TROUBLESHOOTING
REFERENCE GUIDE
Aircraft Turbochargers, Valves and Controls

HARTZELL
ENGINE TECHNOLOGIES
MONTGOMERY, ALABAMA USA
Warning:

Owners and Operators that fly must recognize that there are inherent risks involved in this activity, whether for business or pleasure. Every precaution in maintenance and training must be taken to minimize these risks as it is unlikely that they can be eliminated entirely. The turbocharger valves and controls listed herein are critical components of the aircraft. Any failure may result in an unplanned landing or even more severe consequences.

Turbocharger controllers, bypass valves, and pressure relief valves are subject to wear based on conditions that may make the same unit life vary from airplane to airplane and condition to condition. These components are principally used with propeller driven airplanes that subject them to constant vibration stresses from engine operation as well.

Each of the turbocharger valves and controls certified, must demonstrate adequate margins of safety before they are considered as safe to operate on an airplane or rotorcraft. Even when every precaution is taken in the design and manufacture of these components, failures may still occur.

*It is essential that the controllers, bypass valves, and pressure relief valves be properly operated per the flight manual and maintained according to recommended service procedures. The overall turbocharger system must be observed closely to detect any potential problems before they have a chance to become serious. Any abnormal or unusual operating reports should be investigated and repairs effected, as it may be a warning of impending failure.*

The turbocharging system provides power to your airplane for virtually all phases of flight. Without the proper care and maintenance the effectiveness and safety cannot be assured. This Guide helps advise owners, operators and mechanics of necessary information about your turbocharging system to assure safe and long lasting operation. Please assure you give it your undivided attention.

Thank you for choosing Hartzell Engine Technologies LLC components. Maintained properly, it will give you safe and reliable service for many years to come.

Sincerely,
Hartzell Engine Technologies
Product Support

Aircraft Turbochargers, Valves & Controls
Troubleshooting Reference Guide
Foreword

The material contained herein pertains solely to Hartzell Engine Technologies LLC (HET) turbochargers, relief valves, turbocharger controllers and exhaust bypass valves (wastegates)* manufactured by HET: 2900 Selma Highway, Montgomery, Alabama, 36108 U.S.A. This material is applicable to HET products only.

The systems guide and troubleshooting information presented are for use only to aid properly qualified persons in the maintenance of the equipment covered in this publication and in no way whatsoever replaces or changes the appropriate airframe or engine manufacturer’s service publications. Airframe and engine applications listed for HET products are furnished solely as a helpful reference, and are based on information available to HET at the time of publication. Actual HET products applications must conform to aircraft equipment lists published by the airframe and/or engine manufacturers under all applicable Federal Aviation Administration regulations. HET makes no representation or warranty as to the accuracy and correctness of the airframe and engine applications listed for HET products. HET reserves the right to make changes in this publication at any time, without notice.
Within the context of this document, the terms "exhaust bypass valve," "bypass valve," and "wastegate" are used interchangeably.

The equipment covered in this publication includes turbochargers, which are high-technology devices operating at high temperatures with their rotating parts spinning at very high speeds. Persons attempting maintenance of any sort must be qualified legally and technically to service such equipment on aircraft and must observe and satisfy the critical tolerances and necessary high standards of workmanship that are required.

For information on the products and material herein, contact:

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TP20-0128, as referenced in this text, refers to the AID/Garrett “Overhaul Manual for Aircraft System Turbochargers;” and CF601000-0000 refers to the "RAJAY Overhaul Manual – Aircraft Valves and Controls." These manuals have been superseded by HET “Overhaul Manual for Aircraft System Turbochargers” P/N 400600-0000 or for “Overhaul Manual for Valves & Controls” P/N 400999-0000.

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Introduction

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This publication comprises two parts. The first section is an aircraft turbocharger system guide consisting of a reference index listing turbocharger aircraft by manufacturer, engine number and the type(s) of control fitted to the engine. The page number for the proper descriptive section follows each listing. These segments describe each type of system in detail, including controller functions, then lists aircraft by manufacturer plus engine, turbocharger, wastegate and controller part numbers by Hartzell Engine Technologies LLC (HET) and airframe or engine manufacturer designations.

The second section provides a complete troubleshooting guide with truth tables for preliminary system diagnosis.

TURBOCHARGER SYSTEM DESCRIPTION:

The function of an aircraft turbocharger system is to maintain a desired manifold pressure at a given throttle setting, regardless of varying conditions of ambient air temperature and pressure. With few exceptions, the aircraft system comprises a turbocharger, a bypass valve, and one or more controllers. In most cases, a
direct-acting absolute pressure relief valve is also incorporated as a fail-safe feature in the event of total control failure or to avert any tendency towards cold-start overboost.

