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MODEL SPECIFICATION

ENGINE, AIRCRAFT: MODEL V-1710-109 & -109A

ALLISON DIVISION
General Motors Corporation
Indianapolis, Indiana

ALLISON MODEL V-1710-E22 & -E22A

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ENGINE, AIRCRAFT: MODEL V-1710-109 & -109A
Allison Division of General Motors Corporation
Allison Model V-1710-E22 & -E22A

A. APPLICABLE SPECIFICATIONS

A-1. The specifications listed on pages 25 and 26 except as revised herein shall form a part of this specification.

B. TYPE AND MODEL

B-1. This specification covers the requirements for the V-1710-109 and -109A engine and all items apply to both model engines except as otherwise stated.

B-1a. The V-1710-109 is a 12-cylinder, liquid-cooled, 60° Vee-type engine equipped with an outboard reduction gear assembly. An outboard auxiliary stage supercharger is located directly behind the engine and is driven through a variable speed hydraulic coupling. Automatic controls are provided for controlling manifold pressure and auxiliary stage speed. Provision shall be made for the application of water injection.

The V-1710-109A is identical to the -109 except that a propeller shaft with a larger bore and other necessary parts shall be incorporated.

C. MATERIAL AND WORKMANSHIP

C-1. The requirements for material and workmanship shall be as specified in specification AN-9500.

D. GENERAL REQUIREMENTS

D-1. See Section E.

E. DETAIL REQUIREMENTS

E-2. The following Allison Division drawings form part of this specification:

53211	Engine Assembly, Complete (Showing Accessory Drive Oil Seals)
53210	Installation Drawing (Showing Clearances for Engine Accessories and their removal)
43590	Priming System Assembly
54802	Carburetor - Model PD12K15 - Bendix-Stromberg
53466	Spark Plug Assembly Champion C34S*
54861	Spark Plug Assembly Champion RP43S
44099	Spark Plug Assembly AC LS86
42354	Contact Assembly, Spark Plug (Terminal)
	Lubrication System Diagram (To be included in Service Manual)
53122	Radio Shielding Assembly
53837	Control Assembly - Automatic Manifold Pressure
54720	Control Assembly - Supercharger

Photographs - one top and bottom, one each side, one front, one rear. (To be included in model test report)

E-3. Acceptance The acceptance of this engine as a service model shall be predicated on the satisfactory completion of tests outlined in the following paragraphs E-3a and E-3b. The water-alcohol injection equipment shall be installed on the engine during all tests but shall not be in operation since the ratings specified herein do not require the use of water-alcohol injection.

E-3a. Model Test The engine shall be model tested in accordance with AN-9502 with the following exceptions:

(1) (Ref. Par. F-1. General) The model test shall be conducted at the contractor's plant.

(2) (Ref. Par. F-3. Test Methods) Two engines shall be used for the tests required by this specification. One of the engines shall be used for dynamometer runs to determine altitude performance, automatic control operation and other tests which may be required. The other engine shall be used for the endurance test only.

(3) (Ref. Par. F-3e(2). 150-Hour Endurance Run) The following schedule for model testing shall be followed. All testing shall be accomplished on a sea level stand. During Runs No. 1 to 9, inclusive, the auxiliary stage air shall be wasted and the engine shall be operated at an air flow through the power section equal to that required at the specified altitude to give the specified power. During these runs, the auxiliary stage shall be loaded by a weight of air equal to that flowing through the power section. During Runs No. 10 to 16, inclusive, the engine shall be run at the specified horsepower with the inter-stage duct installed and the speed of the auxiliary stage determined by the auxiliary stage automatic control.

150-HOUR ENDURANCE SCHEDULE

Run No.	Ref. Par.	Hours	Alternate Periods	Specified HP	Specified ALT	Speed RPM	Auxiliary Stage Engagement
1.	F-3d(1)	7	3 1/2	1050	10,000	2600	Slip for Normal HP
			3 1/2	945	10,000	2520*	at 10,000 ft.
2.	F-3d(1)	3	1 1/2	950	24,000	2600	Minimum Slip
			1 1/2	855	24,000	2520	Minimum Slip
3.	F-3d(3)	15	15 min.	1100	26,000	3000	Minimum Slip
			30 min.	Prop.Load	26,000	55-66% Mil.	Minimum Slip
4.	F-3d(4)	7	3 1/2	1050	10,000	2600	Slip for Normal HP
			3 1/2	840	10,000	2420*	at 10,000 ft.
5.	F-3d(4)	3	1 1/2	950	24,000	2600	Minimum Slip
			1 1/2	760	24,000	2420	Minimum Slip
6.	F-3d(5)	7	3 1/2	1050	10,000	2600	Slip for Normal HP
			3 1/2	735	10,000	2315*	at 10,000 ft.
7.	F-3d(5)	3	1 1/2	950	24,000	2600	Minimum slip
			1 1/2	665	24,000	2315	Minimum Slip
8.	F-3d(6)	7	3 1/2	1050	10,000	2600	Slip for Normal HP
			3 1/2	630	10,000	2185*	at 10,000 ft.
9.	F-3d(6)	3	1 1/2	950	24,000	2600	Minimum Slip
			1 1/2	570	24,000	2185	Minimum Slip

*During the 10,000 ft. runs, the same coupling oil control tube setting shall be used for the low speed runs that is used for the 2600 RPM runs.

n Ref. Par.	Hours	Alternate Periods	Specified HP	Specified ALT	Speed RPM	Auxiliary Stage Engagement
. F-3d(1)	15	2 1/2	1050	SL	2600	As determined by controls
		2 1/2	945	SL	2520	As determined by controls
. F-3d(2)	15	5 min.	1425	SL	3000	As determined by controls
		10 min.	Idle	SL	Idle	As determined by controls
. F-3d(4)	15	2 1/2	1050	SL	2600	As determined by controls
		2 1/2	840	SL	2420	As determined by controls
. F-3d(5)	15	2 1/2	1050	SL	2600	As determined by controls
		2 1/2	735	SL	2315	As determined by controls
. F-3d(6)	15	2 1/2	1050	SL	2600	As determined by controls
		2 1/2	630	SL	2185	As determined by controls
. F-3d(7)	15	Continuous	441	SL	1456*	As determined by controls
. F-3D(8)	5	Continuous	1050	SL	2860	As determined by controls

*Note (1) The speed for Run No. 15 shall be as low as can be obtained with the propeller available for testing but not lower than 1456 RPM. nor greater than 1600 RPM.

Note (2) The speed changes required by Par. F-3e(2) of AN-9502 shall not be made.

(4) (Ref. Par. F-4a(1). Knock Rating of Fuels) The fuel used for model testing shall conform to Referee Fuel 28R Batch No. 1.

(5) (Ref. Par. F-4c. Carburetor Air Temperature) During the altitude runs (No. 1 to 9) on the sea level stand, the carburetor air temperature shall be that observed at the specified altitude during the altitude calibration when operating with standard atmospheric conditions at the auxiliary stage inlet but not less than 70°F. During the sea level runs with the interstage duct installed (No. 10 to 16), the auxiliary stage inlet air shall be 70°F. to 90°F.

(6) (Ref. Par. F-4g. Fuel and Oil Consumption) The specific fuel consumption for the normal power 110% normal speed run (No. 16) shall be increased by .03 lbs/BHP/hr above the guaranteed value for normal power and speed. During the altitude runs (No. 1 to 9) on the sea level stand, the fuel air ratio shall be that determined from the fuel air vs. air flow curve established by the sea level guarantees.

(7) (Ref. Par. F-4i. Inspection and Adjustments) In addition to the normal cleaning and adjustments, the spark plugs may be cleaned before the 15-hour take-off period, Run No. 11.

E-3b. Acceptance Test The acceptance of this engine in production shall be based upon tests run in accordance with AN-9503 with the following exceptions:

(1) (Ref. Par. F-5a(1). Two-Hour Initial Run) In lieu of the requirements of this paragraph, the following runs shall be made in the order listed:

One-hour run at 89% normal rated speed on propeller load
- One-half hour at 90% normal sea level manifold pressure on propeller load
One-half hour at 100% normal sea level rated manifold pressure at normal rated speed.

