircraft, High Temperature.
MIL-E-13856	- Electrical Components for Automotive Vehicles, Waterproofness Tests.
MIL-R-14368	- Regulator Assembly, Relay Assembly and Voltage Regulator Assembly, 24 Volt (Nominal Rating), 100 to 400 Ampere, Direct Current.
MIL-L-21260	- Lubricating Oil, Internal Combustion Engine, Preservative and Break-in.
MIL-S-45005	- Seal, Plain and Seal, Plain Encased, Fluid Radial, Single and Multiple Lip Sealing Member.
MIL-L-46167	- Lubricating Oil, Internal Combustion Engine, Arctic.
MIL-E-46736	- Element, Air Cleaner Intake, Dry Type.
MIL-A-62048	- Air Cleaner, Automotive, Heavy Duty, Dry Type (for Internal Combustion Engines).
MIL-R-62104	- Regulator, Engine Generator, Solid State, 28 Volt, 300 Ampere, Direct Current.

STANDARDS

MILITARY

MIL-STD-130	- Identification Marking of U.S. Military Property.
MIL-STD-193	- Painting Procedure, Tactical Vehicles (Tracked and Wheeled).

DRAWINGS

ARMY

8725265 - Engine Assembly (AVDS1790-2).
10912450 - Engine Assembly (AVDS1790-2A).
11668583 - Regulator, Solid State.
11682700 - Engine Assembly (AVDS1790-2C).
11684000 - Engine Assembly (AVDS1790-2D).
11684150 - Engine Assembly (AVDS1790-2DR).
With Supplementary Quality Assurance Provisions.

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

3. REQUIREMENTS

3.1 Construction.

3.1.1 Assembly. Assembly shall be in accordance with the applicable drawings listed in 1.2. All parts requiring identification shall be identified in accordance with MIL-STD-130 and the requirements of the specific product drawings.

3.1.2 Accessories and equipment. Unless otherwise specified (see 6.2), all accessories and equipment shall be installed on the engine and properly adjusted. All electrical accessories and equipment, including wiring and electrical connections, shall conform to the applicable requirements of MIL-E-13856.

3.1.3 Greases. Where applicable, all engine greases shall comply with MIL-G-3545.

3.1.4 Oil seals. Oil seals shall conform to MIL-S-45005.

3.1.5 Interchangeability of parts. Component assemblies and parts of the engine shall be so constructed that any part, except those furnished in matched sets or for which a selection fit is specified, may be installed, replaced, and adjusted without requiring modification.

3.1.6 Materials. Materials shall be as specified herein, on applicable standards or drawings and in applicable specifications (see 6.9).

3.1.7 Interface definition.

3.1.7.1 Engine inputs. The engine shall function with external interface inputs as follows:

Fuel supply flow rate (min.)	1400 lbs./hr. at 2400 rpm
Fuel supply pressure (min.)	3.0 psi
Combustion air restriction (max.)	20 inches of water at 2000 cfm (approx.)
Intake air filter per MIL-E-46736 and MIL-A-62048	
Cooling airflow	24,000 cfm (approx.)

3.1.8 Climatic. The engine shall be suitable for operation under climatic categories 1 thru 6 as defined in appendix B.

3.2 Characteristics.

3.2.1 Performance. Engine performance must comply with the requirements stated herein.

3.2.1.1 Speed range. The engine shall operate satisfactorily under all loads and conditions as specified in 3.2.1.2.

3.2.1.2 Governor. The engine governor shall limit the engine speed as follows:

Idle	675 to 725 rpm
Maximum speed (no load)	2640 rpm
Speed (full load)	2400 to 2450 rpm
Auxiliary drive operation	1750 to 1800 rpm (AVDS1790-2DR only)

The engine speed shall stabilize within 30 seconds after full power control arm position is reached.

3.2.1.3 Gross horsepower. The engine configuration (see 6.4) shall develop not less than 735 nor more than 780 corrected gross horsepower at full power setting, when using diesel fuel as specified in 3.2.1.12 and corrected to the operating conditions of 3.2.1.11 using tables of 6.8.

3.2.1.4 Torque. Under full power control arm setting, the engine configuration (see 6.4) shall develop the following gross torques (table I) using diesel fuel as specified in 3.2.1.12 and corrected to the operating conditions of 3.2.1.11 using tables of 6.8.

TABLE I. Gross torques.

Speed - rpm	Corrected gross torque (lb.-ft.)
1800	1770 - 1842
2400	1609 - 1707

3.2.1.5 Fuel consumption. The fuel consumption of the engine configuration (see 6.4), operating at full power control arm setting, shall not exceed that shown in table II when using diesel fuel as specified in 3.2.1.12 and with the power and fuel consumption corrected to the conditions of 3.2.1.11 using tables of 6.8.

TABLE II. Fuel consumption.

Speed - rpm	Full power maximum corrected gross specific fuel consumption (lb./CGHP-hr.)
1800	.400
2400	.420

3.2.1.6 Intake manifold pressure. The intake manifold pressure at full power control arm setting, 2400 rpm, shall be 2.05 to 2.35 times the turbocharger compressor housing inlet pressure.

3.2.1.7 Exhaust smoke density. The maximum exhaust smoke density (see 6.5) at full power setting, when measured within the exhaust pipe and not more than three feet from the turbocharger exhaust outlet flange, shall not exceed the conditions shown in table III when using diesel fuel as specified in 3.2.1.12.

