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AEROSPACE STANDARD

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Engines, Aircraft, Reciprocating, General Specification For

FSC 2810

RATIONALE

AS25109 has been reaffirmed to comply with the SAE five-year review policy.

NOTICE

This document has been taken directly from U.S. Military Specification MIL-E-25109(ASG), Notice-1, Notice-2 and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-E-25109(ASG), Notice-1, Notice-2. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

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1. SCOPE:

1.1 Scope:

This specification covers standard requirements for reciprocating aircraft engines.

1.2 Classification:

The type and model designation will be assigned by the Government in accordance with ANA Bulletin No. 395 and shall be specified in the model specification.

2. APPLICABLE DOCUMENTS:

2.1 The applicable publications listed in the following bulletin, of the issue of the bulletin in effect on date of invitation for proposals, form a part of this specification:

PUBLICATIONS

Air Force-Navy Aeronautical Bulletin

No. 343 Specifications and Standards Applicable to Aircraft Engines and Propellers, Use of

(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 Model specification:

A reciprocating engine model specification conforming to Specification MIL-E-25110 shall be submitted by the engine manufacturer for approval.

3.2 Mockup:

Unless otherwise specified in the model specification, a full scale mockup shall be prepared for examination as soon as the contractor has established the installation features of the engine. After the engine mockup has been approved, the engine installation drawing shall be forwarded to the using service for approval. Any changes required by the using service shall be subject to negotiation as provided in the contract.

3.2.1 Installation changes: Changes to the engine features requiring changes in the airplane or propeller installation made after approval of the mockup shall be submitted to the using service for approval. The mockup shall be kept current with approved changes, at least through the first production contract, unless otherwise authorized.

3.3 Performance characteristics:

The engine performance characteristics shall be specified in the model specification. These performance characteristics shall be determined using fuel in conformance with Specification MIL-F-5572; alcohol in conformance with Specification MIL-A-6091 or O-M-232, if water-alcohol injection is required; and oil in conformance with Specification MIL-L-6082 of a grade as specified in the model specification.

3.3.1 Ratings: The performance ratings shall be specified in the model specification.

3.3.2 Estimates: The estimated performance shall be specified in the model specification.

3.3.3 Specific oil consumption: The specific oil consumption shall not exceed the amount specified in the model specification.

3.3.4 Altitude operating limits: The engine altitude operating limits shall be defined in the model specification.

3.3.5 Ambient temperature conditions: The complete engine shall perform satisfactorily under the following conditions.

3.3.5.1 High and low temperature: The engine shall suffer no detrimental effects and shall start successfully after being subjected to:

(a) A soaking period of 8 hours at an ambient temperature of 160°F when supplied with fuel at 110°F and inlet air at 130°F.

(b) A soaking period of 72 hours at an ambient temperature of -65°F when supplied with fuel and air at -65°F.

3.3.5.2 Airspeed and altitude: The engine shall operate satisfactorily within the ambient air temperature ranges shown on figure 1 throughout the airspeed and altitude operating limits specified in the model specification.

3.3.6 Engine starting: The engine shall consistently start when its temperature is stabilized at an ambient temperature of -65°F when cranked through the starter dog at a speed of 40 ±5 rpm for a period not to exceed 60 seconds. Starting shall be accomplished with lubricating oil so diluted with fuel that the viscosity of the oil is 35,000 Saybolt seconds at the starting temperature. The fuel and oil used shall be as specified in 3.3 entitled “Performance characteristics.” Priming of the engine shall be by injection by a means approved by the Government. A special starting fuel or system acceptable to the Government may be used for priming. If a special priming system is necessary for starting the engine at temperatures below -20°F, the type of the special priming system and its performance requirements shall be specified in the model specification. The engine shall be provisioned to accept the special priming system, as required, with minimum effort. Special starting fuel shall not be required for starting at temperatures above -20°F. Consistent starting shall be defined as a complete start following not more than two starting attempts of 60 seconds each.