During the last ten minutes of the 100% normal manifold pressure run, the auxiliary stage coupling control shall be adjusted by throttling the air stack to give minimum slip and the manifold pressure reduced to a limit with a safe operation margin to prevent damage to the engine. During the first part of this run, the auxiliary stage coupling control shall be adjusted to give maximum slip. During the 100% normal manifold pressure run, the oil consumption shall be measured.

(2) (Ref. Par. F-5a(1)a. Clutch Shift Run) The requirements of this paragraph shall not apply. Hydraulic coupling operation shall be checked by the changes in speed and power during the runs specified in paragraph E-3b(1) above.

(3) (Ref. Par. F-5a(1)b. Take-off Run) During the take-off run, the auxiliary stage coupling control shall be set to obtain the slip required for take-off manifold pressure.

(4) (Ref. Par. F-5a(3). Penalty Run) At the option of the contractor, penalty runs affecting any one of the major assemblies (engine or outboard reduction gear or auxiliary stage) may be run with other "workhorse" or standby assemblies.

(5) (Ref. Par. F-5c(1). One-Hour Final Run) The one-half hour normal manifold pressure run shall be made first followed by the one-half hour 90% normal manifold pressure run. The last ten minutes of the normal manifold pressure run shall be made with the auxiliary stage coupling control set for minimum slip and the manifold pressure reduced to a limit with a safe operation margin to prevent damage to the engine. During the first twenty minutes of the first run and during the last one-half hour run, the auxiliary stage coupling shall be set for maximum slip.

(6) (Ref. Par. F-5c(2). Clutch Shifts) The requirements of this paragraph are not applicable. Hydraulic coupling operation shall be checked by the runs specified in paragraphs E-3b(1) and E-3b(5) above.

(7) (Ref. Par. F-5c(3). Take-off Check) The take-off check shall be made as specified in E-3b(3) above and shall be made prior to the final run of Par. F-5c(1). Following the take-off check, the engine shall be shut down and inspected for coolant, oil and fuel leaks.

(8) (Ref. Par. F-5c(4). Magneto Check) The magneto check shall be made starting at a speed of 2300 RPM instead of 85% normal rated speed. The auxiliary stage coupling shall be set as per above Par. E-3b(3) (Ref. F-5a(1)b) slip.

(9) (Ref. Par. F-6j. Multistage Superchargers) In lieu of the requirements of this paragraph, the tests outlined under Par. E-3b of this specification shall be applicable since the auxiliary stage air shall not be wasted.

(10) (Ref. Par. F-9. Preparation for Storage) The engine shall be prepared for storage in accordance with Par. E-14 of this specification.

E-4. Dry Weight of Complete Engine The total dry weight of the engine complete shall not exceed the value indicated below:

Basic engine, including integral supercharger, supercharger drive mechanism, coolant pump and piping on the engine, engine lubrication system oil pumps, starter connection, including starter dog, tachometer drives, fuel pump drive, generator drive, vacuum pump drives, front half of interstage duct, and all piping and controls between engine parts and water-alcohol injection equipment.

Basic Engine		1218.0 lbs.
Carburetor & nozzle (Part 54802-Assembly)		38.0
Carburetor Screen		Not furnished
Magneto		14.0
Ignition Distributors (Included in Shielding Assembly)		
Radio shielded Ignition Assembly Complete with Cable and Distributors		33.0
Spark Plugs		6.0
Priming System on Engine		1.0
Cooling air deflectors and Baffles		None
Accessory Drive Covers		2.0
TOTAL, POWER SECTION		1312.0 lbs.
Auxiliary Stage Supercharger, Flexible Drive and Rear Half of Interstage Duct	112.0	
Automatic Manifold Pressure Regulator and Auxiliary Supercharger Coupling Control	13.0	
TOTAL, AUXILIARY STAGE UNIT		125.0 lbs.
Outboard Reduction Gear Assembly		175.0
Two Extension Shafts and Support Bearing		48.0
TOTAL DRY WEIGHT OF ENGINE		1660.0 lbs.

E-5. Performance Characteristics The ratings specified herein and the curves specified herein and shown on pages 20, 21, 22 and 23 shall constitute the power and specific fuel consumption guarantees unless specifically stated otherwise on curve sheet. The terms used and the standard conditions shall be in accordance with the applicable definitions contained in either Specification AN-9502 or AN-9503.

E-5a. Ratings The engine shall be rated as follows: (Using Grade 130 fuel conforming to Specification AN-F-28, Amendment No. 2; oil conforming to Specification AN-VV-O-446, Grade 1120; and coolant conforming to Specification AN-E-2 (Ethylene Glycol)

1050 BHP at 2600 RPM at sea level
950 BHP at 2600 RPM at 24,000 feet normal rated altitude
1425 BHP at 3000 RPM take-off for five minutes
1100 BHP at 3000 RPM at 28,000 ft. military rated altitude
3120 RPM rated overspeed dive RPM.

Note (1). Military rating shall be 15 minutes duration for flight and model test purposes.

Note (2). The engine shall be suitable for operation with a 30% Specification AN-E-2 Ethylene Glycol-70% water coolant solution.

Note (3). Any demonstration of ratings shall be made on Referee Fuel 28R, Batch No. 1.

E-5b. Curves The following curves shall be furnished as part of this specification:

E-5b(1). Horsepower vs. altitude at rated speeds up to and including the guaranteed altitude of the engine as shown on page 20.

E-5b(2). Estimated horsepower at full throttle vs. altitude as shown on page 21.

E-5b(3). Specific fuel consumption at low powers and low speeds and a table of fuel consumption as shown on pages 22 and 23.

E-5b(3)a. The data furnished on the above curves shall be based upon standard temperature and pressure at the entrance to the auxiliary stage. Since intercooling is not required, the requirements of paragraph E-5b(3)a of AN-9501 are not applicable.

E-5e. Specific Oil Consumption The specific oil consumption shall not exceed .025 lb/BHP/hr at normal rated power and speed, and .025 lb/BHP/hr at 70 per cent normal rated power and 89 per cent normal rated speed.

E-5h. Coolant Flow and Heat Rejection The following guarantee is given for coolant flow and heat rejection to the coolant when operating on a dynamometer for 5 minutes with a 60°F, 10 MPH air blast over the engine, using 100% AN-E-2 glycol.

I. Conditions (Take-off Powers)

Power	Take-off 1425 BHP (Sea Level Conditions)
Speed	Take-off 3000 RPM
Fuel Consumption	Guaranteed
Oil Inlet Temperature	203°F
Oil Pressure	65 psi
Coolant Outlet Temp.	250°F
Coolant Flow	240 to 265 GPM

Guarantee (Take-off Power)

Coolant flow through the radiator not to exceed 265 GPM
Heat rejection to coolant not to exceed 20160 Btu/min.
(475 HP)

F. Conditions (Normal Power)

Power	Normal 1050 BHP (Sea Level Conditions)
Speed	2600 RPM
Fuel Consumption	Guaranteed
Oil Inlet Temperature	185°F
Oil Pressure	65 psi
Coolant Outlet Temperature	220°F
Coolant Flow	210-230 GPM

Guarantee (Normal Power)

Coolant Flow through the radiator not to exceed 230 GPM.
Heat rejection to coolant not to exceed 16,340 Btu/min.
(385 HP)

E-5h(1). Coolant Pump Characteristics In lieu of the coolant pump flow data required by AN-9501, Paragraphs E-5h(1); E-5h(1)a; E-5h(1)b, the curves shown on page 24 are submitted as the estimated performance of the pump furnished with the engine.

E-5j. Oil flow and Heat Rejection The following guarantee is given for oil flow and heat rejection to the oil when operating on a dynamometer with a 60°F, 10 MPH air blast over the engine:

Conditions

Power	Take-off 1425 BHP
Speed	Take-off 3000 RPM
Fuel Consumption	Guaranteed
Oil Inlet Temperature	203°F
Oil Pressure	65 psi
Coolant Outlet Temp.	250°F
Coolant Flow	265 GPM

Guarantee

Engine:
Oil Flow not to exceed 170 lbs/min.
Heat rejection to oil not to exceed 7215 Btu/min.
(170 HP)

Auxiliary Stage:
Oil flow not to exceed 50 lb/min.
Heat rejection to oil not to exceed 2334 Btu/min.
(55HP)

E-6. Engine Performance The complete engine shall function satisfactorily up to 39,000 feet at the powers and speeds not exceeding those shown on page 20.