TABLE III. Exhaust smoke density.

Engine speed - rpm	Robert Bosch Meter No.
1800	3.5
2000	3.2
2200	2.6
2400	2.4

3.2.1.8 Oil consumption. The engine shall consume not more than .0075 maximum pounds of lubricating oil per gross horsepower per hour when operating at full power with the engine oil temperature between 140°F and 250°F, measured at the oil cooler outlet using Grade 30 oil conforming to MIL-L-2104 or MIL-L-21260, Type I.

3.2.1.9 Oil pressure. At engine speeds of 2400 rpm with an oil cooled outlet oil temperature of 140°F to 250°F, using Grade 30 oil, gallery oil pressure shall not be more than 70 psi nor less than 40 psi, measured at the pressure sending unit, and shall be not less than 15 psi when the engine is idling (see 3.2.1.2) at all oil levels ranging from the add mark to the full mark on the dipstick.

3.2.1.10 Leakage requirements.

3.2.1.10.1 Air pressure. The engine shall withstand an internal air pressure of five pounds per square inch (psig) without any indication of faulty seals and without more than a 1.75 psi pressure drop from 3.0 psig in a period of three minutes.

3.2.1.10.2 Submergence. The engine configuration (see 6.4), with intake and exhaust ducted to the atmosphere, shall operate satisfactorily for a period of 30 minutes while submerged in water to a depth of 60 inches above the cooling fans, and after said operation and while submerged, shall restart after being stopped for three minutes and shall operate satisfactorily for an additional 15 minutes. The basic engine shall operate with field excitation only to the alternator. The alternator shall operate at no load. The bare engine shall operate with the generator unloaded.

3.2.1.10.2.1 Water contamination. A maximum of 2 percent water contamination by volume in the lubricating oil is permissible after being subjected to submersion conditions as specified in 3.2.1.10.2.

3.2.1.11 Rated operating conditions. The engine rating shall be corrected to the following (using correction factor tables contained in 6.8 of this specification):

Dry air barometer	29.92 in. Hg. (abs.)
Turbocharger inlet air	60°F
Fuel temperature at the inlet of primary fuel filter	60°F

3.2.1.12 Fuels. The engine performance requirements are based on the use of diesel fuel in accordance with Grade DF-2 of VV-F-800.

3.2.1.13 Lubricating oil. The engine performance requirements are based on using lubricating oil in accordance with seasonal requirements of MIL-L-2104 for -10°F to +115°F and MIL-L-46167 for -65°F to 0°F.

3.2.1.14 Flame heater. The manifold flame heater must ignite and sustain burning within the manifold without interruption for a minimum of 15 seconds.

3.2.1.15 Break-in requirement. Each engine installed in combination with a dynamometer or other variable-loading device, shall satisfactorily operate in accordance with table IV (see 4.2.2.1 and 4.3.2.1), using diesel fuel per 3.2.1.12 and oil per 3.2.1.13, with no evidence of malfunction.

3.2.2 Physical characteristics.

3.2.2.1 Weight. The engine, including generator/alternator, shall weigh 4925 pounds maximum (dry weight).

3.2.2.2 50-hour quality control requirement. Overhauled engine samples must withstand a 50-hour quality control test as shown on table VII. Inspection of the engine sample at the conclusion of the test must show no severe degradation of engine components.

3.2.3 Environmental requirements.

3.2.3.1 Starting ability at extreme temperatures. The engine shall start within two minutes under any of the following conditions.

a. Without external aids and after being cold-soaked, without benefit of solar radiation, to an ambient temperature of -25°F. (Cold-soak shall be defined as reducing the temperature of the engine and its fuel and lubricating oil to within 5°F of the ambient air temperature surrounding the engine.)

b. After being cold-soaked to an ambient temperature of -65°F, with the authorized winterization kit preheating the cold-soaked batteries and engine oil to -25°F.

c. Without external aids and when operated at the following temperatures with exposure to maximum solar radiation:

Ambient air temperature	115°F
Oil temperature	At maximum temperature attainable up to 250°F measured at the oil cooler outlet

3.2.3.2 High temperature operations. The engine shall not exceed the following limiting temperatures when operating at full power control arm setting with a maximum air inlet temperature of 115°F, throughout the speed range (see 3.2.1.1) of the engine.

Oil temperature (measured at the oil cooler outlet)	250°F
Exhaust gas temperature (measured at individual cylinder ports)	1250°F

3.2.3.3 Humidity conditions. The engine shall operate under relative humidity conditions as low as 5 percent at a temperature of 115°F and as high as 100 percent at all temperatures from -25°F to 85°F.

3.2.3.4 Elevation. The engine shall be capable of operation at the pressure and temperature corresponding to the altitude of 8000 feet. At simulated elevation of 8000 feet, the observed power of the engine shall be not less than 75 percent of rated power.

3.2.3.5 Grades and slopes. The engine shall perform satisfactorily on longitudinal grades up to 60 percent and on lateral slopes up to 36 percent for not less than 30 minutes in each position and, as a result of said operation, there shall be no evidence of faulty lubrication, cooling, fuel supply, or leakage.

