CHAPTER 81

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CHAPTER 81 - TURBINES

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GENERAL - DESCRIPTION AND OPERATION

TURBOCHARGER SYSTEM

(Figure 1)

The turbocharger is standard equipment on the Duke. It increases the power output and efficiency of the engine by supplying compressed air to the intake manifold. In operation, engine exhaust gas passing over the turbine wheel causes the turbocharger compressor, mounted on the same shaft, to rotate. Ambient, ram air, supplied through the RH cowl door, is filtered and routed to the compressor where it is compressed and delivered to the engine and through a sonic nozzle to the cabin. The sonic nozzle, located on the intake housing, between the turbocharger compressor and throttle valve, supplies air flow for cabin pressurization. As the engine power increases, the flow of exhaust also increases, resulting in a proportionate increase in the speed of the rotating assembly and turbocharger output.

CONTROL SYSTEM

The turbocharger control system is automatic and functions continuously as engine power, speed and altitude are varied. The variable pressure controller, wastegate, wastegate actuator and engine oil are the principal components of the control system. The pressure controller senses compressor outlet pressure and regulates the oil pressure controlling the wastegate actuator position. The wastegate actuator is a hydraulic cylinder with spring tension holding the wastegate butterfly valve open. When oil pressure increases in the actuator, the spring tension is overcome and the butterfly valve closes, routing all exhaust through the turbocharger turbine. The variable pressure controller regulates the oil pressure in the actuator by means of an aneroid bellows which is sensitive to pressure changes at the induction manifold. The metering valve, which is connected to the bellows within the controller, is held closed by spring tension and vacuum. As the induction manifold pressure increases, the force of the aneroid bellows causes the metering valve to open. The controller is regulated by a cam which is connected to the throttle valve. Through this linkage, the pressure setting of the controller is varied proportionally to the amount of power the pilot selects with the throttle. The control system prevents the engine from exceeding 41.5 in. Hg manifold pressure; however, rapid movement of the throttle with low oil temperature or operation at low rpm with high manifold pressure may result in an overboost condition. An overboost condition may cause turbocharger surge, detonation or detuning of the engine counterweight system; any of which may cause serious engine damage.

OVERBOOST CONTROL

On serials P-247 and after, the engine incorporates a relief valve in the induction system which is set to relieve at approximately 44 in. Hg. (See Figure 1.) This valve will open only in the event of a malfunction in the variable absolute pressure controller system.

CAUTION

To avoid exceeding the normal limits, particularly in cold weather, the last 1-1/2 inches of throttle travel should be applied slowly while observing the manifold pressure. Momentary overboost to the limits of the relief valve (44 in. Hg) will have no detrimental effect on the engine, but is indicative of a malfunctioning variable absolute pressure controller. If overboost is more than momentary, or occurs when engine oil temperatures are normal, the controller should be checked by a authorized facility.