E-7. Propeller : The engine shall have a No. 60 propeller shaft end in accordance with AN-9506 except as modified below. The -109 (E22) incorporates the small bore shaft and holes are provided in the end of the shaft for locking the propeller hub nut as required in AN-9506. The -109A (E22A) incorporates the large bore and the holes mentioned above are omitted. Details of the two propeller shafts are shown on the Installation drawing sheet No. 3.

Deviations to AN-9506 are shown below:

Identification of AN-9506 requirement	Requirement AN-9506	-109 (E22)	-109A (E22A)
Dim. C Table II	4.3114 Min.	4.3114 min.	4.321 +.010 -.020
Dim. D Table II	.2233 +.000 -.001	.2233 +.000 -.001	.2233 +.000 -.003
Dim. E Table II	3 5/16	2 13/16	2 3/8
Dim. F Table II	10.500±.015	8.500 +.013 -.011	Not applicable
Dim. J Table II	7.062±.015	6.125 ±.030	See Install. Dwg.
Dim. N Table II	6.687 ±.030	5.750 ±.030	See Install. Dwg.
Dim. H. Table II	1 1/8	See Install. Dwg.	See Install. Dwg.
Dim. M Table II	9/16	9/16	1/8
Fig. 4 & Table II	Gov. oil transfer tube requirements	Not furnished	Not furnished
Fig. 9	11.125±.030 +.030	9.125 +.032 -.020 +.007	Not applicable +.002
Fig. 9 - Stud length See amend. No. 2 to AN-9506	.938-.000	1.000-.028	1.000-.033

Provision shall be made for mounting a propeller governor as specified in Para. E-36g of this specification.

E-12. Overall Dimensions The overall dimensions of the engine shall not exceed the following:

	-109	-109A
Length	211 3/16	210 3/4
Width	29 9/32	29 9/32
Height	40 17/64	40 17/64

E-14. Preparation for Storage The engine shall be prepared for storage in accordance with AN-F-E-568 with the exceptions to paragraphs as listed below:

(1) (Par. B-1a. AN Aero Specification) The requirements of Specification AN-C-80 shall not be applicable.

(2) (Par. B-1b. ANA Standard Drawings) The following Allison drawings shall apply in lieu of AN parts:

41616 - Envelope - Engine Protector
41310 - Cap - Propeller Shaft Thread

(3) (Par. C-2 Auxiliary Oil Tank) The auxiliary oil tank shall not be included in the test stand equipment but shall be installed as part of the "motoring-in" equipment used subsequent to the clear fuel run.

(4) (Par. F-2a(1) Operation Procedure) The requirements of this paragraph shall not apply. As soon as possible and not later than 8 hours after the clear fuel run, the engine shall be "motored-in" at 40 to 80 RPM crankshaft speed for a minimum of 5 minutes after the engine oil outlet temperature reaches 220°F. Also during this operation, dry air at approximately 30% relative humidity at room temperature heated to approximately 250°F shall be circulated through the breather system.

(5) (Par. F-3d. Exhaust Ports and Manifolds) Dehydrating agent shall not be installed in the exhaust ports.

(6) (Par. F-3h. Intake Manifold) A one-pound bag of dehydrating agent shall be placed in the inlet to the carbureter and the opening sealed with a gasketed cover. ted cover to the carburetor.

(7) (Par. F-3m. Crankcase) The dehydrator plug shall be installed in a suitable opening of the crankcase.

(8) (The auxiliary stage supercharger and outboard reduction gear assembly shall be prepared for storage as nearly as practical in conformance with AN-F-E-568.

E-18. Propeller Drive The engine shall be equipped with a reduction gear ratio of 2.23:1. The propeller drive shall be mounted on a remote gear box located outboard of an extension shaft which operates at crankshaft speed. The gear box shall be lubricated from an external tank of not less than 2 gallons oil capacity, which shall not be provided with the engine. The direction of propeller rotation when viewed from the anti-propeller end, shall be clockwise. The maximum oil flow required for the reduction gear box is 20.0 lbs/min. at military speed. The gear box will function satisfactorily provided the correct specified lubricant is used and an oil inlet temperature of 65.6°C (150°F) is not exceeded. The lubricant for the gear box oil system shall conform to Specification AN-O-3 Grade M.

E-19. Impeller Gear The impeller gear ratios and diameters shall be as follows:

Engine stage 8.1:1 and 9 1/2 inches
Auxiliary stage 7.23:1 and 12 3/16 inches

E-20. Pistons The engine shall be fitted with pistons of 6.65:1 compression ratio.

E-23a(1). Spark Plugs The engine shall be fitted with AC IS86, Champion RP43S or Champion C34S* spark plugs in accordance with AN-P-4, except that the date of manufacture shall not be marked on the plug.

E-23b. Radio Shielded Ignition Assemblies The ignition distributors and magneto shall be designed to permit supercharging from the auxiliary stage supercharger outlet. The engine shall be equipped with Allison designed radio shielded ignition assemblies with the following exceptions to Specification AN-9510:

(1) (Ref. Par. A-1) The following specifications except as modified herein shall apply in lieu of those listed in AN-9510.

AAF Spec. 32427	High Tension Cable
AN-P-4	Plugs - Spark
AN-M-4	Magneto - (except [illegible]

(2) (Ref. Par. D-1b. Accessibility) The requirement shall be met except that it shall be necessary to loosen part of the shielding assembly to replace the intake spark plug conduits or cable.

(3) (Ref. Par. D-3. Marking) The high tension ignition cables shall be marked with the proper cylinder designation.

(4) (Ref. Par. D-5. Bonding) The requirements of this paragraph shall not apply.

(5) (Ref. Par. D-8. Nameplate) A nameplate shall not be provided.

(6) (Ref. Par. E-1a. Single Cable Conduits) Single cable conduit connections shall be as shown on Allison Drawing Nos. 44888 and 53166.

(7) (Ref. Par. E-6. Weight) The requirements of this paragraph shall not apply.

(8) (Ref. Par. E-7. Watertightness) The requirements of this paragraph shall not apply.

(9) (Ref. Par. E-8. Capacitance) The capacitance between the shielding and each ignition cable contained therein shall not exceed 175 micromicrofarads.

E-23c. High Tension Ignition Cable (Ref. AN-9500, Par. D-23c) High tension cable shall conform to AAF Specification No. 32427.

E-23d. Magnetos The engine shall be equipped with one Scintilla type DFLN5 magneto in accordance with AN-M-4 with the following exceptions:

(1) (Ref. Par. D-1g(1)a. Type Designation) The type designation shall be DFLN5, utilizing the "F" to denote a flange type mount and omitting the numeral to designate the number of cylinders.

(2) (Ref. Par. D-1h. Distributor Block Cable Connection) The requirements of this paragraph are not applicable. The distributor blocks are not furnished with the magneto.

(3) (Ref. D-1j. Ground Terminal) Each magneto shall be provided with a primary ground terminal conforming to AN-3105 and terminal socket as shown in Figure 2 except that the terminal shall be secured by a hexagon nut.

(4) (Ref. Par. D-3b. Installation Instruction) The requirements of this paragraph are not applicable.

(5) (Ref. Par. D-4g(4)a. Rain and Spray) Requirements of this paragraph shall not be applicable. The installation of this magneto on Vee-Type engines requires and permits maximum ventilation in the breaker cover.

(6) (Ref. Par. D-4h. Endurance) The requirements of this paragraph shall be applicable except as modified by deviations to paragraphs F-6h(1).

(7) (Ref. Par. E-2a. Mounting Pad) The mounting pad and drive shall conform to the dimensions shown on the Allison Division drawing of the magneto, No. 53101.

(8) (Ref. Par. E-2b. Coupling) The coupling shall conform to the detail requirements indicated on the Allison Division drawing of the magneto, No. 53101.

(9) (Ref. Par. F-5. Test Conditions) The requirements of this paragraph shall apply except that the tests specified at room temperature shall be performed at an atmospheric temperature of 15°C to 35°C (approx. 59°F to 95°F.)