3.3 Name plates. Overhaul data plates shall conform to MIL-P-514.

3.4 Workmanship. Manufacturing techniques shall not cause the degradation of inherent engine reliability and durability.

3.5 Protective coatings. Exposed exterior surfaces of the engine and its components, except the turbocharger compressor housing and the fuel injection pump aluminum parts, shall be cleaned, painted or treated for corrosion resistance as specified on the applicable drawings in accordance with the applicable provisions of MIL-STD-193.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, 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 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 Contractor's quality assurance system. The contractor shall provide and maintain an effective inspection and quality assurance system acceptable to the Government covering the supplies under the contract. A current written description of the system shall be submitted to the contracting officer prior to initiation of overhaul. The contractor will not be restricted to the inspection station or to the method of inspection listed provided that an equivalent control is included in the approved quality assurance procedure. The contractor shall notify the Government and obtain approval for any change to the written procedure that might affect the degree of assurance required by this specification or other applicable documents referenced herein.

4.1.2 Documentation. Inspection records of all examinations and tests shall be kept complete and available to the Government as contractually specified.

4.1.3 Government verification. All quality assurance operations performed by the contractor will be subjected to Government verification at scheduled intervals. Verification will consist of (a) surveillance of operations to determine that practices, methods, and procedures are being properly applied; and (b) Government product inspection to measure quality of products offered for acceptance. Deviation from the prescribed procedures or instances of poor practices which might have an effect upon the quality of the product will be immediately called to the attention of the contractor. Failure of the contractor to promptly correct deficiencies discovered shall be cause for suspension of acceptance until corrective action has been taken or until conformance of the product to prescribed criteria has been demonstrated.

4.2 Special test and examination.

4.2.1 Initial overhaul qualification. Unless otherwise specified (see 6.2), the procuring activity shall select one sample from the first ten produced under an overhaul contract. The contractor shall inspect this item for conformance to all requirements listed in table V. Once verification and validation of compliance with these requirements has been accomplished, quality conformance inspection of the remainder of the overhaul contract shall be as specified (see 4.1).

4.2.1.1 Initial overhaul failure. Failure of an initial overhaul item during or as a result of initial overhaul inspection shall be cause for rejection of the item. Further, the procuring activity shall refuse acceptance of overhauled items until evidence of corrective action is provided.

4.2.2 Qualification performance inspection.

4.2.2.1 Break-in. Each sample selected for test per 4.2.1 shall first receive a break-in per table IV.

TABLE IV. Break-in schedule.

Run no.	Time (min.)	Rpm	Torque (lb. ft.)
1	10	700	Warm up
2	15	1000	85
3	15	1400	440
4	20	1800	837
5	20	2200	1024
6	20	2400	1092
7	30	2400	1202
8	30	2400	Full power control arm setting

Bare engine shall operate without generator.
Basic engine shall operate with alternator and field excitation only.

Check for low idle at 675-725 rpm - adjust if necessary.
Visually inspect for air, exhaust, oil and fuel leaks.

Check governor high idle speed. This shall not exceed 2640 rpm (no load - water off). If adjustment is required, recheck horsepower at 2400 rpm and full power control arm setting.
Governor must be resealed after adjustment.

TABLE IV. Break-in schedule. - Continued

Run no.	Time (min.)	Rpm	Torque (lb. ft.)
9	5	2400	Full power control arm setting
10	5	2200	Full power control arm setting
11	5	2000	Full power control arm setting
12	5	1800	Full power control arm setting
Borescope inspect cylinders, pistons, and valves.			

4.2.2.1.1 Data acquisition. During the break-in, full power control arm setting, torque and horsepower curves shall be produced from readings taken at engine speeds of 1800 thru 2400 rpm. The following data shall be recorded on appropriate log sheets (see 6.2).

Full power control arm setting governed speed	(ref. 4.2.2.2.2)
Minimum power control arm setting governed speed	(ref. 4.2.2.2.2)
Speed range	(ref. 4.2.2.2.1)
Gross horsepower	(ref. 4.2.2.2.3)
Gross torque	(ref. 4.2.2.2.4)
Fuel consumption	(ref. 4.2.2.2.5)
Exhaust smoke density	(ref. 4.2.2.2.6)
Oil pressure	(ref. 4.2.2.2.7)
Oil temperature	(ref. 4.2.2.2.7)
Oil consumption	(ref. 4.2.2.1.2)

4.2.2.1.2 Oil consumption test. During break-in period no. 8 of table IV, record the oil consumption. On the initial overhaul test only, extend the time period to 120 minutes to insure stable oil consumption data prior to the test (see 3.2.1.8).

4.2.2.1.3 Inspection during break-in. The following characteristics shall be inspected during the break-in:

Characteristics	Defects	Examination Method
a. Linkage	Improperly adjusted	Visual
b. Completeness	Missing or loose parts or assemblies	Visual
c. Improper painting	Spots missed, sags, or runs	Visual
d. Workmanship	Not following good practice, improper installation of components	Visual

e.	Borescope inspect	Cracked, broken, or scuffed components	Visual
f.	Leakage	Gaskets and seals	Visual

As a minimal level of inspection acceptance, fluid loss to the degree defined as "droplet" (see 6.6) will be allowed on all components.

4.2.2.1.4 Failure. Failure of the engine to pass any inspection or test outlined in 4.2.2 shall be cause for refusal by the Government to accept subsequent engines until corrective measures, satisfactory to the Government, have been taken.