In the accompanying schematic diagram (Figure 1) of a simplified aircraft turbocharger system, the flow of exhaust gasses, compressed air, and pressurized engine oil can be clearly seen. Although this system features only one controller, coupled with a butterfly-type exhaust bypass valve plus an absolute pressure relief valve, it is typical of common aircraft systems.

**Figure 1 - Aircraft Turbochargers System Schematic**
Controllers may be found in multiples, or combined in a common housing; but, as they operate in parallel (though in response to differing stimuli), their actions on the system remain the same as if only one controller were fitted.

The turbocharger compressor discharge pressure (upstream of the throttle) is regulated by controlling the flow of exhaust gases through the turbocharger turbine. The exhaust gas flow is modulated by diverting excess gas through an exhaust bypass valve of either a poppet-type, mounted directly on the turbocharger turbine housing, or a butterfly design mounted on a diversion duct that bypasses the turbine inlet. Both types are actuated by pressurized engine oil that first flows into the bypass valve actuator via a restricting orifice or capillary tube, then out of the actuator into one or more controllers. Ultimately, the now depressurized oil returns to the engine oil sump. Regardless of the type of controller used, when the controller (within its parameters) senses insufficient compressor discharge pressure, a poppet valve in the controller moves towards a closed position, thereby raising the oil pressure in the upstream, actuator side, closing the bypass valve and forcing more exhaust gas through the turbocharger turbine. This raises the turbine/compressor shaft speed, and consequently the compressor discharge pressure.

When the controller senses excessive compressor discharge pressure, the opposite action occurs. The controller poppet opens, reducing upstream oil pressure, and permitting springs in the actuator cylinder to open
the bypass valve. Exhaust gases then bypass the turbine; turbine/compressor shaft speed is reduced and the compressor discharge pressure drops.
Turbo Systems Listed by Aircraft

- Turbocharger Systems Listed By Aircraft

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This page intentionally left blank.
Use this section to determine which type of system the aircraft has by turning to the indicated page of chapter 3.

### Table 1 - Turbocharger Systems Listed by Aircraft

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* Venturi Dumps Overboard

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**Aircraft Turbochargers, Valves & Controls Troubleshooting Reference Guide**

- [HARTZELL ENGINE TECHNOLOGIES](#)
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*Venturi Dumps Overboard*
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Turbo Systems
Listed by Type

FIXED ABSOLUTE PRESSURE SYSTEM:

Installation Features:


1978-81 Cessna P210; and 1969-84 Cessna T206, T207, T210: Turbocharger below engine oil level. Check valves in inlet oil line and scavenge return line.

Cessna Skyknight: Turbocharger high-mounted with scavenge pump. Wastegate butterfly furnished by Cessna.

Piper Aztec A/B: Separate oil system with on-off switch.

Piper Aztec C/D: Low mounted turbochargers with scavenge pump, inlet check valve, and oil-out accumulator.

Component Operation:

The fixed absolute pressure controller hydraulically regulates the wastegate opening for high engine power.
settings from sea level to altitude. The controller senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes.

If fitted, a pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.

A sonic venturi, if fitted, is incorporated to provide a constant source of compressed air to the cabin pressurization system.

**NOTE:** On Piper Aztec C models only, a transfer valve is used to allow sensing of manifold pressure rather than deck pressure at near to full-throttle settings for climb and cruise power. This permits lower turbocharger speeds, less back-pressure, more power and economy.
Figure 2 - Fixed Absolute Pressure System Schematic
# Table 2 - Fixed Absolute Pressure System Applications

## System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>L-Wastegate</th>
<th>R-Wastegate</th>
<th>Controller</th>
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<th>Venturi</th>
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*Table 2 - Fixed Absolute Pressure System Applications*

*System Specifics:*
FIXED ABSOLUTE PRESSURE / PRESSURE RATIO SYSTEM:

Installation Features:

1969 Cessna Turbocharger 310, 401A, 402A:
Turbocharger mounted above crankcase oil level.
Scavenged oil return.

Component Operation:

The fixed absolute pressure controller hydraulically regulates the wastegate opening for high engine power settings from sea-level to altitude. The controller senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes.

The pressure ratio controller is designed to override the fixed absolute pressure controller during high-altitude cruising to prevent turbocharger overspeed and lower the part-throttle critical power point of the engine. The controller senses deck and ambient pressures and compares them to a referenced absolute pressure. When the ratio of outlet to ambient pressure exceeds a preset proportion, the controller opens the wastegate and lowers turbocharger output.
### Table 3 - Fixed Absolute Pressure / Pressure Ratio System Applications

**System Specifics:**

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<th>Engine</th>
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<th>R-Wastegate</th>
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DUAL ABSOLUTE / RATE CONTROL SYSTEM:

Installation Features:

1966-68 Cessna T206, T210: Low mounted turbochargers. Scavenged oil system with check valves on inlet and scavenge return lines.