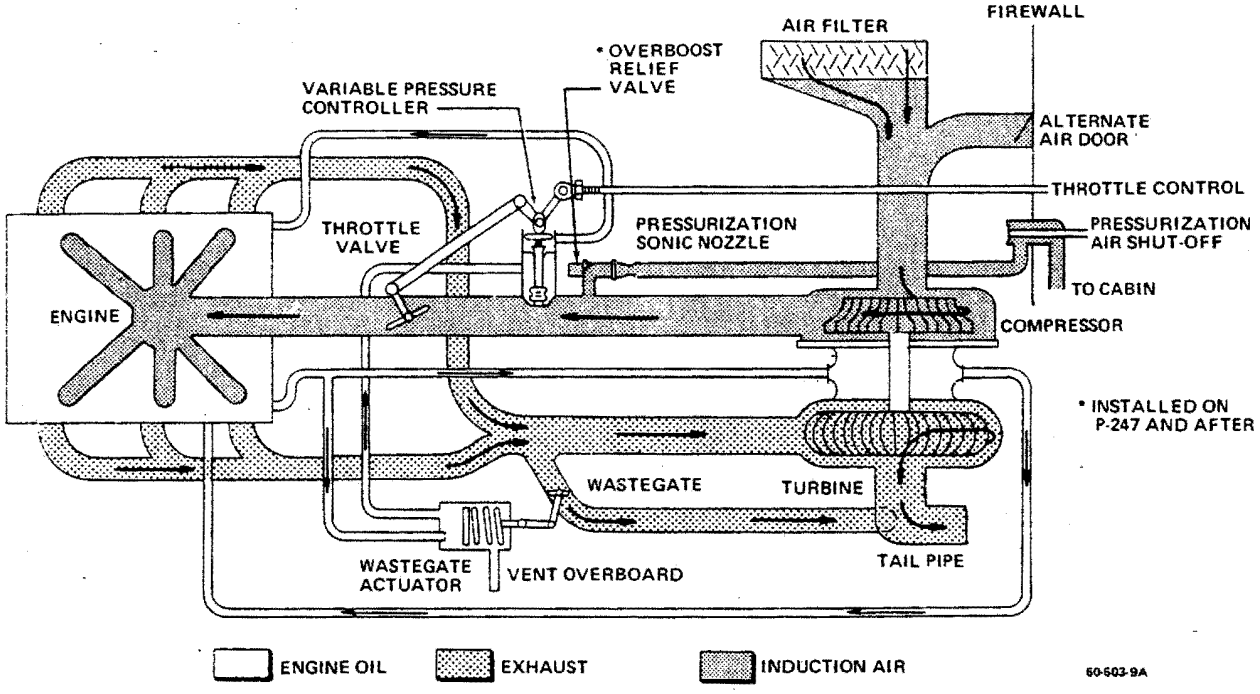
ENGINE AIR INDUCTION SYSTEM

Engine induction air is available as two sources, primary and alternate air. The primary air source is supplied through an intake duct, located on the engine RH cowl door, passes through an air filter, and then into the turbocharger.

NOTE

The air filter, located in the air box assembly, has a service life of 500 hours with periodic cleaning.

When the primary source of air is obstructed, the turbocharger forms a suction that opens the "Alternate Air Source" door and permits the required volume of air flow for normal engine performance. The alternate air door is located on the firewall behind the induction air box assembly.



Turbocharger System
Figure 1

"END"

TROUBLESHOOTING
TURBOCHARGER

	TROUBLE		*PROBABLE CAUSE*		*REMARKS*
1.	Excessive noise or vibration.	a.	Improper bearing lubrication.	a.	Supply required oil pressure. Clean or replace oil line. If trouble continues, remove turbocharger and return to approved overhaul station for overhaul or repair.
		b.	Leak in engine intake or exhaust manifold.	b.	Tighten loose connections, or replace manifold gaskets as necessary.
2.	Engine will not deliver rated power.	a.	Clogged manifold system.	a.	Clean all ducting.
		b.	Foreign material lodged in compressor impeller or turbine.	b.	Remove turbocharger and return to approved overhaul station for overhaul or repair.
		c.	Excessive dirt buildup in compressor.	c.	Service engine induction air filter and check for leakage. Remove turbocharger and return to approved overhaul station for overhaul or repair.
		d.	Leak in engine intake or exhaust manifold.	d.	Tighten loose connections, or replace manifold gaskets as necessary.
		e.	Rotating assembly bearing seizure.	e.	Remove turbocharger and return to approved overhaul station for overhaul or repair.
		f.	Restriction in return lines from actuator to wastegate controller.	f.	Remove and clean lines.
		g.	Wastegate controller out of adjustment.	g.	Have wastegate controller adjusted.
		h.	Oil pressure too low.	h.	Tighten fittings, replace lines or hoses. Increase oil pressure.
		i.	Inlet orifice to actuator clogged.	i.	Remove inlet line at actuator and clean orifice.
		j.	Wastegate controller malfunction.	j.	Replace unit.
		k.	Wastegate butterfly not closing.	k.	Low pressure, butterfly shaft binding.