4.2.2.2 Performance tests. The following performance tests shall be run separately or as part of the break-in per 4.2.2.1. The tests shall be run at the rated operating conditions of 3.2.1.11 with diesel fuel per 3.2.1.12 and oil per 3.2.1.13.

4.2.2.2.1 Speed range. Operate the engine to demonstrate satisfactory performance over the speed range as specified in 3.2.1.2.

4.2.2.2.2 Governor. Demonstrate full power rpm, high idle rpm, and low idle rpm operation of the bare engine. On AVDS1790-2DR engine, check auxiliary drive operation for required rpm.

4.2.2.2.3 Gross horsepower. Operate engine at 2400 to 2450 rpm and full power control arm setting. Determine and record the corrected gross horsepower.

4.2.2.2.4 Torque. With a full power control arm setting, operate the engine at 1800 and 2400 rpm. Determine and record the corrected gross torque.

4.2.2.2.5 Fuel consumption. Operate the engine at full power control arm setting to determine the fuel consumption.

4.2.2.2.6 Exhaust smoke density. Measure exhaust smoke density at full power setting at engine speeds of 1800, 2000, 2200, and 2400 rpm.

4.2.2.2.7 Oil pressure and temperature. Operate the engine at 2400 rpm with oil cooler outlet temperatures of 140°F and 250°F, and measure the gallery oil pressure.

4.2.2.2.8 Engine leakage check. Close all engine configuration (see 6.4) openings to ambient with appropriate plugs and covers. Provide a port for applying air pressure into the engine crankcase with a gage and a shut-off valve. Apply pressure at 5 psig to the engine and check all joints, seals, etc., for leaks by applying liquid soap.

4.2.2.2.8.1 Pressure drop. Using the setup in 4.2.2.2.8, apply a pressure of 3 psig to the engine and shut off the air and determine the drop in pressure over a 3-minute period.

4.2.2.2.9 Submersion. Operate the engine with intake and exhaust ducted to the atmosphere for a period of 30 minutes while submerged to a depth of 60 inches above the cooling fans in either fresh or sea water (4 percent by volume salinity). After this operation and while it is submerged, restart the engine after being stopped for three minutes and operate it for an additional 15 minutes.

TABLE V. Qualification inspection applied to each sample.

Requirement paragraph no.	Requirement description	Test/ examination paragraph no.	Initial overhaul sample
3.2.1.1	Speed range	4.2.2.2.1	X
3.2.1.2	Governor	4.2.2.2.2	X
3.2.1.3	Gross horsepower	4.2.2.2.3	X
3.2.1.4	Torque	4.2.2.2.4	X
3.2.1.5	Fuel consumption	4.2.2.2.5	X
3.2.1.7	Exhaust smoke density	4.2.2.2.6	X
3.2.1.8	Oil consumption	4.2.2.1.2	X
3.2.1.9	Oil pressure	4.2.2.2.7	X
3.2.1.10.1	Air pressure	4.2.2.2.8	X
3.2.1.10.1	Air leakage	4.2.2.2.8.1	X
3.2.1.10.2	Submergence	4.2.2.2.9	X
3.2.1.10.2.1	Water contamination	4.2.2.2.9.1	X
3.2.1.14	Flame heater	4.2.2.2.10	X
3.2.1.15	Break-in	4.2.2.1	X
3.2.2.1	Weight	4.2.3.1	X
3.2.3.1	Starting at extreme temperatures	4.2.4.1	
3.2.3.2	High temperature operation	4.2.4.2	
3.2.3.3	Humidity conditions		
3.2.3.4	Elevation	4.2.4.3	
3.2.3.5	Grades and slopes	4.2.4.4	
3.1.6	Materials		
3.1.3	Greases		
3.1.4	Oil seals		
3.1.1	Product marking	4.2.5.1	
3.3	Name plates	4.2.5.1	X
3.4	Workmanship	4.2.5.2	X
3.1.5	Interchangeability of parts		
3.5	Protective coatings		

TABLE VI. Category of inspections.

Requirement paragraph no.	Requirement description	Quality conformance	
		Acceptance methods (100%)	Quality control test methods (1/50)
3.2.1.1	Speed range	4.3.2.2.1	
3.2.1.2	Governor	4.3.2.2.2	
3.2.1.3	Gross horsepower	4.3.2.2.3	
3.2.1.4	Torque	4.3.2.2.4	
3.2.1.5	Fuel consumption	4.3.2.2.5	
3.2.1.7	Exhaust smoke density	4.3.2.2.6	
3.2.1.8	Oil consumption	4.3.2.2.7	4.3.3.1.6
3.2.1.9	Oil pressure	4.3.2.2.8	
3.2.1.10.1	Air pressure	4.3.2.2.9	
3.2.1.10.1	Air leakage	4.3.2.2.10	
3.2.1.10.2	Submergence		4.3.3.1.5
3.2.1.14	Flame heater	4.3.2.2.11	
3.2.1.15	Break-in	4.3.2.1	
3.2.2.2	Quality control test		4.3.3.1
3.2.2.2	Inspection		4.3.3.1.7
3.1.1	Product marking	4.3.4.1	4.3.4.1
3.3	Name plates	4.3.4.1	4.3.4.1
3.4	Workmanship	4.3.4.2	4.3.4.2

4.2.2.2.9.1 Water contamination. Measure water contamination in the lubricating oil after being subjected to submersion conditions.