Component Operation:

The rate/absolute dual controller performs the functions of both the rate controller and the absolute pressure controller. Components serving the separate functions are housed in a common body and capillary assembly with shared sensing and hydraulic ports.

The fixed absolute pressure controller portion of the dual controller hydraulically regulates the wastegate opening for high engine power settings from sea-level to altitude. The controller senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes.

The rate controller portion of the dual controller senses deck pressure and acts to prevent excessive increase in the turbocharger discharge air pressure. Thus, when a too rapid throttle advance causes an excessive rate of change in deck pressure, the controller overrides the absolute pressure controls and opens the wastegate butterfly and slows the compressor, lowering deck pressure and preventing overboost.
If fitted, a pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
### Table 4 - Dual Absolute / Rate Control System Applications

#### System Specifics:

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<td>470930-1  C482002-0101</td>
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</tbody>
</table>
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DUAL ABSOLUTE / RATE CONTROL SYSTEM
WITH PRESSURE RATIO CONTROL:

Installation Features:


Component Operation:

The rate/absolute dual controller performs the functions of both the rate controller and the absolute pressure controller. Components serving the separate functions are housed in a common body and capillary assembly with shared sensing and hydraulic ports.

The fixed absolute pressure controller portion of the dual controller hydraulically regulates the wastegate opening for high engine power settings from sea-level to altitude. The controller senses deck pressure, compares it to a reference absolute pressure and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes.

The rate controller portion of the dual controller senses deck pressure and acts to prevent excessive increase in the turbocharger discharge air pressure. Thus, when a too rapid throttle advance causes an extreme rate of change in deck pressure, the controller overrides the
fixed absolute pressure controller and opens the wastegate butterfly and slows the compressor, lowering deck pressure and preventing overboost.

The pressure ratio controller is designed to override the fixed absolute pressure controller during high-altitude cruising to prevent turbocharger overspeed and lower the part throttle critical point of the engine. The controller senses deck and ambient pressures and compares them to a referenced absolute pressure. When the ratio of outlet to ambient pressures exceeds a pre-set proportion, the controller opens the wastegate and lowers turbocharger output.

If fitted, a pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
Figure 5 - Dual Absolute / Rate Control System With Pressure Ratio Control Schematic
## Table 5 - Dual Absolute / Rate Control System With Pressure Ratio Control Applications

### System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>L-Wastegate</th>
<th>R-Wastegate</th>
<th>Controller</th>
<th>2nd Controller</th>
<th>PRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cessna 411/411A '65-'68</td>
<td>GTSIO-520-C</td>
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<td>5050154-14</td>
<td>C165004-0101</td>
<td>C165004-0401</td>
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<tr>
<td>Cessna '66-'68 320 D-F Skyknight</td>
<td>TSIO-520-B</td>
<td>406610-9025</td>
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<td>470780-13</td>
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<td>5050154-14</td>
<td>5050152-13</td>
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<td>C165004-0401</td>
<td>C482002-0101</td>
</tr>
<tr>
<td>Cessna 401/402 '67-'68</td>
<td>TSIO-520-E</td>
<td>406610-9025</td>
<td>470780-15</td>
<td>470780-16</td>
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DUAL ABSOLUTE / PRESSURE RATIO CONTROL SYSTEM:

Installation Features:


Component Operation:

The ratio/absolute dual controller performs the functions of both the pressure ratio controller and the absolute pressure controller. Components serving the separate functions are housed in a common body assembly, with shared pressure sensing and hydraulic ports.

The fixed absolute pressure controller portion of the dual controller hydraulically regulates the wastegate opening for high engine power settings from sea-level to altitude. The controller senses deck pressure, compares it to a reference absolute pressure and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes.

The pressure ratio controller portion of the dual controller is designed to override the fixed absolute pressure controller during high altitude cruising to prevent turbocharger overspeed and lower the part
throttle critical point of the engine. The controller senses the deck and ambient pressures and compares them to a referenced absolute pressure. When the ratio of outlet to ambient pressure exceeds a preset proportion, the controller opens the wastegate and lowers turbocharger output.

If fitted, a pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
Figure 6 - Dual Absolute / Pressure Ratio Control System Schematic
Table 6 - Dual Absolute / Pressure Ratio Control System Applications

System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
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<th>R-Wastegate</th>
<th>Controller</th>
<th>PRV</th>
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<td>406610-9025 632729-11</td>
<td>470780-14 5050154-14</td>
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<td>470948-1 C165002-0102</td>
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<td>Cessna '80-Up 335</td>
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<td>406610-9025 632729-11</td>
<td>470780-15 5050154-15</td>
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<td>Cessna '73-'75 340</td>
<td>TSIO-520-K</td>
<td>470810-1 635630</td>
<td>470908-6 C165006-0104</td>
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<td>Cessna '70-'78 401B/402B</td>
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<td>470948-1 C165002-0102</td>
<td>470930-4 C482002-0103</td>
</tr>
</tbody>
</table>
DENSITY CONTROL SYSTEM (FIXED WING):

Installation Features:

*Piper Aztec; Aerospatiale Trinidad TC; Lake 250 Renegade:* Turbocharger mounted below engine oil level. Scavenged oil system with oil inlet check valve and oil out accumulator.