(10) (Ref. Par. F-6a. Conditioning) In lieu of the requirements specified, the following shall apply:- The standard sphere gap as shown in Figure 3 set at 3 millimeters, unless otherwise specified, shall be used to calibrate test gaps used on all tests described below.

(11) (Ref. Par. F-6h(1). Operating Run) In lieu of the requirements of this paragraph, the following shall apply:

The magneto shall be run for 600 hours continuously, except when stopped for short intervals for servicing, in an ambient air temperature of 60°C, (140°F), with the air passing over the magneto at 20 MPH, full spark advance, and rated maximum rotor speed with each lead connected to a standard test gap shunted by a normal load. No attention shall be required except by the breaker mechanism which may be reset and lubricated at 100-hour intervals. At the end of each hour, the primary current shall be short-circuited and grounded for a period of 5 seconds.

E-23f. Cooling (Ref. Spec. AN-9500, Par. D-23f) Provision for cooling the spark plugs and the spark plug elbows shall consist of spark plug cooling manifolds as shown on the Installation Drawing. The airplane manufacturer shall make provision for circulating sufficient air through the cooling manifolds, and shall maintain engine compartment temperature suitable for operation of ignition parts when manufactured and installed in accordance with the following specifications:

Spark Plug - AN-P-4
High Tension Cable - AAF Specification 32427
Magneto - AN-M-4 (except as modified herein)

E-24. Lubricating System The oil supply for the outboard reduction gear assembly shall be separate from the engine as stated in Par. E-18 of this specification. The auxiliary stage supercharger shall be equipped with scavenge and pressure oil pumps which are independent from the engine. The unit is designed to operate from either the engine oil supply tank or a separate oil supply tank.

E-24e. Scavenging System. The engine scavenging system shall also operate satisfactorily at take-off power and speed with an oil having a viscosity equivalent at 100°F to specification AN-VV-O-446, Grade 1100 plus 30% by volume of gasoline in accordance with specification AN-F-28 with 40 lb/sq.in. gage back pressure on the scavenging pump outlet. For demonstration purposes the oil shall contain no gasoline.

A five-minute run at room temperature conditions with temperatures stabilized at 90°F to 120°F "oil in", and 160°F to 180°F "coolant out" and at take-off power and speed on an engine other than the model test endurance engine shall constitute the requirements for demonstrating satisfactory scavenging.

E-24g. Oil Cleaner The engine shall be equipped with one Airmaze oil strainer, Allison Part No. 53073. The auxiliary stage shall be equipped with one airmaze oil strainer Allison Part No. 53238. Foreign matter removed by the cleaners shall not reenter the lubricating system except under operating conditions when the by-pass valve is open.

E-24o. Lubrication Points The various components of the assembly requiring lubrication other than from the engine lubrication system are as follows:

Component	How lubricated
Outboard Reduction Gear Assembly	Separate Oil Tank, see Par. E-18
Extension Shaft Center Bearing	Manual Lubrication AN-G-3
Auxiliary Stage Supercharger	Separate System as described in Par. E-24
Auxiliary Stage Supercharger-Flexible Drive	Manual Lubrication Use Federal Specification VV-O-611 Grade 2

E-24q. Crankcase Breathing The requirements of Par. D-24q of AN-9500 shall be met except that pressure in the crankcase may exceed the 1/2 psi requirement during operation with diluted oil.

The breather shall likewise operate satisfactorily at take-off conditions with oil specification AN-VV-O-446 Grade 1100 diluted 20% by volume with Grade 130 (AN-F-28) fuel at an ambient temperature of 60° to 100°F. Satisfactory operation shall be defined as an oil loss of not over 3 quarts during operation at the following conditions. Gasoline loss shall not be included in the above three quarts.

Manifold Pressure	Control Setting for Take-off
Speed	3000 RPM
Period	5 minutes
Oil inlet Temp. at start of test	80-90°F
Oil inlet Temp. at end of test	Not over 140°F
Coolant out Temp. at start of test	175° to 185°F
Coolant out Temp. at end of test	Not over 250°F
Diluted mixture in oil tank	8-9 gal.

NOTE: A warm-up period of at least 10 minutes at approximately 1400 RPM shall be allowed.

It is desired that the airplane manufacturer locate the front and rear breather outlets to maintain a crankcase pressure measured at the front breather within the limits of +8 to -4 inches of water. It is also desired that the pressure at the front breather be held to 2 to 6 inches of water higher than pressure at the rear breather to provide ventilation through the engine from front to rear.

E-25. Fuel Metering System The engine shall be equipped with one Bendix-Stromberg Model PD12K15 injection carburetor in accordance with Specification AN-9515 except for the following:

(1) (Ref. Par. D-7. Strainer) The carburetor shall meet the requirements except that foreign material is not removed with the strainer.

(2) (Ref. Par. D-9) The normal operating fuel pressure shall be 17 ± 1 lb/sq/in. in excess of the pressure of the air entering the carburetor.

(3) (Ref. Par. D-32a(2) and Par. D-32a(3). Density Compensation) Carburetors which compensate automatically for densities shall hold at constant air flow the fuel air ratios obtained at standard sea level conditions to within the following limits at carburetor entrance densities and temperatures given below:

DENSITY COMPENSATION

Density (#/cu.ft.)	Temp. °F	% Limits
.10 - .05	-40° - +170°	±3%
.05 - .03	-40° - +150°	±7%

(4) (Ref. Par. D-32b(1)) The military power referred to in this paragraph shall be sea level military or take-off power. The military guaranteed fuel consumption at critical altitude shall not apply to this paragraph.

(5) (Ref. Par. D-32b(2)C) In the range from a speed midway between minimum idling speed and 50% of normal rated speed to 30% of normal rated power the mixture strength shall not be richer than a straight line drawn between the following points:

(a) A point at the speed midway between the minimum idling speed and 50% of normal rated speed which is 12% richer than best power at this speed.

(b) A point at the air flow corresponding to 30% of normal rated power on propeller load which is 9% richer than best power.

(6) (Ref. Par. D-32b(2)D) In the range between the air flows corresponding to 30% of normal rated power and 65% of normal rated power on propeller load the mixture strength in auto-rich shall fall within the limits specified below:

(a) The minimum mixture strength at any point shall not be leaner than best power.

(b) The rich limit shall not exceed 9% richer than best power at the air flow corresponding to 30% of normal rated power and 6% richer than best power at the corresponding airflows from 40% to 60% of normal rated power. At 65% of normal rated power the mixture strength shall fall between 2% and 7% richer than best power.

(7) (Ref. Par. D-32b(3)) With the mixture control in the automatic lean position and in the range between the air flows corresponding to 30% of normal rated power and 65% of normal rated power on propeller load the mixture strength of the reference carburetor shall fall within the limits specified below:

(a) The minimum mixture strength at any point shall not be leaner than best economy.

(b) The rich limit shall not exceed 9% richer than best economy at the airflows corresponding to 30% and 65% of normal rated power and 6% richer than best economy at the corresponding airflows from 40% to 60% of normal rated power.

(8) (Ref. Par. F-4e(3)) Metering Test of Production Carburetors) The requirements of this paragraph shall be met except that mixture readings in automatic lean shall not be checked at air flows corresponding to 40, 80 and 90% normal rated air flows.

The carburetor shall be checked for automatic altitude compensation at airflows equivalent to 50% of normal rated power airflow with the mixture control in the auto-lean position at air box pressure of 0, -4, -8, -16 inches. Hg. less than atmospheric pressure.

The mixture ratio on production carburetor tests at altitude air box conditions shall be within ±2% of the reference carburetor at densities of .076 to .050 lbs/cu.ft. at any constant temperatures in the range of 65°F to 85°F and within ±3% of the reference carburetor at densities of .050 to .030 lb/cu.ft.

E-25c. Carburetor on Air Throttle Entrance Screen (Ref. Spec. AN-9500, Par. D-25c) Provision shall be made for installing a screen in accordance with Allison Division drawing 43655 at the auxiliary stage inlet but the screen shall not be furnished with the engine.