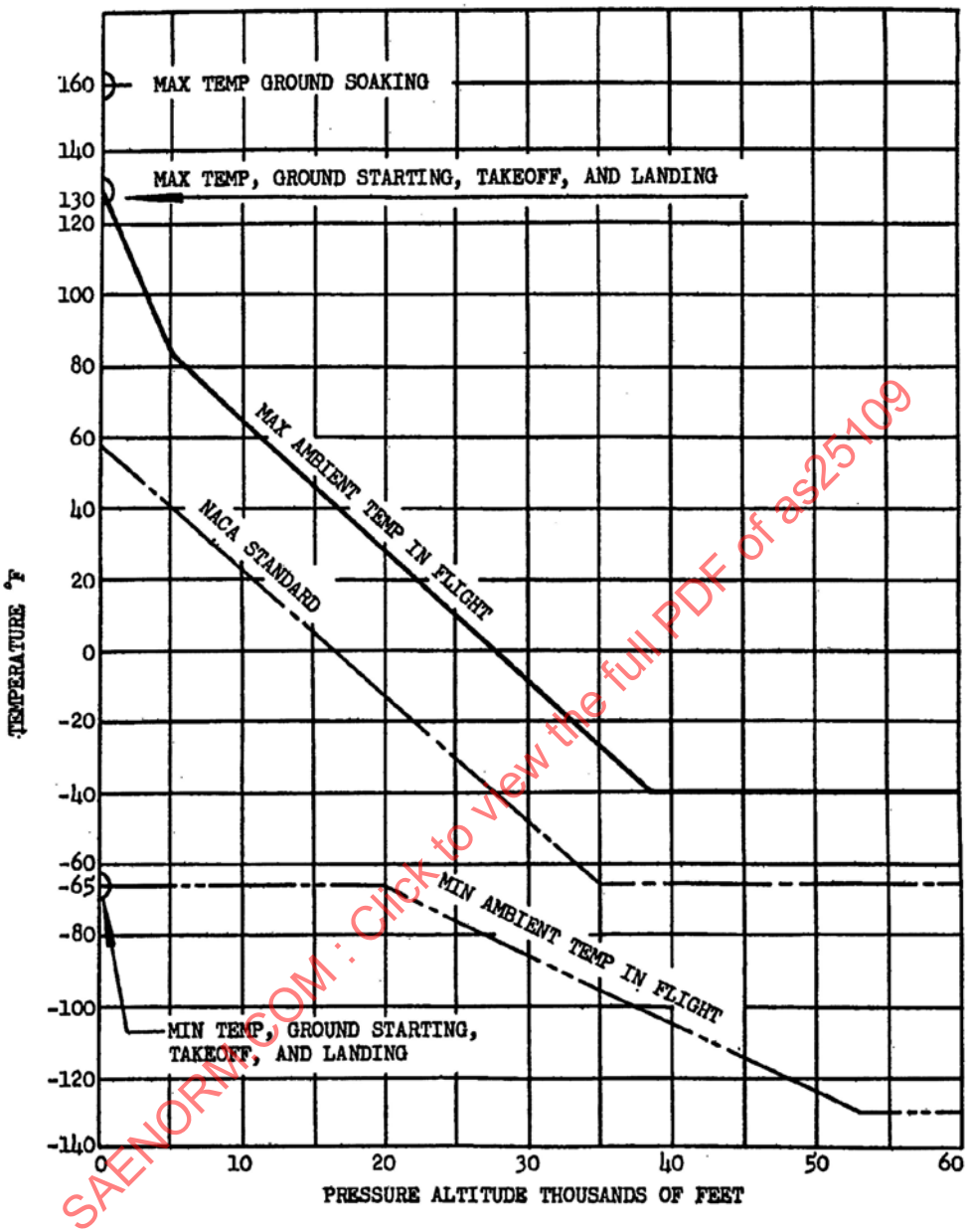

FIGURE 1. Temperature range vs altitude

3.3.7 Idling speed: The closed throttle idling speed, with an approved flight propeller, on a ground propeller load through takeoff power and speed and with the mixture strength for best power, shall not exceed 24 percent of normal rated speed with open stacks, or 18 percent with an exhaust collector. Idling speeds below 600 rpm with open stacks, or 450 rpm with exhaust collector, are not required. In the case of engines for helicopters or other applications where the engine is subject to operation while disconnected from the rotor or propeller system, the closed throttle idle speed shall not exceed 40 percent of takeoff speed with the minimum inertia (flywheel effect) specified in the model specification.

3.3.8 Acceleration: The complete engine shall consistently accelerate from 50 percent normal rated speed to takeoff speed in the time specified in the model specification, when the engine is operated on a test stand with a flight-type propeller set for takeoff propeller load. The acceleration shall be such that the complete engine will accelerate satisfactorily regardless of the frequency of opening and closing the throttle, provided the frequency does not exceed that required under the most adverse tactical conditions.

3.3.9 Operating data: Operating data shall be as specified in the model specification.

3.4 Materials and processes:

Materials and processes used in the manufacture of military reciprocating aircraft engines shall be of high quality, suitable for the purpose, and shall conform to applicable specifications listed in ANA Bulletin No. 343. When contractor's specifications are used for materials and processes which affect performance or durability of the finished product, such specifications will be subject to release by the Government. The use of nongovernmental specifications shall not constitute waiver of Government inspection.

3.4.1 Critical materials: The use of critical materials shall be held to a minimum. The use of the following materials shall be particularly minimized: Chromium, cobalt, columbium, molybdenum, natural rubber, nickel, and tungsten. The actual weight of each of these materials, based on the finished parts plus manufacturing scrap losses, required in the construction of the engine shall be made known to the using service on request or at such times as mutually agreed upon by the contractor and using service.

3.5 Standards:

3.5.1 Standard parts: AN, JAN, or MS standard parts shall be used, unless they are determined by the contractor to be unsuitable for the purpose, and shall be identified by their standard part numbers.

3.5.2 Design standards: MS and AND Design Standards shall be used wherever applicable.

3.6 Drawings and data:

The contractor shall furnish the following preliminary drawings and data to the using service with the submission of the model specification:

(a) Engine assembly, complete - showing accessory drive oil seals.

(b) Engine installation - including clearances for maintenance, checking, adjustment, and removal of accessories.

3.7 Engine design and construction changes:

3.7.1 Material substitutions: Temporary material substitutions shall be made in accordance with ANA Bulletin No. 182.

3.7.2 Changes in design: No changes shall be made in the design or materials of parts listed in an approved engine parts list, except when such changes are approved in accordance with the provisions of ANA Bulletin No. 391.

3.7.2.1 Class I changes: Class I changes are of a nature affecting:

(a) Contract cost or delivery.

(b) Model specification requirements.

(c) Interchangeability of all parts contained in engines and components, as defined hereunder:

(1) When performance or durability is affected to such an extent that superseded parts must be removed from service for reasons of safety or unsatisfactory performance.

(2) When dimensions of parts, subassemblies, or complete engines are affected to such an extent that the superseded and superseding items are not directly and completely interchangeable with respect to installation or performance.

3.7.2.2 Class II changes: All other changes shall be classified as class II changes.

3.7.2.3 Approval of changes: Approval of changes does not relieve the contractor of full responsibility for the results of such changes on any engine characteristics.

3.7.3 changes in vendors: No changes shall be made in vendors or fabrication sources, except when such changes are approved in accordance with the provisions of ANA Bulletin No. 423.