*Piper Navajo and Chieftain:* High mounted turbochargers with gravity drain oil system.

Component Operation:

The density controller senses both the temperature and pressure (therefore density) of the compressor discharge. When density of the air reaches a pre-set level, the density controller modulates the wastegate, raising or lowering the compressor output pressure to the proper level for wide-open throttle operation.

The differential controller is designed to keep deck pressure from exceeding manifold pressure by more than a specified amount during part throttle operation. When deck pressure exceeds manifold pressure by more than a pre-determined value, the controller opens the wastegate, reducing turbocharger output.

If fitted, a pressure-relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
Figure 7 - Density Control System (Fixed Wing) Schematic
### Table 7 - Density Control System (Fixed Wing) Applications

#### System Specifics:

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<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>Wastegate</th>
<th>Controller</th>
<th>2nd Controller</th>
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<tr>
<td>Aerospatiale</td>
<td>TIO-540-AB1AD</td>
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<td>Trinidad TC</td>
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<td>Aztec E-F</td>
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### Table 7 - Density Control System (Fixed Wing) Applications (Cont.)

#### System Specifics:

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<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>Wastegate</th>
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<th>2nd Controller</th>
<th>Intercooler</th>
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<td>LW-10682</td>
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</table>
DENSITY CONTROL SYSTEM
(ROTARY WING):

Installation Features:

1961-75 Bell 47G3B Helicopter; Hiller SL-4 Helicopter: Dry-sump, vertical-mount engine. Scavenged oil system with check valves in oil inlet and outlet lines. Controllers use hydraulic system oil rather than engine oil.

Component Operation:

The density controller senses both the temperature and pressure (therefore density) of the compressor discharge. When density of the air reaches a pre-set level, the density controller modulates the wastegate, raising or lowering the compressor output pressure to the proper level for wide-open throttle operation.
Figure 8 - Density Control System (Rotary Wing) Schematic
Table 8 - Density Control System (Rotary Wing) Applications

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>Wastegate</th>
<th>Controller</th>
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</table>
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VARIABLE ABSOLUTE PRESSURE SYSTEM
(SINGLE ENGINE, WITHOUT COVER):

Installation Features:


1985-Up Cessna T210R; P210R; and Mooney 252: Low-mounted turbocharger. Scavenge oil system with check valve in oil return line.

Component Operation:

The variable absolute pressure controller (direct-sensing, without cover) works much like the non-variable absolute pressure controller in that it senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes. It differs from the non-variable version, however, in that it is directly linked to the engine throttle, and through a system of cams and followers, adjusts itself to varying power settings, achieving the optimum deck pressure for a given throttle movement.

A pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
A sonic venturi, if installed, is incorporated to provide a constant source of compressed air to the cabin pressurization system. In the Cessna T210R, this air is bled overboard.

An intercooler is incorporated in the Cessna T210R, P210R and Mooney 252 to cool compressor discharge air and increase cylinder charge density.
Figure 9 - Variable Absolute Pressure System (Single Engine, Without Cover) Schematic
### Table 9 - Variable Absolute Pressure System (Single Engine, Without Cover) Applications

#### System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>Wastegate</th>
<th>Controller</th>
<th>PRV</th>
<th>Venturi</th>
<th>Intercooler</th>
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<td>481064-4</td>
<td>481008-26</td>
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<td>P210R/T210R</td>
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<td>C165004-0605</td>
<td>C482003-0110</td>
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</table>

- **Aircraft Engine Turbocharger**: Wastegate, Controller, PRV, Venturi, Intercooler.
VARIABLE ABSOLUTE PRESSURE SYSTEM
(TWIN ENGINE, WITHOUT COVER):

Installation Features:

All Lycoming Engine Systems (Except Piper Mojave): High-mounted turbochargers with gravity drain oil systems.

All Continental Engine Systems (Except Cessna Skymaster): High-mounted turbochargers with scavenge oil systems.

Cessna Skymaster: Low-mounted turbochargers with scavenged oil systems and oil inlet and outlet check valves.

Piper Mojave: High-mounted turbochargers with intercooler. Scavenged oil system.

Rockwell Commander 700

Component Operation:

The variable absolute pressure controller (direct-sensing, without cover) works much like the non-variable absolute pressure controller in that it senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes. It differs from the non-variable version, however, in that it is directly linked to the engine throttle, and through a system of cams and followers, adjusts itself to varying power settings,
achieving the optimum deck pressure for a given throttle movement.

A pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.

A sonic venturi, if installed, is incorporated to provide a constant source of compressed air to the cabin pressurization system.