4.2.2.2.10 Flame heater test. Check the operation of the flame heaters of all engines by cranking the engine and energizing the flame heater.

4.2.3 Physical characteristics.

4.2.3.1 Weight. Weigh the dry engine, including generator/alternator.

4.2.4 Environmental tests.

4.2.4.1 Cold-soak starting test. Cold-soak the engine, its fuel, and its lubricant to -25°F. Then, without external aids and without benefit of solar radiation, start the engine.

4.2.4.2 High temperature test. The engine configuration (see 6.4) shall be run under full power control arm setting until the engine cooler outlet oil temperature is stabilized at 250°F maximum or the highest stabilized temperature obtainable in an ambient air temperature of 105°F to 115°F. Shut engine down. After the engine is completely at rest, restart the engine. Measure exhaust gas temperature at each cylinder port.

4.2.4.3 Elevation test. The engine configuration (see 6.4) shall be operated at a range of simulated barometric pressures and ambient temperatures to demonstrate general performance and 75 percent rated power at altitude. Barometric pressure to be used in altitude tests shall be as follows:

Elevation - feet	Pressure - inches of mercury	Temperature - °F
3000	26.?	115
4000	25.8	108
5000	24.9	100
6000	24.0	97
7000	23.1	93
8000	22.2	90

4.2.4.4 Grade and slope test. Operate the engine configuration (see 6.4) for not less than 30 minutes in each position of forward and backward inclinations at 50 percent and of left and right inclinations at 36 percent.

4.2.5 Design and construction.

4.2.5.1 Identification and marking. The engine shall be examined for identification and marking as specified.

4.2.5.2 Workmanship. Workmanship examinations shall be performed on each engine at all phases of inspection testing.

4.3 Quality conformance inspection.

4.3.1 Quality conformance inspection. Each engine configuration (see 6.4) shall be test run for break-in and final acceptance with appropriate measurements and data acquisition to make certain all deliverable engines are serviceable and meet the requirements of table VI. Fuels and lubricants utilized for performance tests listed herein must comply with 3.2.1.12 and 3.2.1.13.

4.3.2 Performance inspection.

4.3.2.1 Break-in. Each production engine shall receive a break-in on an engine dynamometer test stand in accordance with the schedule in table IV and per 4.2.2.1.

4.3.2.2 Performance tests. The following performance tests shall be run separately or as part of the break-in per 4.3.2.1. The test shall be run at the rated operating conditions of 3.2.1.11 with diesel fuel per 3.2.1.12 and lubricating oil per 3.2.1.13.

4.3.2.2.1 Speed range. Operate the engine configuration (see 6.4) to demonstrate satisfactory performance over the speed range as specified in 3.2.1.2.

4.3.2.2.2 Governor. Demonstrate full load rpm, high idle rpm, and low idle rpm operation of the engine configuration (see 6.4). On AVDS1790-2DR engine, check auxiliary drive operation for required rpm.

4.3.2.2.3 Gross horsepower. Operate engine configuration (see 6.4) at 2400 to 2450 rpm and full power control arm setting. Determine and record the corrected gross horsepower.

4.3.2.2.4 Torque. With a full power control arm setting, operate the engine at 1800 and 2400 rpm. Determine and record the corrected gross torque.

4.3.2.2.5 Fuel consumption. Operate the engine configuration (see 6.4) at full power control arm setting under full load to determine the fuel consumption.

4.3.2.2.6 Exhaust smoke density. Measure exhaust smoke density at full power setting at engine speeds of 1800, 2000, 2200 and 2400 rpm.

4.3.2.2.7 Oil consumption test. During break-in period no. 8 of table IV, paragraph 4.2.2.1 being run per paragraph 4.3.2.1, record the engine oil consumption.

4.3.2.2.8 Oil pressure and temperature. Operate the engine at 2400 rpm with oil cooler outlet temperature of 140°F and 250°F and measure the gallery oil pressure.

4.3.2.2.9 Engine leakage check. Close all engine openings to ambient with appropriate plugs and covers. Provide a port for applying air pressure into the engine crankcase with a gage and shut-off valve. Apply pressure at 5 psig to the engine and check all joints, seals, etc., for leaks by applying liquid soap.

4.3.2.2.10 Air pressure drop test. Each engine shall withstand application of 3 psi internal air pressure to the engine crankcase chamber. The pressure drop and leak rate shall be measured.

4.3.2.2.11 Flame heater test. At the conclusion of the break-in per 4.3.2.1, the operation of the flame heater on every engine shall be tested by cranking the engine and energizing the flame heater.

4.3.3 Physical characteristics.

4.3.3.1 Quality control test (50 hours). A 50-hour quality control test shall be conducted as shown on table VII.

4.3.3.1.1 Selection of test sample for quality control test. Engines shall be selected at the rate of one per month when production exceeds 100 per month, or one in every 100 engines when production is below 100 units per month, or on curtailed production, at least one every 60 days. Test engines shall be identified as to production period and examined for defects.

4.3.3.1.2 Settings and adjustments. After initial warm-up, and with engine temperature stabilized, all deviant settings shall be reset before test run is begun.

4.3.3.1.3 50-hour quality control test schedule. Each engine, except the AVDS1790-2C, selected in accordance with 4.3.3.1.1, shall be operated as specified in table VII for 50 hours. For the AVDS1790-2C engine, the even numbered runs will use a control arm power setting of "AS REQUIRED" in place of "MINIMUM" and an engine speed of 900-925 rpm in place of 700 rpm.