3.7.4 Parts list: The parts list for the engine which successfully completes Qualification tests shall constitute the approved parts list for subsequent engines of the same model. Changes to the approved engine parts list shall be governed by the requirements specified in 3.7.2 entitled “Changes in design.”

3.8 Interchangeability:

All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance, except that matched parts or selective fits will be permitted where required. Changes in manufacturer's part numbers shall be governed by the drawing requirements of Specification MIL-D-5028.

3.9 Accessibility:

Insofar as practicable, parts of the engine requiring routine service checking, adjustment, or replacement shall be made readily accessible for servicing without teardown of the engine and removal of any major part, component, or accessory.

3.10 Dry weight of complete engine:

The dry weight of the complete engine shall not exceed that specified in the model specification.

3.10.1 Weights of additional equipment: The weights of items which are not engine components but which are furnished with the engine shall be listed in the model specification. These items shall not be included in the engine dry weight.

3.11 Over-all dimensions:

The over-all dimensions of the engine and allowances for expansion shall be as shown on the installation drawing.

3.12 Engine mounting:

Engine mounting provisions shall be suitable for the installation of vibration isolators capable of adequately isolating engine vibrations. The number and location of mounting brackets, pads, or bosses, the clearance provisions, and the maximum allowable loads and moments of mounting pads shall be shown on the engine installation drawing.

3.12.1 Clearance: At each mounting pad or boss, clearance shall be provided for using standard wrenches to disconnect the engine from the antivibration engine mount assemblies.

3.13 Torquemeter:

All engines using propeller reduction gears and having a displacement of 2,000 cubic inches or above shall have provisions for torquemeters, preferably without major change to the engine. When installed in an engine, the torquemeter shall function satisfactorily up to and including the altitude specified in the model specification and shall not materially affect the oil flow or heat rejection to the lubricating oil. The torquemeter shall measure accurately the torque developed by the engine for any torque corresponding to any power-rpm combination within the following tolerances:

(a) Takeoff and military rated power to normal rated power - ±2 percent.

(b) Normal rated power to 40 percent normal rated power - ±3 percent.

(c) 40 Percent normal rated power to idling speed - ±5 percent, except that there shall be no requirement for accuracy in the latter portion of the power range if the torquemeter is not used for power control actuation.

3.13.1 Torquemeter design and construction: Hydraulic torquemeter construction shall be such that engine lubricating oil shall not be discharged in the event of failure or removal of the external line. Any device required for dampening pressure fluctuations shall be integral with the engine.

3.14 Crankshaft torsional vibration:

3.14.1 Helicopter and convertiplane engines: Torsional vibration tests on the actual engine load system may be required prior to the aircraft tie-down tests, if deemed necessary by the using service, to demonstrate that excessive torsional vibration will not occur.

3.15 Helicopter engine effective flywheel requirements:

The minimum inertia to be provided as flywheel effect on helicopter-type engines shall be specified in the model specification.

3.16 Compression ratio:

The engine shall be fitted with pistons giving the compression ratio specified in the model specification. The compression ratio may vary as permitted by drawing dimensions and tolerances.

3.17 Propeller drive requirements:

3.17.1 Propeller drive: The propeller drive(s) used shall conform to drawings and tables shown on Drawing AND10152, as applicable. The model specification shall specify the following:

(a) The type of propeller control mechanism(s) for which provisions are to be made in the engine.
(b) The type of propeller shaft(s).
(c) The shaft number(s).
(d) The direction of rotation as viewed from the antipropeller end.
(e) Whether the drive is single or dual rotation.
(f) The reduction gear ratio(s).

3.17.2 Oil seals:

3.17.2.1 Nose to shaft: An oil seal shall be provided between the engine nose and the propeller shaft, and shall be so designed that no objectionable quantities of oil will be discharged from the engine.

3.17.2.2 Between shafts of dual rotation shafts: An oil seal shall be provided between the inboard and outboard shafts, and the seal shall be so designed that no objectionable quantities of oil will be discharged from between the shafts.

3.17.3 Hydraulic provisions for single rotation: The requirements for propeller control mechanism or hydraulic-control valve shall be as follows:

(a) A system incorporating an oil passage from the hydraulic-control valve mounting pad to the propeller through the propeller shaft for engines with No. 20, 30, and 40 shaft sizes, when specified in the model specification.

(b) A single acting system (incorporating a separate passage for high pressure oil supply from the control mounting pad to the propeller through the outer supply holes on the propeller shaft and another separate passage connecting the center hole on the propeller shaft to the engine oil pressure system) for engines with No. 20, 30, and 40 shaft sizes unless otherwise specified in the model specification.

(c) A double acting system (incorporating a separate passage for high pressure oil supply from the control mounting pad to the propeller through the outer supply hole on the propeller shaft and another separate passage connecting the center hole on the propeller shaft to another appropriate high pressure oil supply at the control pad) shall be provided for No. 50 shafts and above.

(d) Engines with shaft sizes 7-1/2, 10, 70, or above, shall not require shaft hydraulic transfer provisions unless otherwise specified in the model specification.

3.17.3.1 Oil passages: When engine lubricating oil is used to operate the propeller controls, it is desired that all oil passages shall be within the engine. The design of the hydraulic system shall be adequate to meet at least the following pressure drops, oil flow, and oil leakage requirements when the engine is operating at normal rated power and speed and with oil and oil inlet temperature conforming to that specified for the engine in the model specification. The pressures and deliveries specified shall be determined by means acceptable to the using service.

3.17.3.2 Pressure drop: The oil passages shall be of such size as to permit the following flows and pressure drops from the propeller passage at the control pad to the outer oil holes in the propeller shaft, as applicable.

(a) 11 quarts per minute at 20 pounds per square inch maximum pressure drop for 20, 30, and 40 shafts.

(b) 22 quarts per minute at 40 pounds per square inch maximum pressure drop with shaft sizes No. 50, or above.