An intercooler, if fitted, is added to cool the compressor outflow and increase cylinder charge air density.
Figure 10 - Variable Absolute Pressure System (Twin Engine, Without Cover) Schematic
**Table 10 - Variable absolute Pressure System (Twin Engine, Without Cover) Applications**

**System Specifics:**  
* Left or Front Engine.  ** Right or Rear Engine.

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>WG (L / F)*</th>
<th>WG (R / R)**</th>
<th>Controller</th>
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<th>Venturi</th>
<th>Intercooler</th>
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**Table 10 - Variable absolute Pressure System (Twin Engine, Without Cover) Applications (Cont’)**

**System Specifics:**  
* Left or Front Engine.  
** Right or Rear Engine.

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<th>WG (R / R)**</th>
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* Left or Front Engine.  
** Right or Rear Engine.
# Table 10 - Variable absolute Pressure System (Twin Engine, Without Cover) Applications (Cont’)

**System Specifics:**  * Left or Front Engine.  ** Right or Rear Engine.

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<tr>
<th>Aircraft</th>
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<th>Turbocharger</th>
<th>WG (L / F)*</th>
<th>WG (R / R)**</th>
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VARIABLE ABSOLUTE PRESSURE SYSTEM
(WITH COVER):

Installation Features:

*Beechcraft (Raytheon) Bonanza; Cessna Skymaster:* Turbochargers mounted below engine oil level. Scavenged oil system with oil inlet and outlet check valves.

Component Operation:

The variable absolute pressure controller (remote sensing with cover) works much like the non-variable pressure controller in that it senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes. It differs from the non-variable version, however, in that it is directly linked to the engine throttle, and through a system of cams and followers, adjusts itself to varying power settings, achieving the optimum deck pressure for a given throttle movement.

A pressure relief valve (when used), set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
Figure 11 - Variable Absolute Pressure System (With Cover) Schematic
Table 11 - Variable Absolute Pressure System (With Cover) Applications

System Specifics: * Left or Front Engine. ** Right or Rear Engine.

<table>
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<tr>
<th>Aircraft</th>
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<th>WG (R / R**)</th>
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VARIABLE ABSOLUTE CONTROL SYSTEM  
WITH RATE CONTROL:

Installation Features:

*Cessna 337*: Low-mounted turbochargers with scavenged oil system. Oil inlet and outlet check valves.

Component Operation:

The variable absolute pressure controller (direct sensing, without cover) works much like the non-variable absolute pressure controller in that it senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes. It differs from the non-variable version, however, in that it is directly linked to the engine throttle, and through a system of cams and followers, adjusts itself to varying power settings, achieving the optimum deck pressure for a given throttle movement.

The rate controller senses deck pressure and acts to prevent excessive increase in the turbocharger discharge air pressure. Thus, when a too-rapid throttle advance causes an extreme rate of change in deck pressure, the controller overrides the fixed absolute pressure controller and opens the wastegate butterfly and slows the compressor, lowering deck pressure and preventing overboost.
A pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.
### Table 12 - Variable Absolute Pressure System with Rate Control Application

**System Specifics:**  * Left or Front Engine.  ** Right or Rear Engine.

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<th>Aircraft</th>
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VARIABLE ABSOLUTE PRESSURE SYSTEM
WITH POPPET-TYPE WASTEGATE:

Installation Features:

1976-Up Beechcraft (Raytheon) Baron: High-mounted turbochargers with scavenged oil system.
Rockwell Commander 685

Component Operation:

The variable absolute pressure controller (direct sensing, without cover) works much like the non-variable pressure controller in that it senses deck pressure, compares it to a reference absolute pressure, and adjusts the wastegate butterfly (controlling turbocharger speed) to maintain sea-level horsepower at varying altitudes. It differs from the non-variable version, however, in that it is directly linked to the engine throttle, and through a system of cams and followers, adjusts itself to varying power settings, achieving the optimum deck pressure for a given throttle movement.

A pressure relief valve, set slightly in excess of maximum deck pressure, is provided to prevent damaging overboost in the event of a system malfunction.

A sonic venturi, if fitted, is incorporated to provide a constant source of compressed air to the cabin pressurization system.
Figure 13 - Variable Absolute Pressure System With Poppet-Type Wastegate Schematic
Table 13 - Variable Absolute Pressure System With Poppet-Type Wastegate Applications

System Specifics: * Venturi Dumps Overboard.

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<tr>
<td>Baron</td>
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<td>409680-1</td>
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<tr>
<td>Beech '79-Up</td>
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<td>Press. Baron</td>
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<td></td>
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</tbody>
</table>

* Venturi Dumps Overboard.
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SLOPED CONTROL SYSTEM:

Installation Features:

_Cessna T182T, T206, T303 and 1982-’84 Cessna P210:_ Low-mounted turbochargers with scavenged oil system.