TROUBLESHOOTING
TURBOCHARGER (Cont'd)

	TROUBLE		*PROBABLE CAUSE*		*REMARKS*
2.	Engine will not deliver rated power (Cont'd).	l.	Impeller binding, frozen or fouling housing.	l.	Remove turbocharger and return to approved overhaul station for overhaul or repair.
		m.	Piston seal in actuator leaking.	m.	Replace actuator or disassemble and replace packing.
3.	Critical altitude lower than specified.	a.	Controller not getting enough oil pressure to close by-pass valve.	a.	Check pump outlet pressure, oil filters and lines for leaks or obstructions.
		b.	Chips under metering valve in controller holding it open.	b.	Replace controller.
		c.	Metering jet in actuator plugged.	c.	Remove actuator and clean jet.
		d.	Actuator piston seal leaking excessively.	d.	Clean cylinder and replace piston seal.
		e.	Wastegate valve sticking.	e.	Clean and free action.
4.	Engine surges or smokes.	a.	Air in oil lines or actuator.	a.	Bleed system.
		b.	Control metering valve stem seal leaking oil into manifold.	b.	Replace controller.
		c.	Actuator to by-pass valve linkage binding.	c.	Correct cause of binding.
		d.	Clogged breather.	d.	Check breather for restriction to air flow.

NOTE

Smoke would be normal if engine has idled for a prolonged period.

5.	High deck pressure (Compressor discharge pressure).	a.	Controller metering valve not opening.	a.	Replace controller.
		b.	Exhaust by-pass valve sticking closed.	b.	Shut-off valve in return line inoperative.
		c.	Controller return line restricted.	c.	Clean or replace line.
		d.	Oil pressure too high.	d.	Reduce oil pressure.

TROUBLESHOOTING
TURBOCHARGER (Cont'd)

TROUBLE		*PROBABLE CAUSE*		*REMARKS*
5. High deck pressure (Compressor discharge pressure) (Cont'd).	e.	Wastegate actuator piston locked in closed position.	e.	Disassemble actuator, check condition of piston and packing.
	f.	Wastegate controller malfunction.	f.	Replace controller.

"END"

GENERAL - MAINTENANCE PRACTICES

INSTALLATION AND INITIAL RUN-IN OF TURBOCHARGER

Immediately prior to mounting the unit, prime the turbocharger lubrication system by inverting the turbocharger and filling the center housing with new, clean oil through the oil drain. Rotate the assembly by hand to coat the bearings and the thrust washer with oil.

Coat the threads of the attaching bolts or studs with high temperature thread lubricant. Connect the ducts and make sure all connections are air tight.

Flush oil through the oil supply line to assure the line is clean and unobstructed. Connect the oil supply line at the engine. To be sure that oil is being supplied to the turbocharger, hold the compressor impeller by hand and start the engine.

WARNING

Do not attempt to stop impeller after unit is rotating.

As soon as oil appears at the end of the oil inlet line, attach the line to the turbocharger and allow the rotating assembly to spin.

Operate the engine at a load and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, shut down immediately and replace the unit.

For a list of approved turbocharger overhaul and repair facilities, refer to the Component Maintenance Manual P/N 60-590001-27.

RIGGING THE THROTTLE AND TURBOCHARGER PRESSURE CONTROLLER LINKAGE
(Figure 201)

a. With the injector connecting rod installed, determine that the throttle lever moves freely from idle to full open throttle.

b. Adjust the pressure controller rod so that, with the pressure controller cam arm against the full boost stop (full forward position), the throttle lever is approximately .020 - .030 inch from the full throttle position.

VARIABLE PRESSURE CONTROLLER ADJUSTMENT
(Figure 202)

The variable pressure controller is mounted directly to the turbocharger discharge ducting between the oil filler neck and the engine throttle valve.