4.3.3.1.4 Test documentation. Data listed in table VIII shall be obtained under stabilized operating conditions, with engine coupled to a dynamometer or other power absorption device. Warm-up, starting and stopping times shall be recorded. However, running time of less than 30 minutes shall not be counted toward fulfillment of test run hours. Data shall be recorded at a minimum of one hour intervals during the test, except barometric pressure and wet and dry bulb temperatures (see 6.7).

TABLE VII. 50-hour quality control test.

Run no.	Time	Control arm power setting	Engine speed
1	60 min.	1/2 1/	2000 rpm
2	30 min.	Minimum	700 rpm
3	40 min.	Full	2400 rpm
4	30 min.	Minimum	700 rpm
5	120 min.	1/2 1/	2000 rpm
6	30 min.	Minimum	700 rpm
7	120 min.	Full	2400 rpm
8	60 min.	Minimum	700 rpm
9	300 min.	Full	2400 rpm
10	60 min.	Minimum	700 rpm
11	300 min.	Full	2400 rpm
12	60 min.	Minimum	700 rpm
13	300 min.	Full	2400 rpm
14	60 min.	Minimum	700 rpm
15	300 min.	Full	2400 rpm
16	60 min.	Minimum	700 rpm
17	300 min.	Full	2400 rpm
18	60 min.	Minimum	700 rpm
19	300 min.	Full	2400 rpm
20	60 min.	Minimum	700 rpm
21	300 min.	Full	2400 rpm

1/ 1/2 of the full power control arm setting gross horsepower at 2000 rpm.

Bare engine with generator installed shall be operated with 100 ± 10 amperes external generator load throughout test.

Basic engine shall be operated with 50 ± 10 amperes external generator (alternator) load throughout test.

TABLE VIII. Test documentation.

a. Engine speed, rpm
b. Engine power, ghp
c. Intake manifold pressure, in. Hg.
d. Exhaust manifold pressure, in. Hg.
e. Lubricating oil pressure (gallery), psi
f. Crankcase pressure, inches of water
g. Lubricating oil temperature, °F (sump)
h. Blowby, cfm
i. Fuel flow, lbs./hr.
j. Fuel pressure after secondary filters
k. Fuel temperature at primary fuel filter inlet, °F
l. Fuel temperature at injector pump, °F
m. Test cell ambient air temperature
n. Specified oil consumption, lbs./ghp-hr. (see 4.3.3.1.6)
o. Barometric pressure of test cell
p. Exhaust smoke density
q. Air temperature at turbocharger inlet, °F
r. Air pressure at turbocharger inlet
s. Generator/alternator, volts and amps

4.3.3.1.5 Submergence test. Each 50-hour quality control test engine shall be tested per 4.2.2.2.9.

4.3.3.1.6 Oil consumption. During run no. 21 of the 50-hour quality control test (table VII), measure and record the engine oil consumption (see 3.2.1.8).

4.3.3.1.7 Inspection. Engines subjected to this 50-hour test shall be completely disassembled and all parts subjected to wear or stress shall be inspected. A complete report, including the inspection and testing of the engine, shall be submitted to the Government for inspection and a copy to the contracting officer. Engines subjected to this test shall be reassembled, with new parts replacing those found unsatisfactory during inspection, and disposed of in accordance with 6.3.

4.3.3.1.8 Failure. Failure of a control sample to meet these specified inspections shall be considered cause to reject subsequent units until deficiencies that caused this failure are corrected and proven by test. Control inspection verification for these units shall be limited to those parameters directly related to the failure cause and those parameters affected by the corrective action taken.

4.3.4 Design and construction tests.

4.3.4.1 Identification and marking. The engine shall be examined for identification and marking as specified.

4.3.4.2 Workmanship. Workmanship examinations shall be performed on each engine at all phases of inspection testing.

5. PACKAGING

5.1 Preservation, packaging, packing and marking for spares only. Preservation, packaging, packing and marking for spares shall be in accordance with the applicable packaging data sheet specified by the procuring activity (see 6.2).

6. NOTES

6.1 Intended uses. The overhauled AVDS1790 engines, as classified in 1.2, are to be used as spares, or as replacements in military combat and tactical transport vehicles.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification.
b. Whether all accessories and equipment shall be installed on engines and adjusted (see 3.1.2).
c. Whether initial overhaul qualification inspection shall be waived (see 4.2.1)
d. Type of log sheet to record acquisition data (see 4.2.2.1.1).
e. Selection of applicable levels of preservation, packaging and packing of the referenced specification (see 5.1).

6.3 Disposition of test engines. All 50-hour quality control test engines (see 4.3.3.1.3), after correcting all defects disclosed by such tests, are to be run for a power curve per points 9, 10, 11 and 12 on table IV (see 4.2.2.1) plus tests per 4.2.2.1.2. If found acceptable, these engines are to be shipped as regular overhauled engines.