_Lancair IV & IVP:_ Twin Turbocharger

_Piper Malibu & Malibu Conversion:_ Twin low-mounted turbochargers with scavenged oil system.

_Piper Saratoga TC_

Component Operation:

The sloped controller is designed to maintain the rated deck pressure at wide open throttle, and to maintain a reduced deck pressure at part-throttle settings. The controller senses both deck and manifold pressure and monitors the differential between them. If either the deck pressure or differential pressure rises above predetermined values for a given throttle setting, the controller opens the exhaust bypass valve, thus lowering compressor speed and output.

A pressure relief valve, set slightly in excess of maximum deck pressure, is installed to prevent damaging overboost in the event of a system malfunction.

A sonic venturi, if installed, is incorporated to provide a constant source of compressed air to the cabin pressurization system.
### Table 14 - Sloped Control System Applications

**System Specifics:** * R & L refers to turbocharger location on Piper Malibu engine.

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>L-Turbo*</th>
<th>R-Turbo*</th>
<th>Wastegate</th>
<th>Controller</th>
<th>PRV</th>
<th>Sonic Venturi</th>
<th>Intercooler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cessna Crusader</td>
<td>L/TSIO-520-AE</td>
<td>406610-30</td>
<td>N/A</td>
<td>470954-3</td>
<td>C165006-0601</td>
<td>481058-1</td>
<td>470944-20</td>
<td>C482002-0113</td>
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<tr>
<td>Cessna ’82–’84</td>
<td>TSIO-520-AF</td>
<td>465680-4</td>
<td>N/A</td>
<td>470908-20</td>
<td>C165006-0114</td>
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<td>Centurion P210</td>
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<tr>
<td>Cessna T-206</td>
<td>TIO-540-AJ1A</td>
<td>466881-1</td>
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<td>470954-5</td>
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<td>Stationair</td>
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<tr>
<td>Lancair IV &amp; IVP</td>
<td>TSIO-550-B</td>
<td>(2) 466304-3</td>
<td>N/A</td>
<td>470908-17</td>
<td>636188-17</td>
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<td>Lancair IV &amp; IVP</td>
<td>TSIO-550-E</td>
<td>(2) 466304-3</td>
<td>N/A</td>
<td>481064-1</td>
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<td>Piper Malibu</td>
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<td>Piper Malibu</td>
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<tr>
<td>Piper Saratoga TC</td>
<td>TIO-540-AHI A</td>
<td>466011-2</td>
<td>N/A</td>
<td>470954-9</td>
<td>47122459</td>
<td>481058-7</td>
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<td>Cessna Turbo.</td>
<td>TIO-540-AK1A</td>
<td>466442-6</td>
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<td>470954-1</td>
<td>LW-12960</td>
<td>48B22970</td>
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</table>
PRESSURE RELIEF VALVE CONTROL
SYSTEM:

Installation Features:

*Enstrom; Mooney 231; Piper Arrow, Dakota and Seneca:* Engine fitted with Hartzell Engine Technologies (HET) turbocharger and HET pressure relief valve only.
*Cessna Ag Husky; Page:* Engine fitted with Hartzell Engine Technologies turbocharger and HET pressure relief valve only.

Component Operation:

Continuous management of throttle required to maintain manifold pressure during climb and descent.

Pressure relief valve, set slightly in excess of maximum manifold pressure, is provided to prevent damaging overboost in event of pilot error.
Figure 15 - Pressure Relief Valve Control System Schematic
# Table 15 - Pressure Relief Valve Control System Applications

## System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>PRV</th>
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<tbody>
<tr>
<td>Bellanca</td>
<td>IO-540-G1E5, K1E5</td>
<td>CF600572</td>
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<td></td>
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<td>3DT5FF10J2</td>
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<tr>
<td>Cessna AG Husky</td>
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<td>642518-4</td>
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<td>Enstrom</td>
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<td>600700</td>
<td>470944-18</td>
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<td>Shark</td>
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<td>3BT5EE10J2</td>
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<td>Mooney 201</td>
<td>IO-360-A3B6D</td>
<td>CF600573</td>
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<td>Mooney 231</td>
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<td>Mooney 231</td>
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<td>Piper Arrow / Dakota</td>
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<td>Piper Seneca II</td>
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<tr>
<td>Piper Seneca III</td>
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<td>646396</td>
<td>643511-1</td>
</tr>
</tbody>
</table>
MANUAL WASTEGATE CONTROL SYSTEM
WITH PRESSURE RELIEF VALVE:

Installation Features:


*Piper Lance and Saratoga:* Low-mounted turbocharger with scavenged oil system. Manual, throttle-linked wastegate.

Component Operation:

Wastegate directly and/or proportionately linked to throttle. Requires continuous throttle management to maintain desired manifold pressure during climb and descent.