Adjustment of the controller is made as follows:

a. Head the aircraft into the wind. Set the brakes and chock the wheels.

b. Warm up the engine until the oil temperature reaches a minimum of 185°F.

c. Set the propeller control lever in the high RPM position. Slowly and smoothly apply the throttle until 41 in. Hg manifold pressure or the full throttle position is reached.

CAUTION

Do not exceed 41.5 in. Hg manifold pressure.

d. If at the full throttle position the manifold pressure has not reached 41 in. Hg:

1. Slowly and smoothly shut down the engine.
2. Loosen the locknut on the adjusting screw.
3. Turn the adjusting screw counterclockwise to increase the manifold pressure. (One full turn equals approximately 1 in. Hg manifold pressure).
4. Retighten the locknut on the adjusting screw.

e. If the manifold pressure reaches 41 in. Hg before obtaining full throttle:

1. Slowly and smoothly shut down the engine.
2. Loosen the locknut on the adjusting screw.
3. Turn the adjusting screw clockwise to decrease the manifold pressure. (One full turn equals approximately 1 in. Hg manifold pressure).
4. Retighten the locknut on the adjusting screw.

CAUTION

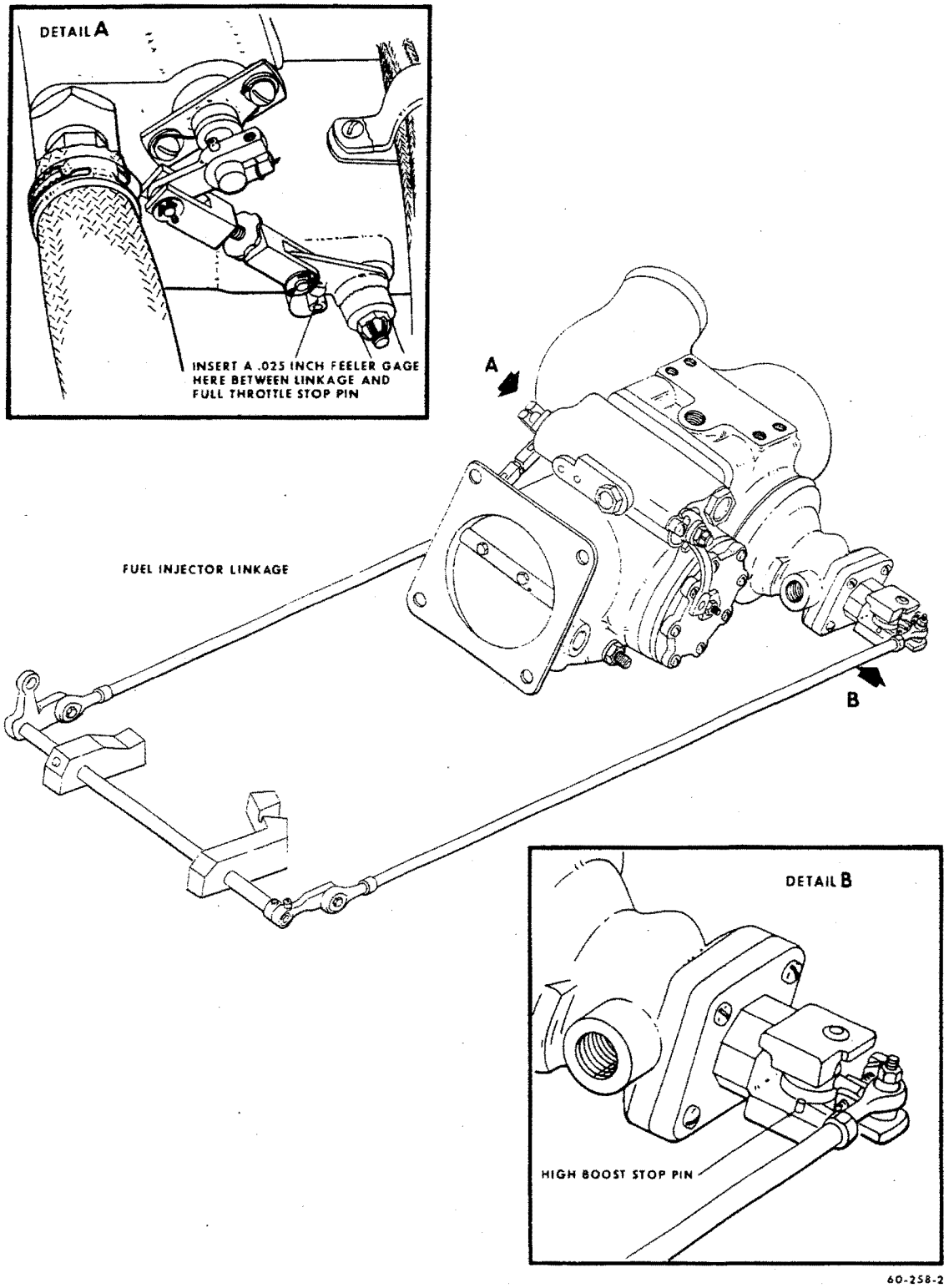
Do not exceed 41.5 in. Hg manifold pressure.