(c) With no flow at the engine oil supply hole of the control pad or at the propeller shaft center hole, as applicable, the pressure at these points shall be not less than 15 pounds per square inch or exceed 100 pounds per square inch.

3.17.3.3 Flow: The engine shall maintain the applicable rate of flow to the propeller control pad through the engine oil supply hole at the minimum pressures and flow specified as follows for the indicated systems described in 3.17.3 entitled "Hydraulic provisions for single rotation."

(a) 50 pounds per square inch minimum for a hydraulic-control valve system and flow specified in 3.17.3.2(a) entitled "Pressure drop."

(b) 5 pounds per square inch minimum for a single acting system and flow specified in 3.17.3.2(a) and 3.17.3.2(b) entitled "Pressure drop."

(c) 5 pounds per square inch minimum for a double acting system and a flow of 6 quarts per minute minimum for 3.17.3.2(b) entitled "Pressure drop."

3.17.3.4 Leakage: At the completion of the 150-Hour engine endurance run of the Qualification tests, the leakage from the oil passages between the mounting pad and the outer oil holes in the propeller shaft or the center oil hole in the propeller shaft, whichever is applicable, including oil transfer gland leakage, shall be not more than 2 quarts per minute at 400 ±20 pounds per square inch oil pressure nor more than 3-1/2 quarts per minute at 650 ±20 pounds per square inch oil pressure measured at the mounting pad. For double acting systems, these leakage requirements apply independently at each passage when using normal engine oil pressure in the other passage.

3.17.3.5 For single acting system only:

3.17.3.5.1 Propeller feathering: With the engine not operating and with no flow at the engine oil supply outlet at the control pad, the pressure required to cause a flow specified in 3.17.3.2 entitled "Pressure drop" into the center hole of the propeller shaft shall be not more than 100 pounds per square inch.

3.17.3.5.2 Engine oil supply to propeller: With no flow at the engine oil supply outlet at the control pad, the rate of discharge from the center hole in the propeller shaft to atmospheric pressure shall be not less than 11 quarts per minute for engines with No. 20, 30, 40, and 50 shafts.

3.17.3.6 Oil transfer plug: When an oil transfer plug is used to accommodate hydraulic controllable propellers, the shaft end shall conform to Drawing AND10152, Sheet 3, as applicable, and if not used, the shaft shall be plugged as shown on Drawing AND10152, Sheet 3, to prevent oil leakage in either direction under a pressure head of 12 inches of oil.

3.17.4 Hydraulic provisions for dual rotating propellers: For engines intended for use with dual rotation propellers and other engines without shaft hydraulic transfer provisions, the engine shall maintain an oil flow of at least 2 quarts per minute to the propeller control pad through the engine oil supply hole at a minimum pressure of 4 pounds per square inch. With no flow at the engine oil supply hole at the contact the pressure at this point shall be not less than 15 pounds per square inch nor more than 100 pounds per square inch.

3.17.5 Special drive provisions: When special drive provisions are incorporated for helicopter engines or other special applications, these provisions shall be described in the model specification.

3.18 Supercharging system:

When an integral gear-driven supercharger is used, the following shall apply.

3.18.1 Supercharger drain valve: Wherever downdraft carburetors are used, an automatic drainage system shall be provided to prevent accumulation of fuel in the induction system. A straight-threaded opening shall be provided for drainage.

3.18.2 Supercharger control: Where applicable, the location of the various step positions of the supercharger control shall permit positioning in the following sequence:

(a) Low speed or main stage only.
(b) High speed or low speed auxiliary stage.
(c) High speed auxiliary stage.

3.18.3 Supercharger drives: When supercharger drives are used, the control mechanism shall be so designed that upon shifting from one speed combination to another combination at normal or military rated speed, full power shall be obtainable within 5 seconds after making the shift.

3.18.4 Impeller gear: Impeller gear ratio and diameter of the impeller shall be specified in the model specification.

3.19 Automatic engine control:

The operating characteristics of an automatic control, when used, shall be specified in the engine model specification. These characteristics shall be reflected in the estimated engine performance curves furnished as part of the engine model specification. Such controls shall function satisfactorily up to and including the altitude specified in the engine model specification.

3.19.1 Functional data: All functional data on the operating characteristics of the automatic control, including a schematic diagram with functional tolerances, which includes regulation, stability, and acceleration characteristics, and a block layout giving description of each component, shall be furnished prior to submitting the first engine of each model (for other than contractor's test) to Acceptance tests, unless the same data have been submitted on a previous engine of identical control characteristics, in which case the model specification shall so designate.

3.19.1.1 Ambient humidity: Controls of the electrical or electronic type shall operate satisfactorily following periods of inoperation of 30 days during which the humidity is 100 percent and the temperature is 130°F.

3.19.1.2 Protection: Provisions shall be made for protecting the control from any detrimental foreign material. When screens are used, they shall be capable of being removed with the control installed on the engine.

3.19.1.3 Drainage: Suitable provisions shall be incorporated for draining condensates from air chambers of the control while installed on the engine. Provisions shall be made for complete drainage of all passages and chambers when the control is not installed on the engine. If necessary, disassembly of the control to an extent not requiring readjustment upon reassembly shall be permitted.

3.19.1.4 Adjustments and stops: When adjustments of limiting values of the controlled variable are required, provision shall be made for external adjustment. Positive stops shall be provided at the limits of travel of the datum lever.

3.19.2 Manifold pressure control: Single lever control of manifold pressure shall be provided. When the engine is intended for use with a turbosupercharger not supplied with the engine, single lever control of manifold pressure shall not include control of the turbosupercharger.

3.19.3 Compensation for operating fluid pressure: Performance of the control shall not be adversely affected by variations in pressure of the operating fluid normally encountered in service. The minimum allowable operating pressure at the control shall be specified in the engine model specification.