E-26. Engine Starting The engine shall be furnished with priming lines in accordance with Allison Division Drawing No. 43590. The airplane manufacturer shall supply fuel to the priming lines for Engine priming. In lieu of the requirements of Par. D-26 of AN-9500, the following shall apply:

"The engine shall be capable of consistent starting when its temperature has been stabilized in an ambient temperature of minus 30°F when cranked at a minimum of 30 RPM. This shall be accomplished with the specified lubricant diluted 30% by volume using the fuel specified in the engine model specification. The pour point of the diluted oil shall be minus 40°F or lower. The use of special starting fuel shall be permitted. Consistent starting shall be defined as a complete start following not more than two 30-second cranking periods. Starting demonstrations when required shall be made in a laboratory under controlled conditions."

The specified lubricant for cold starting demonstration only shall be Grade 1100 P of Specification AN-O-5.

E-30. Coolant Temperature The cooling liquid outlet temperature shall be 121°C (250°F) for all powers above normal power and 104.4°C (220°F) at normal power and below.

E-30a. Coolant Pressure The maximum inlet pressure to the cooling liquid pump shall be 54" Hg. absolute.

E-31a(3). Supercharger Drain Valve (Ref. Spec. AN-9500 Par. D-31a(3)) A fuel aspirator without a valve shall be the only provision made for automatic drainage of the induction system.

E-32a. Exhaust Flanges (Ref. Spec. AN-9500, Par. D-32a) It is recommended that exhaust flanges in accordance with Allison Part No. 44018 (AMS-5080) or Part No. 34667 (AMS-5645) be used in the installation of this engine. The exhaust flanges shall not be furnished with the engine. Exhaust flange nuts and gaskets in accordance with Allison Part No. 40751 shall be furnished with the engine.

E-34c. Coating Threaded Parts AN-C-53 shall be used except that other compounds may be used on certain parts if specifically approved by the Government.

E-36 Accessory Drives The gear ratio of each accessory drive to the engine crankshaft, the maximum permissible torque in inch-pounds for continuous operation, the maximum permissible static torque in inch-pounds, and the direction of rotation when looking at the end of the accessory drive shaft in the engine shall be as follows:

ACCESSORY AND TYPE	NO. USED	RATIO TO C.S.	MAX.TORQUE CONTINUOUS LBS. IN.	MAX.TORQUE STATIC LBS. IN.	ROTATION C-CLOCKWISE CC-COUNTER CL.
Starter Type I	1	1.000:1	- - - - -	16,200	C
Generator Type I	1	1.440:1	600	3,600	C
Fuel Pump	1	0.864:1	25	450	CC
Vac. & Hyd. Power Pump Side Drive Type II	1	1.440:1	150	2,250	CC
Vac. & Hyd. Power Pump Rear Drive Type II	1	1.440:1	150	2,250	C
Tachometer Type I & II (2 drives)		0.500:1	2.5	12.5	C
Gun Synch.	2	0.449:1	25	125	CC

E-36a. (Ref. AN-9500 Par. D-36a. Starter) The starter mounting pad and drive shall conform to AND-10004 Type I with the following exceptions:

(1) One stud shall be off location by 15° to facilitate removal of the starter.

(2) The studs shall be located by rectangular dimensions from the center line of the pad with ±.005 tolerance instead of by a stud circle with studs equally spaced.

(3) The gasket shall be 1/32 aluminum instead of as specified by AN-4047, and shall have one hole off location by 15°.

E-36a(1). (Ref. Par. AN-9500, Par. D-36a(1). Starter Clearance) Clearance shall not be provided in accordance with AND-10304. (Interference with AND-10304 outline is shown on the Installation Drawing.)

E-36b. Generator and Power Take-off One Type I pad and drive shall be furnished in accordance with AND-10002 except as follows:

(1) Provision for supplying oil to the pad shall be furnished except that the oil shall not be transferred through the adapter described below and the oil hole plug shall be 1/16-27 NPT instead of 1/8 NPT. The drain and vent hole shall be tapped and plugged with removable pipe plugs.

(2) The studs shall be located by rectangular dimensions from the center line of the pad with ±.005 tolerance instead of by a stud circle and angles.

(3) A special adapter to facilitate removal of the generator shall be provided. The adapter shall consist of two flanges - one secured to the accessory mounting pad, and the other to be secured to the generator flange. The two special flanges shall be bolted together by four bolts. Two aluminum gaskets 1/32 thick shall be utilized instead of AN-4047, and the gasket on the generator side of the adapter shall have 12 holes instead of 6. The above adapter decreases the spline engagement by approximately 11/16 in.

E-36b(1). Lubrication Provision shall be made for supplying oil to the pad and for draining oil back into the engine except that oil shall not be transferred through the adapter.

E-36b(2). Generator Accessibility (Ref. AN-9500, Par. D-36c(2)) Clearance shall not be provided in accordance with AND-10305. (Interference with AND-10305 outline is shown on the Installation Drawing.)

E-36d. Gun Synchronizing Generators Provision shall be made for mounting and driving Gun Synchronizing Impulse Generators in accordance with AND-10006 with the exception that no oil seal shall be provided and the slotted screw shall not be provided in the end of the drive shafts.

E-36d(1). Lubrication No provision shall be made for supplying pressure oil to the drive through the drive shaft.

E-36d(2). Location The two pads shall be located on the rear face of the reduction gear box and the face of the pads shall be perpendicular to the longitudinal axis of the engine.

E-36e. Vacuum and Hydraulic Power Pump The rear vacuum and hydraulic power pump pad shall be provided with a drain and vent hole tapped and plugged with a removable pipe plug.

E-36f(1). Tachometer Accessibility. The clearance requirements of Par. D-36g(1) of AN-9500 and AND-10310 shall not be met. Clearance back of the Type I pad shall be made for installing a flexible cable drive in accordance with AN-5533. Clearance back of the Type II pad shall be provided for installation of a tachometer generator in accordance with AN-5531-1.

E-36g. Propeller Governor Drive Provision for mounting a propeller governor shall be made on the rear face of the outboard reduction gear box except that the drive mechanism shall not be furnished.

E-36g(2). Accessibility - Governor. Space shall not be provided back of the governor mounting pad in accordance with AND-10307. Clearance shall be provided as required in Specification AN-9507.

E-44. Supercharger and Manifold Pressure Regulator. The engine shall be equipped with automatic controls designed to coordinate magneto timing, manifold pressure, water-alcohol injection and auxiliary stage supercharger speed.