f. Repeat steps "b." through "e." until the manifold pressure at full throttle is 41 in. Hg.

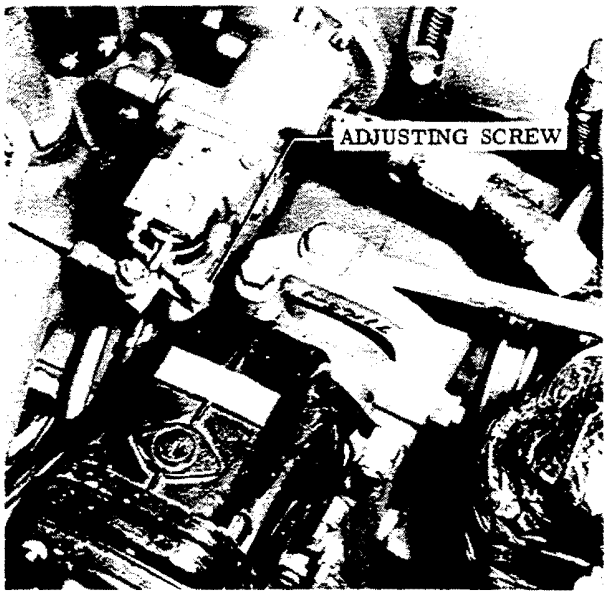
LUBRICATION OF WASTEGATE BUTTERFLY SHAFTS

Rust deposits may form in the area of the wastegate butterfly shaft bosses as a result of water vapor accumulation if the aircraft is subjected to short intervals of engine operation.

This condition occurs only when the unit is new and combustion deposits have not formed a protective barrier



Throttle and Turbocharger Controller Adjustment
Figure 201



Variable Pressure Controller
Figure 202

on the shaft surface. Units which are binding after long service time are coked internally and must be removed for cleaning or replacement.

When this condition is noted, remove the exhaust discharge stack and apply Mouse Milk or Kano Kroil (37, Chart 207, 91-00-00) liberally to the shaft and boss. After a few minutes attempt to turn the shaft. A light tap on the shaft end will assist in freeing the shaft. Once the shaft is free the engine may be started and a power check made to confirm the turbocharger output, either on the ground or in flight.