A pressure relief valve, set slightly in excess of maximum manifold pressure, is installed to prevent damaging overboost in the event of system malfunction.
Figure 16 - Manual Wastegate Control System With Pressure Relief Valve Schematic
Table 16 - Manual Wastegate Control System With Pressure Relief Valve Applications

System Specifics:

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Engine</th>
<th>Turbocharger</th>
<th>Wastegate</th>
<th>PRV</th>
</tr>
</thead>
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<tr>
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<td>Piper Lance; Saratoga</td>
<td>TIO-540-SIAD</td>
<td>406610-26</td>
<td>Textron Lycoming</td>
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<td>LW14445-10</td>
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</tbody>
</table>
Chapter 4 - Introduction to Troubleshooting

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  Operates Sluggishly ..................................120
Controller Does Not Open Oil Flow .................123
Too often, in the event of malfunction of a turbocharged engine, the turbocharger is immediately assumed to be at fault, and is replaced. Frequently the replacement unit soon fails, finally prompting an investigation into the real cause of the initial failure. Such a sequence of events is both frustrating and expensive.

Hartzell Engine Technologies’ (HET) stringent quality controls make it highly unlikely that a turbocharger could leave the factory incorrectly assembled, or not up to specifications. A “bad” turbocharger would operate badly almost from the moment of installation. But a turbocharger which has operated successfully for a period of time, and then fails, almost invariably fails due to a deficiency in the operation of the associated engine systems. Years of actual experience with service failures demonstrate the major cause of turbocharger failures to be faulty lubrication systems. Abnormal wear in the bearings or seals results from abrasives in the oil, or an insufficient supply of oil. Other systems, such as fuel and ignition, can also play a part in causing engine troubles in which turbocharger system malfunction is originally suspected.

The overall objective of troubleshooting is to find the cause of trouble and take corrective action to prevent a recurrence. This objective must be kept in mind even
while determining whether anything is actually wrong with the turbocharger system components, and just what is wrong, to enable repairs. Even perfectly operational turbocharger system components cannot compensate for incorrect engine operating procedures, for deficiencies in the engine oil supply, oil drain, ignition, air induction, fuel, or exhaust systems, or for damaged engine internal components.

**CAUTION:** Turbochargers operate at high speed and high temperatures. Caution should be used at all times when operating turbochargers to avoid injury and damage by keeping fingers and foreign objects away from openings and avoiding contact with its hot surfaces and other hot connecting parts.

**TROUBLESHOOTING PROCEDURES:**

An important rule of turbocharger system troubleshooting is to try to find the cause of engine malfunctions before removing or disassembling the turbocharger system components: i.e., to leave the evidence intact. For instance, if there are loose connections permitting leakage from the compressor, this can be discovered only if the connections are checked for looseness before they are removed.

**SEQUENCE OF OPERATIONS:**

The sequence of operations for troubleshooting, prescribed in this manual, can be summarized as follows:
a. List the engine trouble which seems to be related to turbocharger-supplied air, and if applicable, the specific flight conditions in which the malfunctions occurred, such as altitude, engine rpm, manifold pressure, and fuel flow.

b. Carry out the systematic “Pre-Troubleshooting Inspection,” below, which may correct the trouble without further troubleshooting.

c. If the trouble persists, consult the text and/or the troubleshooting chart for the specific engine trouble, narrow down the possible causes, and apply the specified remedy or remedies.

d. If the “remedy” of the chart in step c, above, is to consult the troubleshooting chart for a specific turbocharger system component condition, proceed to that chart and continue to trace the cause(s) and apply the remedy or remedies. For instance, troubleshooting the “Manifold Pressure Low” trouble may eliminate other possible causes except “Turbocharger Output Low or Operates Sluggishly.” Following the troubleshooting procedure for this trouble may acquit the turbocharger itself of any deficiency but lead to the conclusion that the “Exhaust Bypass Valve Fails to Close or Operates Sluggishly,” and lead the troubleshooting mechanic to the troubleshooting chart for that component malfunction. The troubleshooting chart for bypass valve failure to close may lead to the discovery of a clogged inlet port orifice, or it may conclude that the command to close never reaches the bypass valve from the controller. In this hypothetical case, the
“Controller Fails to Close Oil Flow” troubleshooting chart may help discover a leak in a sensing line to the controller, or foreign particles in the oil in the controller, holding open an internal poppet valve. Simple flushing of the controller may be the only remedy required, except for finding the source of the foreign particles.

LISTING ENGINE TROUBLES:

The following is a list of engine troubles, or symptoms of malfunctions, related to the supplying of air to the engine by the turbocharger. For each symptom there is a troubleshooting chart and a written troubleshooting procedure. For example:

a. Manifold pressure low or fluctuating, or aircraft cannot reach critical altitude.

b. Oil leakage into engine intake air or exhaust.

c. Engine overboosts.

d. Cabin loses pressure at altitude and partial power.