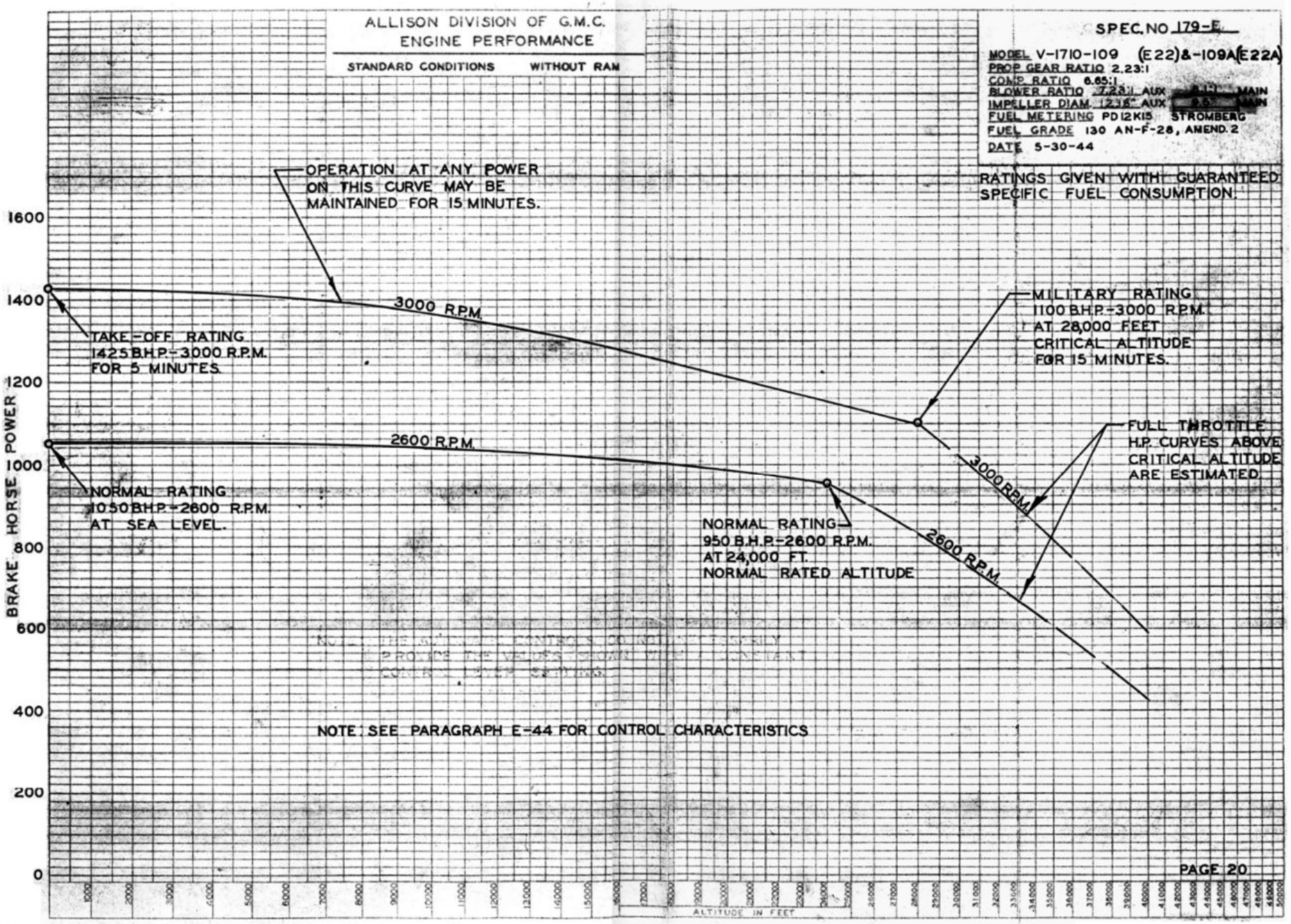
The automatic control altitude - vs. - BHP characteristics at constant lever setting are determined by dry war emergency detonation limits of the fuel. Estimated constant control lever setting line is shown dashed on page 21.

E-46. Torquemeter The engine shall not be equipped with a torquemeter.

F. METHODS OF SAMPLING, INSPECTION AND TESTS

F-2b. Magnetic Inspection. Magnetic Inspection of steel parts shall be in accordance with AN-QQ-M-181 with the following exception to Par. D-1:

> The liquid used as a vehicle for carrying the magnetic substance shall conform to Allison Division Engineering Specificiation ES-6, Revision A.


ALLISON DIVISION OF G.M.C.
ENGINE PERFORMANCE
STANDARD CONDITIONS WITHOUT RAM
SPEC. NO 179-E
MODEL V-1710-109 (E22) & -109A (E22A)
PROP GEAR RATIO 2.23:1
COMP RATIO 6.65:1
BLOWER RATIO 7.28:1 AUX [redacted] MAIN
IMPELLER DIAM. 12.16" AUX [redacted] MAIN
FUEL METERING PD12K15 STROMBERG
FUEL GRADE 130 AN-F-28, AMEND. 2
DATE 5-30-44
RATINGS GIVEN WITH GUARANTEED SPECIFIC FUEL CONSUMPTION.
OPERATION AT ANY POWER ON THIS CURVE MAY BE MAINTAINED FOR 15 MINUTES.
3000 R.P.M.
TAKE-OFF RATING 1425 B.H.P.-3000 R.P.M. FOR 5 MINUTES.
MILITARY RATING 1100 B.H.P.-3000 R.P.M. AT 28,000 FEET CRITICAL ALTITUDE FOR 15 MINUTES.
FULL THROTTLE H.P. CURVES ABOVE CRITICAL ALTITUDE ARE ESTIMATED
2600 R.P.M.
NORMAL RATING 1050 B.H.P.-2600 R.P.M. AT SEA LEVEL.
NORMAL RATING 950 B.H.P.-2600 R.P.M. AT 24,000 FT. NORMAL RATED ALTITUDE
3000 R.P.M.
2600 R.P.M.
NOTE: SEE PARAGRAPH E-44 FOR CONTROL CHARACTERISTICS
BRAKE HORSE POWER
1600
1400
1200
1000
800
600
400
200
0
ALTITUDE IN FEET
PAGE 20

ALLISON DIVISION OF G.M.C.
ENGINE PERFORMANCE

STANDARD CONDITIONS WITHOUT RAM

ESTIMATED FULL THROTTLE
AUTO RICH MIXTURE STRENGTH

SPEC. NO 179-E

MODEL V-1710-109 (E22) & -109A(E22A)
PROP GEAR RATIO 2.23:1
COMP RATIO 6.65:1
BLOWER RATIO 7.23:1 AUX 8.1:1 MAIN
IMPELLER DIAM 12 3/16 AUX 9 1/2 MAIN
FUEL METERING PD12K15 STROMBERG
FUEL GRADE 130 AN-F-28 AMEND. 2
DATE 5-30-44

BRAKE HORSE POWER

1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400

CHARACTERISTIC OF CONTROLS WITH CONSTANT LEVER SETTING (SEE PARAGRAPH E-44).