6.4 Engine configuration.

a. Bare engine. The term "bare engine" is defined as a -2, -2A, -2D or -2DR engine without air cleaners, mufflers, or generator and less all other power consuming accessories not considered essential for the operation of the engine.

b. Basic engine. The term "basic engine" is defined as a -2C engine without air cleaners and mufflers, but with a generator (alternator), operated with field excitation and minimum external electrical load. In addition, no other power consuming accessories not considered essential for the operation of the engine are included.

c. All -2, -2A, -2D and -2DR engine testing is to be done with the "bare engine" unless otherwise specified.

d. All -2C engine testing is to be done with the "basic engine" unless otherwise specified.

e. Testing of the "bare engine" with external electrical loading when specified, shall be performed with a MIL-R-14368 or a MIL-R-62104 regulator in the generator electrical circuit.

f. All testing of the "basic engine", with or without electrical loading, shall be performed with a regulator conforming to drawing 11668583 in the generator electrical circuit.

6.5 Exhaust smoke measurement. A Robert Bosch Model EFAW 68 Smoke Meter or equal (as approved by responsible engineering activity), and a Model EFAW 65 Sampling Pump or equal (as approved by responsible engineering activity), have been found satisfactory in determining the degree of smoke density. The following table may be used to visually define the degree of exhaust smoke density in lieu of the smoke meter.

Description of exhaust smoke	Classification
Clear	1
Haze	2
Light gray	3
Medium gray	4
Dark gray to black	5

NOTE: Observation of exhaust smoke should be made against a white background within three feet of the exhaust outlet (see 3.2.1.7).

6.6 Classification of leakage defects. The following definitions shall be used for the classification of defects for leakage:

a. Weep - Slight loss of fluid which causes staining of discoloration of surfaces (usually dry to the touch).

b. Seep - Any recurring evidences of fluid that does not result in the formation of a droplet (usually moist to the touch).

c. Droplet - Loss of fluid which forms no more than one drop per hour.

d. Leak - Loss of fluid which forms more than one drop per hour.

The term "drop" is defined as a volume of fluid equal to .05 cubic centimeter.

6.7 Record of atmospheric conditions. The following data shall be recorded at two hour intervals when any power test for full load, full power control arm setting is being conducted.

a. Barometer pressure, in. Hg.
b. Temperature, wet and dry bulb, ^{o}F

6.8 Correction factors for engine characteristics. Formulas and pertinent tables are provided in appendix A for calculating and reporting the following:

a. Corrected gross horsepower
b. Corrected gross specific fuel consumption
c. Gross specific oil consumption

6.9 Recycled materials. The use of recycled materials which meet the requirements of the applicable material specification without jeopardizing the intended use of the item shall be encouraged (see 3.1.6).

Custodian:
Army - AT

Preparing activity:
Army - AT

Project No. 2815-A135

APPENDIX A

ENGINE CORRECTION FACTORS

Horsepower will be corrected to 60°F and 29.92 inches Hg absolute barometric pressure using the following formulae:

Corrected Net HP = Observed BHP x CF_p x CF_t x CF_f

Corrected Gross HP = Observed BHP x CF_p x CF_t x CF_f + Fan Horsepower

Where:

Observed BHP = $\frac{2\pi LNW}{33000} = \frac{LNW}{5252}$

L = Length of torque arm in feet

N = Rpm of dynamometer shaft

W = Force in lbs. at length L

When the length of the beam arm is 1.75 feet and the scale has a constant of 3, the formula becomes:

Observed BHP = $\frac{LNW}{5252} = \frac{(1.75 \times 3)}{5252} \quad NW = \frac{Beam \times Rpm}{1000}$

Where:

Observed BHP = $\frac{Speed(rpm) \times Scale\ units(beam)}{1000}$

CF_t = Temperature correction factor at the turbocharger inlet, table I

CF_p = Barometric pressure correction factor at the turbocharger inlet, table II

CF_f = Temperature correction factor for the fuel at the primary filter inlet, table III

Cooling fan horsepower - table IV
Alternator horsepower - table V
Generator horsepower - table VI

Corrected Gross Specific Fuel Consumption shall be calculated as follows:

$$\text{Corr. GSFC} = \frac{\text{Observed fuel flow(lbs./hr.)}}{\text{Corrected Gross HP}}$$

Gross Specific Oil Consumption shall be calculated as follows:

$$\text{Gross SOC} = \frac{\text{Oil consumption(lbs./hr.)}}{\text{Corrected Gross HP}}$$

TABLE I. Air entrance temperature correction.

Temp. F	Corr.	Temp. F	Corr.	Temp. F	Corr.
60	1.00000	80	1.01100	100	1.02200
61	1.00055	81	1.01155	101	1.02255
62	1.00110	82	1.01210	102	1.02310
63	1.00165	83	1.01265	103	1.02365
64	1.00220	84	1.01320	104	1.02420
65	1.00275	85	1.01375	105	1.02475
66	1.00330	86	1.01430	106	1.02530
67	1.00385	87	1.01485	107	1.02585
68	1.00440	88	1.01540	108	1.02640
69	1.00495	89	1.01595	109	1.02695
70	1.00550	90	1.01650	110	1.02750
71	1.00605	91	1.01705	111	1.02805
72	1.00660	92	1.01760	112	1.02860
73	1.00715	93	1.01815	113	1.02915
74	1.00770	94	1.01870	114	1.02970
75	1.00825	95	1.01925	115	1.03025
76	1.00880	96	1.01980	116	1.03080
77	1.00935	97	1.02035	117	1.03135
78	1.00990	98	1.02090	118	1.03190
79	1.01045	99	1.02145	119	1.03245

TABLE II. Air entrance pressure correction.
(Static pressure as measured in 6 inch diameter tube within 3 inches of compressor inlet.)