3.19.4 Voltage and frequency variation:

3.19.4.1 Alternating current: The control or any part thereof, when operating on alternating current, shall provide satisfactory operation throughout a variation of voltage and frequency not exceeding 10 percent of the rated values.

3.19.4.2 Direct current: The control or any part thereof, when operating on direct current, shall provide satisfactory operation throughout a voltage range of 18 to 30 volts, or 103 to 121 volts, as applicable.

3.19.5 Emergency operations: Whenever practicable, fail-safe provisions shall be made for manual control of engine power in the event of engine control failure. Manual control shall be possible with a maximum permissible torque of 50 pound-inches at the datum lever.

3.19.6 Combat power: The control shall automatically reset the datum, wherever applicable, when changing from military to combat power or vice versa.

3.19.7 Operating limits: The control shall automatically reset the datum at military and combat power to the extent required by changes in altitude, supercharger ratio, engine speed, etc, to prevent exceeding safe operation limits of the engine.

3.20 Manifold pressure:

Provisions shall be made for the measurement of the intake manifold pressure, the location of which shall be indicated on the installation drawing. The boss shall be tapped 7/16-20 UNF-3B in accordance with Specification MIL-S-7742. The installation drawing shall indicate that a No. 50 drilled opening is supplied on the engine or is required in the companion fitting.

3.21 Exhaust system:

Steel parts of the exhaust system which come in contact with exhaust gases shall be constructed of or protected by a suitable corrosion- and heat-resisting material.

3.21.1 Exhaust flanges: Exhaust flanges and gaskets shall not be furnished with the engine. Where an exhaust-driven supercharger installation is specified, adequate provisions for anchorage and tightness of the connections to the exhaust pipe shall be provided, and the exhaust flange connection or the exhaust system attachment arrangement furnished.

3.22 Cowling:

3.22.1 Cowl or shroud attachment: If provision for attachment of cowling or shrouding is to be furnished on the engine, the location of the points of attachment shall be dimensionally controlled within the tolerances shown on the installation drawing.

3.22.2 Ring: Provision shall be made on the rocker boxes of radial engines for attachment of the ring cowl at the front and rear of each cylinder for single row radials and at the front of the front cylinders and rear of the rear cylinders on multirow radials.

3.23 Cylinder cooling baffles:

If baffles are used, it is desired that their attachment to the engine shall be such that it shall be possible to replace the baffles without removing cylinders from the engine.

3.24 Coolant pump (liquid-cooled engines):

It shall be possible to remove those portions of the coolant pump requiring routine service inspection without removing other accessories. The pump shaft packing shall be accessible for adjustment if it is of the adjustable type.

3.25 Coolant temperature (liquid-cooled engines):

The coolant outlet temperature variation shall be not more than 3 Fahrenheit degrees between the cylinder blocks when operating at normal rated power and normal rated speed with a cooling medium outlet temperature as specified in the model specification. It is desired that the engine be designed for use with 70 percent ethylene glycol conforming to Specification MIL-E-5559 and 30 percent water by volume as a coolant.

3.26 Cylinder temperature measurement (air-cooled engines):

Provisions shall be made on all cylinders for the installation of cylinder head resistance bulbs in accordance with Drawing AND10312. If provisions conforming to Drawing AND10312 are utilized, a fitting in accordance with Drawing AN4076 shall be furnished only on cylinders designated by the using service, or an equivalent number of fittings not to exceed four, shall be furnished with the engine. If another arrangement is necessary, it shall be specified in the model specification. A standard plug conforming to Drawing AN5543 shall be used in the resistance bulb openings when a fitting conforming to Drawing AN4076 is not furnished. The type of resistance bulbs used shall be specified in the model specification. The cylinder bases of all cylinders on the first 10 engines of a production order shall be drilled for the installation of base-type thermocouples. If these thermocouples are supplied, the electromotive force characteristics shall conform to Specification MIL-T-5493 or MIL-T-5494.

3.27 Fuel metering system:

3.27.1 Carburetor or fuel injector: If the engine is equipped with a carburetor or fuel injector, it shall be the model of carburetor or fuel injector specified in the engine model specification and shall conform to the following.

3.27.1.1 Carburetor or air throttle entrance screens: Engines equipped with induction system impellers shall have screen installations protecting all impellers. The installation, materials, and construction shall be substantially in accordance with Drawing AND10201. Air cleaners, if furnished with the engine, shall conform to Specification MIL-F-7194.

3.27.1.2 Nameplate: A nameplate shall be suitably fastened to the carburetor in a manner that will not affect the gas or liquid tightness of the carburetor or promote corrosion.

3.27.1.2.1 Parts list numbers shall include any supplementary numbers or letters which cover changes in metering and interchangeability of component parts.

3.27.1.3 Qualification sample: To qualify the carburetor, a qualification sample shall be submitted to the using service for metering tests to determine compliance with the following requirements.

3.27.1.3.1 Load compensation: The carburetor shall maintain, without manual adjustment, fuel-air ratios at constant air flow at all normal operating engine speeds within the limits given in table I based on the values established for the reference carburetor.

TABLE I
Sea level metering characteristics

Percent of airflow for normal rated power and speed	Percent permissible variation from fuel-air ratios established for reference carburetors	Variation in engine speed
0 to 30	±5	Idle - 50 percent N.R.S.
30 to 70	±2	50 percent N.R.S. -100 percent N.R.S.
70 to 100 and above	±2	±10 percent of N.R.S. from applicable speed on normal propeller load

3.27.1.3.2 Altitude compensation: For airflows corresponding to 30, 50, 80, and 100 percent of normal rated power and takeoff power under carburetor entrance conditions as shown in table II, the fuel-air ratio shall not vary from that obtained with standard sea level carburetor entrance conditions by more than the percentage specified for the tabulated conditions up to the engine critical altitude for these air flows.