ADJUSTMENT OF TURBOCHARGER WASTEGATE VALVE
(Figure 203 or 204)

The linkage connecting the butterfly valve to the actuator is adjustable. It is adjusted at the time of valve installation so that the piston in the actuator cylinder bottoms at the same time, or just before, the butterfly valve seats in its bore. Misadjustment of the linkage may cause the butterfly valve to seat before the actuator piston bottoms and will result in damage to the linkage, as the hydraulic closing forces are high at engine idle or during cold engine operation. The linkage adjustment is used to establish critical altitude, which is the altitude at which the wastegate butterfly just fully closes. The adjustment must be made with full hydraulic or air pressure applied to the inlet port of the wastegate actuator. The full open butterfly stop adjustment, located on the center of the actuator cover, may be adjusted to stop the butterfly at the position required for safe engine operation. In the event the butterfly valve fails to close or fully open, adjustment of the valve is made as follows:

a. Disconnect both the inlet and outlet oil lines at the wastegate actuator. Plug the actuator outlet port and connect an air pressure supply line to the inlet port. This line must have a pressure gage installed to maintain 50-60 psi into the wastegate actuator.

b. Loosen the locknut on the adjusting turnbuckle and remove the cotter pin, washers and pin.

c. Apply 50 - 60 psi to the wastegate actuator and adjust the closed position of the wastegate butterfly valve by rotating the turnbuckle counterclockwise to fully close the wastegate butterfly. After the butterfly has made contact with the bore, back off the turnbuckle clockwise until the hole and slot align.

NOTE

Maintain a clearance of .005 to .025 (P-4 through P-143), .005 to .015 (P-144 and after) between butterfly edge and bore.

d. Reinstall the pin, washer and cotter pin. Tighten the locknut against the clevis with 80 to 100 in-lbs. torque.

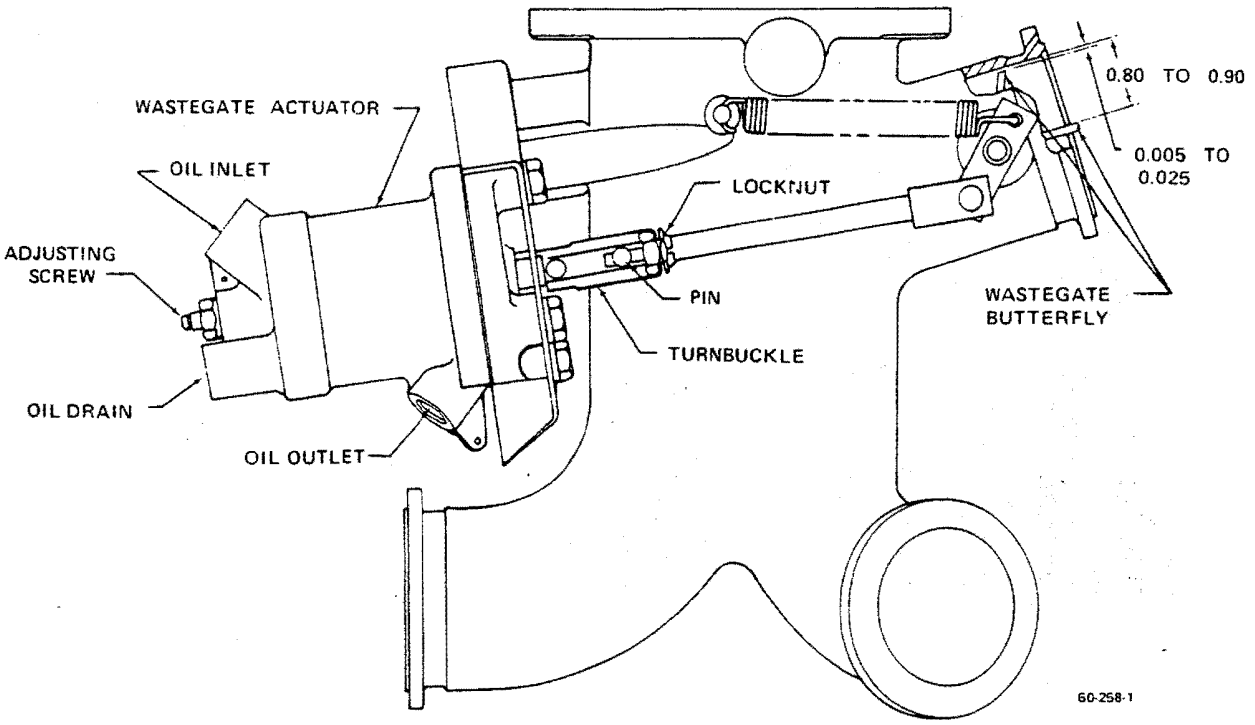
e. With zero air pressure in the wastegate actuator, adjust the full open stop position of the butterfly valve with the adjusting screw located on the end of the actuator.