In. Hg-abs.	Corr.	In. Hg-abs.	Corr.
29.02	1.0000	28.95	1.0114
29.00	1.0003	28.90	1.0120
29.85	1.0009	28.85	1.0126
29.80	1.0015	28.80	1.0132
29.75	1.0021	28.75	1.0137
29.70	1.0027	28.70	1.0143
29.65	1.0032	28.65	1.0149
29.60	1.0038	28.60	1.0155
29.55	1.0044	28.55	1.0161
29.50	1.0050	28.50	1.0167
29.45	1.0056	28.45	1.0173
29.40	1.0062	28.40	1.0178
29.35	1.0067	28.35	1.0184
29.30	1.0073	28.30	1.0190
29.25	1.0079	28.25	1.0196
29.20	1.0085	28.20	1.0202
29.15	1.0091	28.15	1.0207
29.10	1.0097	28.10	1.0213
29.05	1.0102	28.05	1.0219
29.00	1.0103	28.00	1.0225

TABLE III. Fuel temperature correction.

Temp. °F	Corr.	Temp. °F	Corr.
60	1.000	86	1.026
61	1.001	87	1.027
62	1.002	88	1.028
63	1.003	89	1.029
64	1.004	90	1.030
65	1.005	91	1.031
66	1.006	92	1.032
67	1.007	93	1.033
68	1.008	94	1.034
69	1.009	95	1.035
70	1.010	96	1.036
71	1.011	97	1.037
72	1.012	98	1.038
73	1.013	99	1.039
74	1.014	100	1.040
75	1.015	101	1.041
76	1.016	102	1.042
77	1.017	103	1.043
78	1.018	104	1.044
79	1.019	105	1.045
80	1.020	106	1.046
81	1.021	107	1.047
82	1.022	108	1.048
83	1.023	109	1.049
84	1.024	110	1.050
85	1.025		

TABLE IV. Fan horsepower to be used for correcting engine gross horsepower.

Rpm	HP
2520	125.0
2400	108.0
2200	83.2
2000	62.5
1800	45.6
1600	32.0
1400	21.4
1200	13.5
1000	7.8
900	5.7

TABLE V. Alternator horsepower to be used for correcting engine gross horsepower for Type III engine configuration (see 1.2).

Alternator output at 27-31 VDC	HP correction to engine load
290-310 amperes	15
390-410 amperes	20
490-510 amperes	25
650 amperes	32

TABLE VI. Generator horsepower to be used for correcting engine gross horsepower for Types I, II, IV and V engine configurations (see 1.2).

Generator output at 27-31 VDC	HP correction to engine load
90-110 amperes	5.8
190-210 amperes	11.6
290-310 amperes	17.3

APPENDIX B

CLIMATIC CONDITIONS

1. Wet-warm. Wet-warm conditions are found under the canopy of heavily forested tropical areas. In part of the area, these conditions may occur on several days during any month of the year (non-seasonal), and in the rest of the area, these conditions may occur seasonally, but on several days in at least four months of the year.

2. Wet-hot. Wet-hot conditions, characterized by high temperatures accompanied by high humidities and intense solar radiation, are found in the open in tropical areas. These are the same general areas where wet-warm conditions are found, but in the open rather than under the forest canopy. In part of the area, wet-hot conditions may be experienced during any month of the year, while in the rest of the area these conditions occur seasonally, but in at least four months of the year. Wet-hot conditions may be experienced at higher latitudes outside of the area designated as wet-hot, but only for short periods in a season of three months or less.

3. Humid-hot coastal desert. Humid-hot conditions are limited to the immediate coast of bodies of water having a high surface temperature (i.e., the Persian Gulf and the Red Sea). These areas experience the highest water vapor amount associated with air near the ground reported anywhere in the world.

4. Hot-dry. Hot-dry conditions are found in the deserts of Northern Africa, the Middle East, West Pakistan and India, Southwest United States, and Northern Mexico and Australia.

5. Intermediate hot-dry. Intermediate hot-dry conditions are found throughout the world extending outward from the areas of hot-dry conditions in the United States, Mexico, Africa, Asia and Australia. Also, they are found in Southern Africa, South America, Southern Spain, and in Southern Asia during the dry seasons in the areas of seasonal wet-hot conditions.

6. Intermediate cold. Intermediate cold conditions are found only in the Northern Hemisphere in mid-latitudes south of the coldest areas, and on high latitude coasts (i.e., the southern coast of Alaska) where Maritime effects prevent occurrence of very low temperatures.

7. The temperatures for each of the above climatic conditions are depicted in table I.

TABLE I. Temperatures for climatic conditions.

Climatic category	Operational conditions		Storage and transit conditions	
	Ambient air temperature °F	Ambient relative humidity %	Induced air temperature °F	Induced relative humidity %
1 Wet-warm	Nearly constant 75	95 to 100	Nearly constant 80	95 to 100
2 Wet-hot	78 to 95	74 to 100	90 to 160	10 to 85
3 Humid-hot coastal desert	85 to 100	63 to 90	90 to 160	10 to 85
4 Hot-dry	90 to 115	5 to 20	90 to 160	2 to 50
5 Intermediate hot-dry	70 to 110	20 to 85	70 to 145	5 to 50
6 Intermediate cold	-5 to -25	Tending toward saturation	-10 to -30	Tending toward saturation

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