TABLE II
Carburetor entrance conditions

Applicable range of specific weights (lb/cu ft)	Applicable range of temperature °F*	Limits (percent)
0.10 to 0.05 0.05 to 0.034 0.034 to 0.018	*As specified in the model specification	±2 ±3 ±4

3.27.1.3.3 Fuel pressure compensation: With a fuel pressure variation within the limits specified in the engine model specification of the engine for which the carburetor is intended, the fuel-air ratio at any airflow in the range from 40 to 70 percent of the airflow for normal rated power and speed shall not vary more than 1 percent, and for airflows above 70 percent of the airflow for normal rated power and speed, shall not vary more than 2 percent.

3.27.1.4 Performance: Unless otherwise specified in the engine model specification, the engine contractor shall prepare and submit a "Reference carburetor." The "Reference carburetor" shall meet the requirements outlined below when subjected to the metering tests for reference carburetor specified in Specification MIL-E-25111.

3.27.1.4.1 "Rich" and "normal" positions at normal and military rated powers and takeoff power: At takeoff power and speed, the mixture strength in the "rich" position shall be from zero to 4 percent in excess of that corresponding to the "normal" position setting. At normal and military rated powers and speeds, the mixture strength in the "rich" position shall not exceed that obtained at takeoff power nor be less than that corresponding to the "normal" position setting. At takeoff power and speed the mixture strength in the "normal" position shall be from 0 to 2 percent in excess of that corresponding to the guaranteed fuel consumption. At normal and military rated powers and speeds the mixture strength in the "normal" position shall be from 0 to 4 percent in excess of that corresponding to the guaranteed fuel consumption.

3.27.1.4.2 Rich position below normal rated power: With the mixture control in the rich position and with the lowest degree of supercharging required to obtain the specified conditions, the mixture strength shall be as follows:

(a) For minimum idling speed on a propeller load through takeoff power and speed, the mixture strength shall be that necessary for maximum power at that speed.

(b) From minimum idling speed on a propeller load through takeoff power and speed to 50 percent normal rated speed, the mixture strength shall vary uniformly with speed.

(c) From 50 percent of normal rated speed on a propeller load through normal rated power and speed to the maximum power specified for operation with "best economy" mixture, the mixture strength at any point shall be from 0 to 12 percent in excess of best power mixture strength at the corresponding point. The mixture strength at powers above 25 percent normal rated power shall not be affected by adjustment of the idle mixture within the range of adjustment normally required under service conditions.

(d) On a propeller load through normal rated power and speed the mixture strength at any power above the maximum specified for operation with "best economy" mixture shall neither be less than the mixture strength furnished in the normal position at corresponding airflows nor exceed the mixture strength furnished in the rich position at takeoff power and speed.

3.27.1.4.3 Normal position below normal rated power: With the mixture control in the normal position, and with the lowest degree of supercharging required to obtain the specified conditions, the carburetor shall furnish mixture strengths as follows:

(a) For engine operation at any point on normal rated propeller load from minimum idling speed to 30 percent normal rated power, the mixture strength shall be not less than the minimum required for satisfactory acceleration.

(b) For engine operation at any combination of speed and power specified for use with "best economy" mixture, the mixture strength shall be from 2 percent to 8 percent in excess of that corresponding to the midpoint of "best economy" on a curve of specific fuel consumption versus mixture strength at that combination of speed and power. This will be demonstrable with the maximum cylinder cooling obtainable at the extremes of the cruise power range specified in the model specification and at one additional point midway between the extremes of power.

(c) For engine operation at 80 percent power on normal rated propeller load, the mixture strength shall be from 0 to 8 percent in excess of that corresponding to the guaranteed fuel consumption.

3.27.1.4.4 Idle mixture position: Mixture strength requirements shall be met with the position of the idle mixture adjustment fixed. The displacement of this position from the midposition of the effective range of the adjustment shall not exceed 10 percent of the effective range.

3.27.1.4.5 Effect of carburetor air scoop design on metering: Following flight tests conducted by the aircraft manufacturers, sufficient data shall be submitted to the engine manufacturer to enable him to check the performance of the carburetor air scoops with any approved setting and to submit his recommendations to the using service. Approval by the Government of any reference carburetor or required metering curve established therefrom shall not relieve the engine manufacturer of the responsibility for proper functioning of that carburetor and setting in various models of aircraft, provided that the recommendations of the engine manufacturers regarding scoop design changes are placed in effect.

3.27.1.4.6 Curing date of rubber parts: All fuel system components containing synthetic rubber parts shall be governed by the regulations of ANA Bulletin No. 410.

3.27.2 Fuel injection system: If the engine is equipped with an injection system involving timed distribution of fuel, the system shall satisfy the general requirements for carburetors set forth in 3.27.1.1 and 3.27.1.2 entitled "Carburetor or air throttle entrance screens" and "Nameplate," respectively. The qualification and acceptance requirements shall be specified in the model specification.

3.27.2.1 Filter: A suitable filter will be required for the fuel injection system and shall be accessible without dismantling any other parts of the fuel injection system. The model specification shall state whether or not a filter is to be furnished with the engine. When the filter is not supplied with the engine, the filter requirements shall be specified in the model specification.

3.27.3 Speed density carburetor: If the engine is equipped with a carburetor functioning on the parameters of engine speed and manifold mixture density, it shall satisfy the requirements for carburetors set forth in 3.27.1.1 and 3.27.1.2 entitled "Carburetor or air throttle entrance screens" and "Nameplate," respectively. The qualification and acceptance requirements shall be specified in the model specification.

3.27.4 Water injection system: If the engine is equipped with a water injection system the type and model of water regulator shall be designated in the engine model specification.