NOTE

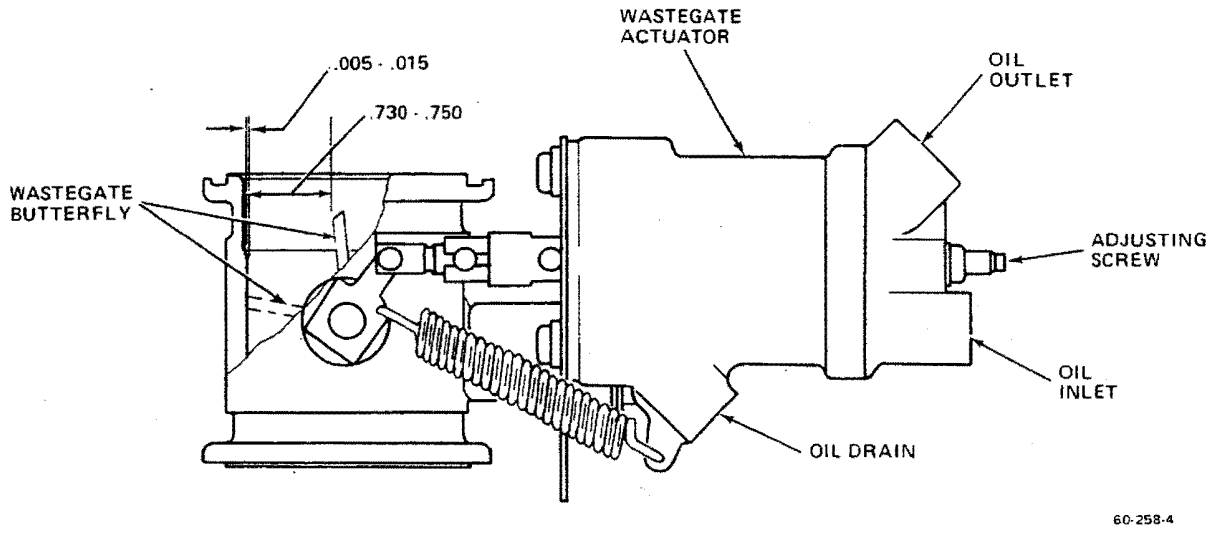
Maintain a minimum clearance of .80 to .90 (P-4 through P-143), .730 to .750 (P-144 and after) between butterfly edge and bore.

TURBOCHARGER CRITICAL ALTITUDE TEST
(Figure 205)

The following procedure provides a means of checking turbocharger performance. Refer to the Turbocharger Performance Graph. This graph indicates the minimum acceptable critical altitude the aircraft can achieve while maintaining 41.0 in. Hg manifold pressure. To check the turbocharger performance against the graph it will be necessary to flight test the aircraft. Place the aircraft in a climb configuration and note the altitude at which the manifold pressure begins to drop off; then observe the outside air temperature gage. Locate these points on the axes of the graph and project lines from these points toward the center of the graph. The point at which the lines intersect is the aircraft's critical pressure altitude. If this point is located below the minimum acceptable pressure altitude line on the graph, a thorough check of the turbocharging system, including variable controller, induction system leaks and wastegate adjustment, should be accomplished.