TAKE-OFF RATING
59.3 "HG

3000 RPM - VARIABLE SLIP

58
56
54
52
50.7
50
48
46
44

IN. HG MANIFOLD PRESSURE

43.5 "HG

2600 RPM - VARIABLE SLIP

42
40
38
36
34
32
30
28
26

2400 RPM - VARIABLE SLIP
38 "HG CONSTANT MANIFOLD PRESSURE

40
38
36

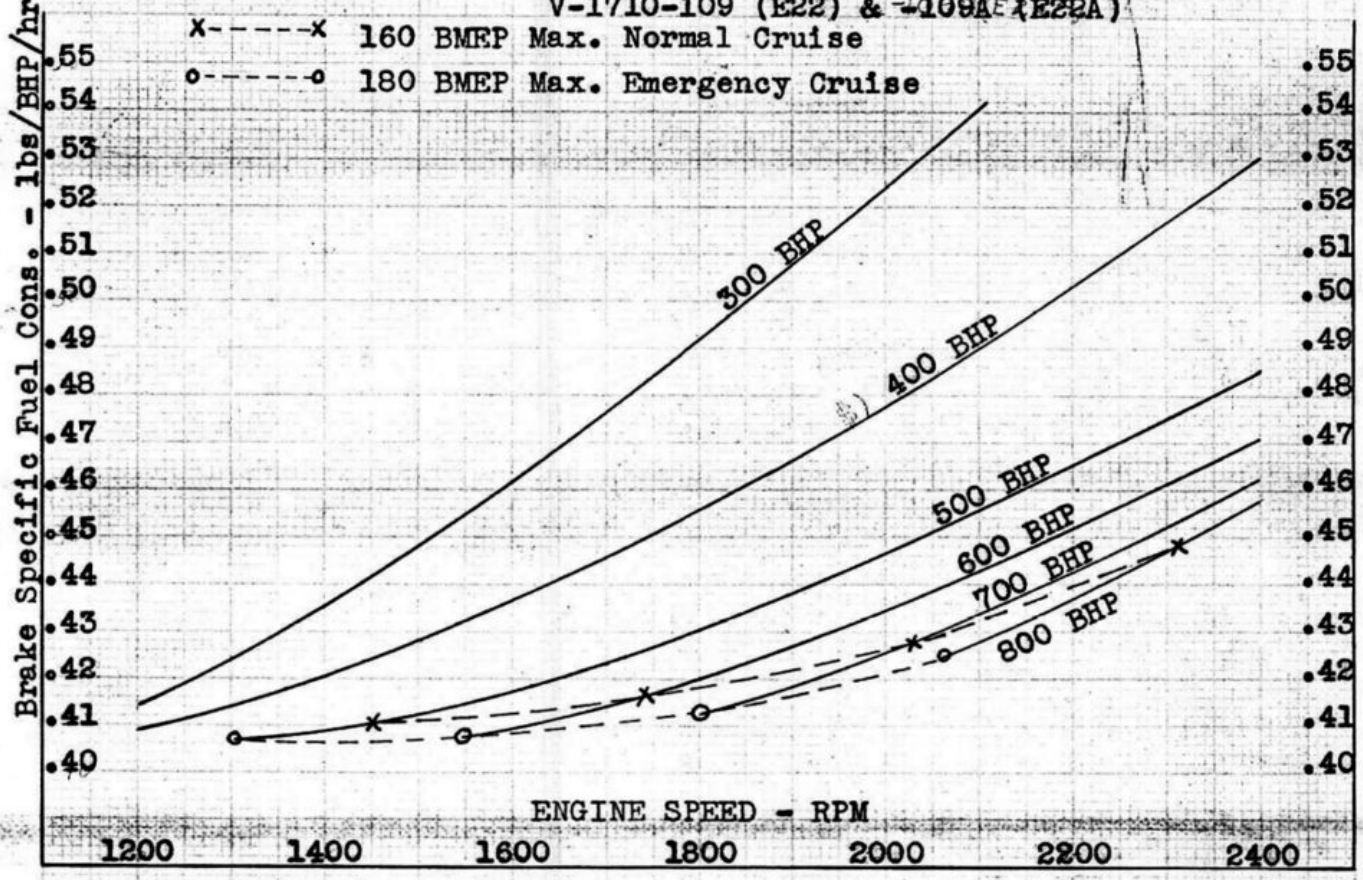
3000 RPM-MINIMUM SLIP
2600 RPM-MINIMUM SLIP
2400 RPM-MINIMUM SLIP

SUBMITTED TO SHOW GENERAL ENGINE CHARACTERISTICS. NOT FOR FLIGHT OR TEST PURPOSES.

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000 20000 21000 22000 23000 24000 25000 26000 27000 28000 29000 30000 31000 32000 33000 34000 35000 36000 37000 38000 39000 40000 41000 42000 43000 44000 45000 46000 47000 48000 49000 50000

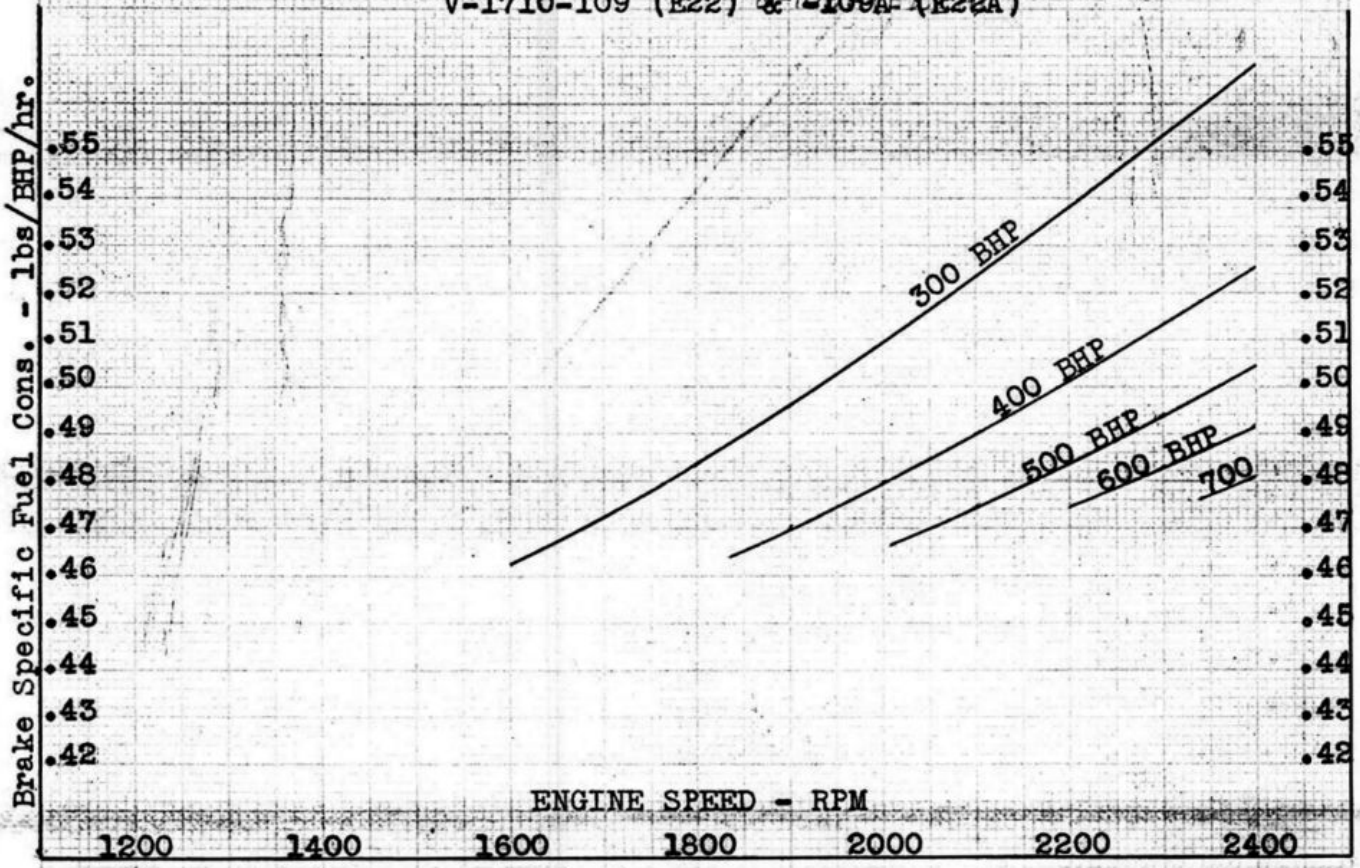
ALTITUDE IN FEET

ESTIMATED BEST ECONOMY SPECIFIC FUEL CONSUMPTION
BASED ON ENGINE REQUIREMENTS AT SEA LEVEL
V-1710-109 (E22) & -109A (E22A)



Guaranteed B.S.F.C. On Normal S.L. Rated Propeller Load at Sea Level.	
% Normal Power	LBS/BHP/HR
100%	0.67
90%	0.65
80%	0.53
70%	0.52
60%	Best Econ.
Take-off power -- 0.72	
Military Power at 3000 RPM Crit. Altitude 0.80	
Military Power at 3200 RPM Crit. Alt. - 0.87	

ESTIMATED BEST ECONOMY SPECIFIC FUEL CONSUMPTION
BASED ON ENGINE REQUIREMENTS AT NORMAL RATED ALTITUDE
V-1710-109 (E22) & -109A (E22A)



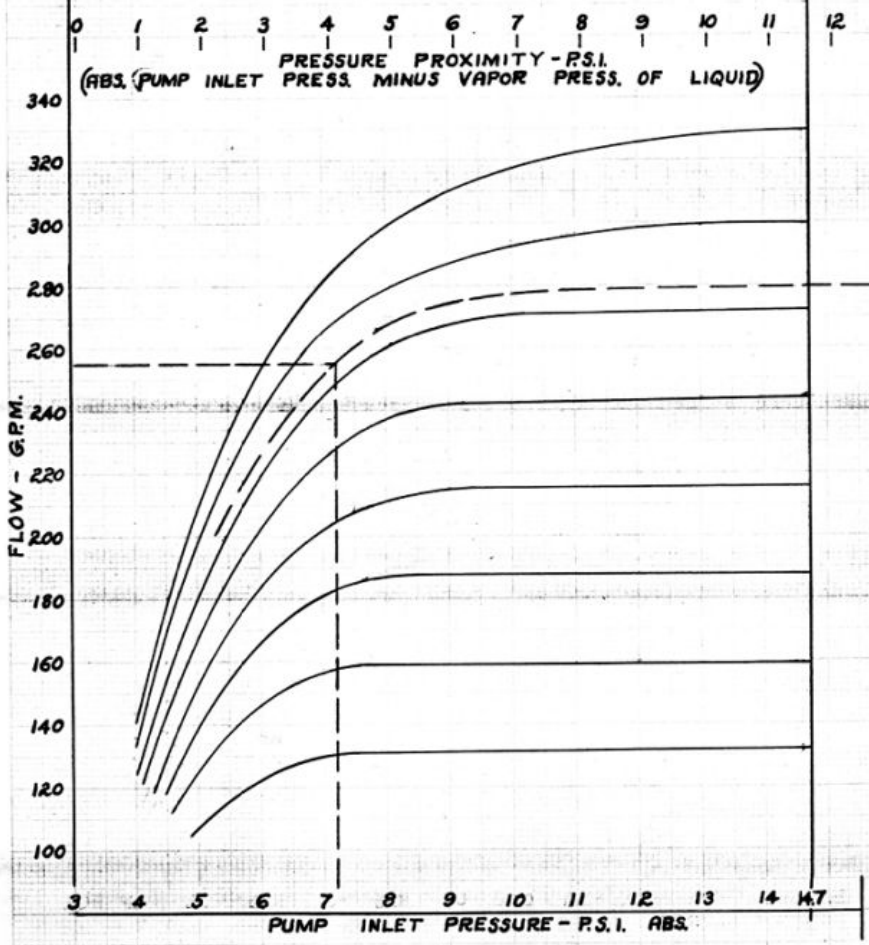
Guaranteed B.S.F.C. At Normal Rated Altitude On Propeller Load.	
% Normal Power	LBS/BHP/HR
100%	0.68
90%	0.63
80%	0.56
70%	0.55
60%	Best Econ.