3.27.4.1 Construction: The design and the materials of construction of the water injection system shall be such as to prevent corrosion of parts.

3.28 Special connections to induction systems:

3.28.1 Before supercharger: A hole tapped 5/8-18 UNF-3B in accordance with Specification MIL-S-7742 shall be provided between the carburetor or air throttle and the main stage supercharger for accommodation of a temperature-sensitive element. Clearance within the engine shall be provided not less than 17/32 inch in diameter, nor 2-3/8 inches in length. Clearance external of the engine shall be provided not less than 4 inches in over-all length and 1-1/2 inches in diameter. The clearance shall be shown on the engine installation drawing. Nonsupercharged engines shall have the same hole located in similar relation to the carburetor or air throttle.

3.29 Lines and fittings:

The fuel lines shall be as short as possible and shall contain no water-collecting traps. External lines on the engine which convey fuel shall be flexible or shall be adequately supported to eliminate the effects of destructive vibration.

3.30 Lubricating system:

3.30.1 Accessory lubrication: Lubrication and operation of the engine shall not be impaired as the result of the use of engine lubricating oil for normal operation of propellers, automatic supercharger regulator, automatic mixture control or engine-driven accessories requiring lubrication with the limits as set forth in the applicable accessory drive standards. This shall include the return of the oil from the above referenced accessories.

3.30.2 Oil pressure adjustment: The lubricating system shall be arranged to indicate pressure at idling speeds. The oil pressure adjustment shall be external to the engine, and it shall be readily accessible for and shall permit adjustment while the engine is running.

3.30.2.1 Relief valve: The pump relief valve shall be so designed that it will be unnecessary to change the adjustment of the relief valve when operating under any conditions specified in the Qualification tests of Specification MIL-E-25111.

3.30.3 Oil pump leakage: After the Qualification tests, with a mixture of equal parts aviation gasoline and an oil having a viscosity of approximately 100 Saybolt universal seconds at 210°F supplied to the oil pump inlet at room temperature and under a head of 3 feet, the total flow of the oil into the engine owing to leakage through the pump shall not exceed 0.2 pound per hour.

3.30.3.1 Check valve: If a check valve, or other device, is installed on the discharge side of the oil pressure pump it shall not adversely affect engine lubrication.

3.30.4 Oil bypass: The oil system of a dry sump engine shall be so arranged that the oil bypassed from the pressure pump will be returned to the inlet of the pressure pump and the scavenge pump will be required to handle only the oil which has passed through the engine. The oil system of a wet sump engine shall be so arranged that the oil bypassed from the pressure pump will be returned to the sump.

3.30.5 Scavenging system: The scavenging system shall adequately scavenge the engine for extended periods of time under normal operating conditions, with a back pressure on the scavenging system of 40 pounds per square inch between the point of maximum flow and 60 percent normal rated speed, thereafter decreasing uniformly not exceeding 10 pounds per square inch at minimum idling speed, of which not more than 2 pounds shall be due to the use of a fixed relief valve in the external scavenge system when using oil conforming to Specification MIL-L-6082 at an inlet viscosity of 100 ±5 Saybolt universal seconds. The scavenging system shall likewise operate satisfactorily at takeoff power and speed with an oil or a diluted oil having a viscosity equivalent to Specification MIL-L-6082, grade 1100 +30 percent by volume of fuel, as specified in the model specification and with the back pressure specified above and oil-in temperature of 122° ±5°F, and within the normal operating temperatures specified in the model specification.

3.30.6 Pressure pump(s): No air traps shall exist at the pump inlet(s). The oil pressure pump(s) shall have sufficient capacity to maintain, at 75 percent normal rated speed, the same pressure obtained at normal rated speed, using oil conforming to Specification MIL-L-6082 at an inlet viscosity of 100 ±5 Saybolt universal seconds. The oil pressure pump shall maintain, with reference to the inlet pressure, an operating pressure as specified in the model specification with an inlet pressure of not less than 8 inches of mercury absolute, and shall provide at least the minimum allowable oil pressure when the inlet pressure is 6 inches of mercury absolute with the oil to the pump containing not more than 10 percent aeration.

3.30.7 Oil cleaner: A suitable oil cleaner shall be installed in such manner that all oil passed through the main oil pressure pump shall immediately pass through the cleaner. The installation shall be so made that dirt extracted from the oil will be deposited on the outside of the cleaning element. It shall be possible to remove the oil cleaning element from its housing without disturbing any oil lines or any other part. Foreign matter removed by the cleaner shall not re-enter the lubricating system under normal operating conditions.

3.30.8 Oil pressure connections: Pressure connections for cockpit indication shall be 7/16-20 UNF-3B internal straight thread. The oil pressure at the connection shall not fluctuate more than ±5 percent under any stabilized operating condition.

3.30.8.1 Temperature measurements: Provision shall be made for measuring oil inlet temperature. A hole, tapped 5/8-18 UNF-3B, in accordance with Specification MIL-S-7742 shall be provided for installation of an oil inlet thermometer which shall be located in a suitable position to measure true inlet oil temperature. A correction factor(s) may be furnished, preferably in the model specification, at the option of the contractor if this requirement cannot be met. Clearance within the engine shall be provided for the sensitive portion of the bulb, Standard MS28034. Clearance external of the engine shall be provided for the removal of the bulb, Standard MS28034. This clearance shall be not less than 3-1/3 inches in length and 1-1/2 inches in diameter and shall be clearly shown on the engine installation drawing.

3.30.9 Provision for oil connections: For engines having oil flows in excess of 75 pounds per minute when using oil conforming to Specification MIL-L-6082, at a viscosity of 100 ±5 Saybolt universal seconds, pads shall be furnished in accordance with Drawing AND10458 for attaching oil inlet and oil outlet connections. Sufficient clearance shall be provided for easy attachment or removal of these oil connections.