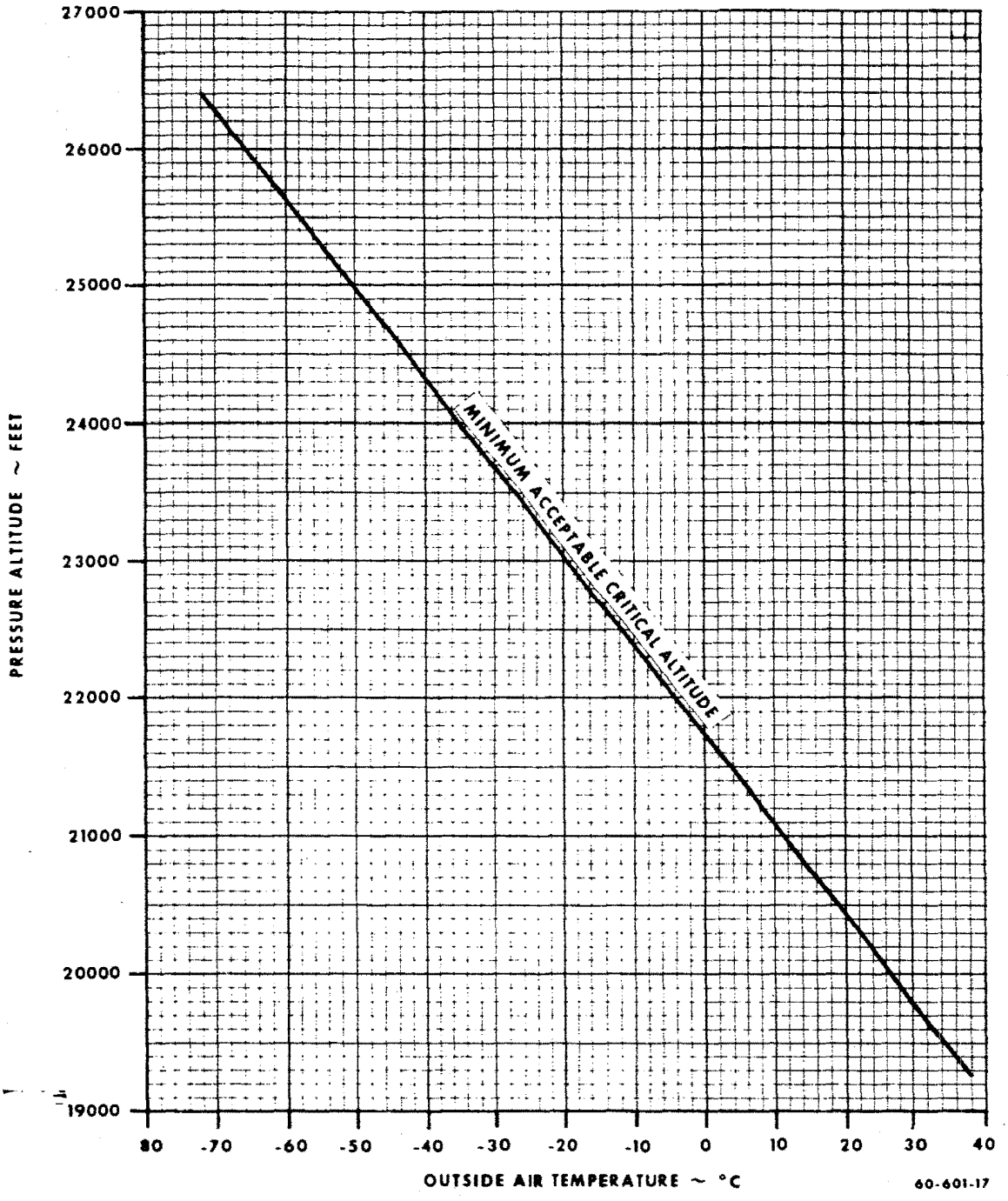


Wastegate Adjustment (P-4 thru P-143)
Figure 203



Wastegate Adjustment (P-144 and after)
Figure 204

CRITICAL PRESSURE ALTITUDE VS OAT



Turbocharger Performance Graph
Figure 205

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