ESTIMATED V-1710 COOLANT PUMP CHARACTERISTICS

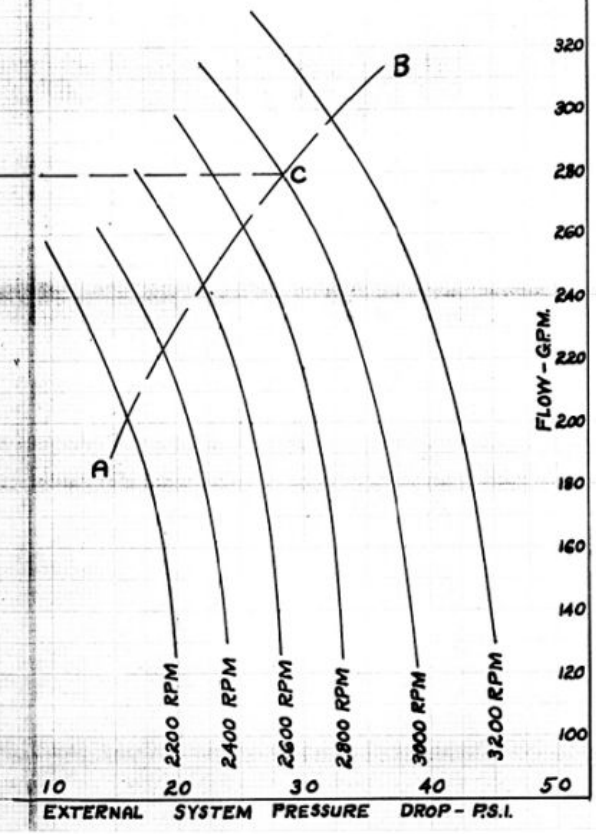
100 % SPEC. AN-E-2 ETHYLENE GLYCOL AT 242 °F APPROX.
SHOWING RELATION BETWEEN ENGINE RPM, EXTERNAL PRESSURE DROP, AND PUMP INLET CONDITIONS

SPECIFICATION NO. 179-B
V-1710-109(E22)&-109A(E22A)
ALLISON DIVISION OF
GENERAL MOTORS CORP.
COOLANT PUMP NO. 53230
5-30-44

CURVES SHOWING EFFECT OF PUMP INLET PRESSURE AND PRESSURE PROXIMITY ON FLOW.



FLOW VS. PRESSURE DROP IN THE EXTERNAL SYSTEM (ENGINE OUTLET TO PUMP INLET) AT 14.7 P.S.I. PRESSURE AT PUMP INLET FOR VARIOUS SPEEDS.



Example

Assume that in a given installation the pressure drop vs. flow curve of the system external of the engine (Block outlet to pump inlet) is as shown by curve A-B. This curve crosses the 3000 RPM line at C and indicates that at 14.7 psi pump inlet pressure the coolant flow will be 280 GPM. Following the dotted example back to the left side of the page, interpolating between curves and assuming that the required flow is 255 GPM, it will be necessary to maintain a minimum pump inlet pressure of 7.2 psi absolute.

The following specifications and drawings of the issue in effect as listed below and as modified herein shall form a part of this specification. Any revisions and/or amendments issued prior to date of bid for this model engine and after the particular dates listed below shall not be applicable.

ANA SPECS.	REV.	AMEND.	DATED	TITLE (IN BRIEF)
AN-VV-C-576	(a)	(1)	6/3/43	Compound - Corrosion Preventive
AN-F-E-568	(b)		10/22/43	Preparation for Storage
AN-GGG-P-363		(2)	5/9/42	Pipe Threads
AN-GGG-S-126	(a)		1/30/43	Screw Threads
AN-QQ-M-181	(a)	(2)	5/10/43	Magnetic Inspection
AN-VV-F-746		(1)	11/5/40	Fuel - Gen. (Knock Test)
AN-VV-F-748	(a)	(1)	3/23/43	Fuel - Gen. (Super Knock Test)
AN-F-22			7/26/43	Fuel - Grade 62
AN-F-26		(2)	11/15/43	Fuel Grade 91
AN-F-28		(2)	10/2/43	Fuel Grade 130
AN-VV-O-446	(a)		1/5/43	Oil Lubricating
AN-P-4		(2)	6/23/43	Spark Plugs
AN-O-5			4/27/43	Oil-Low Pour Lubricating
AN-M-4		(1)	1/19/44	Magnetos
AN-E-2			7/23/42	Ethylene Glycol
AN-G-3	(a)	(2)	3/6/44	Grease Low Temp.
AN-C-53		(2)	12/21/43	Compound-Anti-seize
AN-QQ-P-421	(a)	(1)	11/12/42	Cadmium Plating
AN-O-3		(3)	3/28/44	E.P. Gear Oil

ARMY-NAVY SPECS.

AN-9500	(b)		8/26/42	Engines - General
AN-9501	(b)		8/10/42	Engines - Model Spec.
AN-9502	(b)		8/11/42	Engines - Type Test
AN-9503	(b)		8/6/42	Engines - Acceptance Test
AN-9504		(1)	12/25/40	Engines - Torsional Vibration
AN-9506		(2)	4/1/40	Noses - Engine
AN-9507		(3)	12/28/39	Governors
AN-9510	(a)	(2)	6/19/42	Shielding - Radio
AN-9515	(b)		8/6/42	Carburetors

AAF SPECS.

32427		(1)	11/17/43	Cable-High Tension Ignition

ANA STAND. DWGS.	REV.	AMEND.	DATED	TITLE (IN BRIEF)
AN-4028			12/12/42	Markers - Ignition Cable
AN-4034			11/2/42	Data Plate
AN-4037			6/10/40	Oil Flange-3 bolt
AN-4044	1		8/1/42	Gasket - Vacuum Pump
AN-4048			1/6/42	Oil Flange-4 bolt
AN-4059			9/2/42	Gasket Fuel Pump
AN-5531-1			4/13/43	Generator-Elec. Tach.
AN-5533			3/28/44	Shaft-Tach. Flexible Drive
ANA DESIGN STD.				
AND-10001	1		10/3/42	Hyd. & Vac. Pump Pad-Type II
AND-10002			10/30/42	Generator Pad
AND-10003	1		9/5/42	Fuel Pump Pad
AND-10004	2		4/30/43	Starter Pad (All Types)
AND-10005	1		8/20/42	Tachometer Pad (Both Types)
AND-10006			8/24/42	Gun Syn. Pad and Drive
AND-10301	1		3/28/42	Vacuum Pump Clearance Type II
AND-10302	1		3/19/42	Hyd. Pump Clearance Type II
AND-10304			9/2/41	Starter Clearance Type I
AND-10305			2/28/42	Generator Clearance
AND-10307			11/25/41	Prop. Gov. Clearance
AND-10308			6/25/42	Gun Synch. Clearance
AND-10310			12/5/41	Tachometer Clearance
AND-10320			2/16/42	Fuel Pump Clearance
FEDERAL SPECS.				
VV-O-611			2/5/35	Oil; Lub., Steam Cylinder