3.30.9.1 For engines having oil flows less than the above, oil inlet and outlet connections shall be in accordance with Drawing AND10049, and sufficient clearance shall be provided for installing these connections.

3.30.10 Oil tank vent: Provisions shall be made for a 3/4-inch-minimum tube size opening in accordance with Drawing AND10049 in the engine for an oil tank vent connection located above the centerline of the engine. If practicable, the vent connection shall be located in the rear section. For in-line engines, one additional connection shall be located at the propeller end of the engine. The oil tank vent shall be so located in relation to the breathers that pressure in excess of 1/2 pound per square inch will not be applied to the oil tank vent connection. Sufficient clearance shall be provided for the necessary connection. Connections shall be in such a location that the lubrication or scavenging of the engine will not be adversely affected.

3.30.11 Accessory oil return: At least two 3/16-inch tube size openings in accordance with Drawing AND10049 shall be provided; one of these shall be located preferably in the sump, for returning engine oil from oil-operated accessories. The second opening shall be for the vacuum pump oil separator discharge and shall be so specified on the engine installation drawing. These openings shall be so located that the functioning of the oil scavenging system and breathers will not be adversely affected.

3.30.12 Oil drain: The engine shall be provided with at least one oil drain opening located at the lowest point in the crankcase or sump. The threads shall be 1-18 NS-3. A drain plug, or plugs, shall be installed and properly secured.

3.30.13 Lubrication points: All points in the engine requiring pressure lubrication shall be lubricated from the engine lubricating system. No lubrication from an external source shall be required.

3.30.14 Oil lines: It is desired that all oil passages and lines be located within the engine.

3.30.15 Crankcase breather(s): The crankcase breather(s) shall be so arranged that the pressure in the crankcase under any conditions of operation, including the discharge from the vacuum pump oil separator, which will be considered to be 2 cubic feet of air per minute, will not exceed 1/2 pound per square inch above static atmospheric pressure. It is desired that the breather opening be made as small as possible consistent with satisfactory breathing. No breathing arrangement which discharges from the propeller shaft will be permitted. The breather(s) shall be located and arranged so that oil will not be lost from the engine in any attitude in which the engine may be operated in an aircraft, including vertical dives, with the engine operating not in excess of its rated dive speed. Each breather shall terminate preferably with a connection and a hose for connecting to tubing in such manner that when so connected no other breather opening exists. The hose connection end(s) shall conform to Drawing AND10058 or AND10060. The breather system shall likewise operate satisfactorily at takeoff power and speed with oil conforming to Specification MIL-L-6082, grade 1100, diluted as specified at either of the following conditions:

(a) 20 percent by volume with fuel as specified in the model specification at an ambient temperature of 60.0°F to 100.0°F.

(b) 30 percent by volume with fuel as specified in the model specification at an ambient temperature of 0.0°F to -20.0°F.

3.30.16 Crankcase pressure connection: Provisions shall be made and designated by the manufacturer for a straight-threaded opening in accordance with Drawing AND10049 suitably located in the engine crankcase, for obtaining average crankcase pressure. Sufficient clearance will be maintained for installing a standard hose nipple fitting.

3.30.17 Preoil plug: A 1-14 NF-3B preoil opening shall be provided for engines over 75 pounds per minute oil flow. A 5/8-18 UNF-3B opening shall be provided when specified in the model specification for engines under 75 pounds per minute oil flow. In engines having more than one pressure pump, additional openings shall be similarly provided, if necessary, to insure expeditions and thorough preoiling. Preoiling plugs shall be permanently marked “preoil.”

3.30.18 Wet-sump capacity: Wet-sump engines shall have the oil supply capacity specified in the model specification.

3.31 Electrical system:

3.31.1 Electrical interference: Electrical components as used shall not cause electrical interference beyond the limits specified in Specification AN-I-27. Specification MIL-I-6181 shall be made applicable when mutually agreed upon between the contractor and the using service.

3.31.2 Ignition:

3.31.2.1 Spark plugs:

3.31.2.1.1 Type: Spark plugs shall be of the type and model specified in the model specification, and shall conform to the requirements of Specification MIL-P-7886. Spark plugs from not less than two sources shall be specified by the engine manufacturer for each model engine. At least one type of non-platinum electrode spark plug shall be specified.

3.31.2.2 Installation and connections: Connections required to connect the ignition system to the aircraft shall conform to applicable AN or MS standards, unless alternate connections are approved by the using service. The ignition system shall be designed to locate the connections at a point where connection can be completed without mounting aircraft parts on the engine, and shall be accessible in place or readily removable from the engine when installed in an aircraft and shall be sufficiently durable to withstand such maintenance.

3.31.2.3 High-tension ignition cable: High-tension ignition cable, when used in rewireable harnesses, shall conform to Specification MIL-C-3162. The cable supplied on delivered engines shall be no more than 12 months old.

3.31.2.4 Magnetos: The manufacturer's name and model of magneto or ignition generator shall be specified in the model specification. Magnetos shall meet the following performance and installation requirements.

3.31.2.4.1 Type designations: The type designations of magnetos shall conform to the following:

(a) "S" or "D" indicating single or double type.

(b) A number indicating the number of cylinders fired by the magneto.

(c) "L" or "R" indicating left-hand (counterclockwise) or right-hand (clockwise) rotation when viewed from the drive end.

(d) A letter, specified by the Government, to designate the manufacturer.

(e) Modifications shall be indicated by a dash and an Arabic numeral.

Illustration: Type S9LK, indicates a magneto which is a single type, 9 cylinders, left-hand (counterclockwise) rotation, and made by the contractor to whom the designation "K" has been assigned.