PRE-TROUBLESHOOTING INSPECTION:

The pre-troubleshooting inspection described below, and summarized in Table 17, constitutes a thorough visual inspection capable of detecting and eliminating many possible causes of malfunctions for which troubleshooting would otherwise be necessary. Examine
each disconnected, removed, or replacement part prior to reinstallation for cleanliness, and to prevent the entry of damaging foreign matter into the system.

Consult engine manufacturer maintenance publications for procedures which use an outside source of air pressure, and soap solution, to detect leaks in the air induction system and exhaust system.

a. With the engine shut down, externally inspect all components of the air induction system for loose connections, cuts, cracks, punctures, and corrosion or other evidence of deterioration that could permit air leakage and the ingestion of damaging foreign matter. The components include the engine air cleaner, ducting from the air cleaner to the turbocharger compressor inlet, ducting from the compressor outlet to the engine intake manifold, and the intake manifold. Tighten loose connections and repair or replace parts, as needed, per engine manufacturer maintenance publications.

b. Inspect the air cleaner for a clogged element, and service per manufacturer instructions.

c. Check the engine crankcase breather for restrictions to air flow, and remove any restriction.

d. Inspect the exhaust system for leakage, especially at the exhaust manifold connection to the turbocharger turbine inlet and at the engine exhaust manifold gasket. Tighten connections as needed, and replace damaged components in accordance with the engine manufacturer maintenance publications.
<table>
<thead>
<tr>
<th>System / Location:</th>
<th>Problem to be Found &amp; Corrected:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air induction system</td>
<td>Air leaks, loose connections, damage, deterioration.</td>
</tr>
<tr>
<td>Engine air cleaner</td>
<td>Clogging.</td>
</tr>
<tr>
<td>Crankcase breather</td>
<td>Restriction.</td>
</tr>
<tr>
<td>Exhaust system</td>
<td>Leaks, especially at exhaust manifold connections to turbocharger and to engine (gasket).</td>
</tr>
<tr>
<td>Turbocharger oil</td>
<td>Oil leaks, loose connections, bad gaskets, fittings, check valves.</td>
</tr>
<tr>
<td>Bypass valve and controller oil</td>
<td>Leaks, vibrations.</td>
</tr>
<tr>
<td>lines, sensing lines, and their</td>
<td>Oil leakage due to twisted or damaged piston packing due to cylinder scoring or dirt.</td>
</tr>
<tr>
<td>brackets</td>
<td></td>
</tr>
<tr>
<td>Bypass valve actuator</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>a. Oil leakage past seal of internal poppet.</td>
</tr>
<tr>
<td></td>
<td>b. Air leaks at any place in signal lines.</td>
</tr>
<tr>
<td></td>
<td>c. Oil pressure variations.</td>
</tr>
<tr>
<td>Exterior of bypass valve or</td>
<td>Accumulated debris on cooling fins of poppet-type bypass valve, or on linkage of butterfly-type,</td>
</tr>
<tr>
<td>controller</td>
<td>or on any external controller linkage.</td>
</tr>
<tr>
<td>Turbocharger</td>
<td>With engine running, shrill whine above normal whine - shut engine down and check turbocharger</td>
</tr>
<tr>
<td>Compressor wheel or turbine</td>
<td>Indication of seal leakage, wheel damage or rubbing, binding or dragging. (For any of these</td>
</tr>
<tr>
<td>wheel</td>
<td>defects, check turbocharger bearing clearance and troubleshoot as applicable. For foreign object</td>
</tr>
<tr>
<td></td>
<td>damage, also clean and repair air system or exhaust system.)</td>
</tr>
</tbody>
</table>

---

Table 17 - Summary of Pre-Troubleshooting Inspection
Exhaust gas leakage may be indicated by streaks of exhaust deposits at joints, and by inside scorching of nacelle.

e. Check for oil leakage at the connections to the turbocharger oil inlet and drain ports, and tighten connections or replace gaskets, fittings, etc., as needed. Inspect for faulty check valves which can allow oil to drain into the turbocharger center housing after shutdown, leading to turbocharger seal leakage.

f. Check the oil supply and drain lines to and from the exhaust bypass valve and controller(s), and any air pressure sensing lines, for leakage or vibration. Tighten connections and mounting bracket attachments as needed. Also look for damage which might cause restriction, and repair or replace as needed.

g. Check the oil drain line from the actuator drain port of the exhaust bypass valve for more than slight leakage, or constant leakage. Temporarily disconnect the line if necessary. If there is such leakage, disassemble the actuator and check for cylinder wall scoring. If there is no scoring, replace the actuator piston packing in accordance with the engine manufacturer’s instructions for the specific valve. If there is scoring, overhaul or replace the exhaust bypass valve.

h. Check for oil leakage from the controller(s), past the seal of the controller internal poppet. Significant leakage is cause for overhaul or replacement of a controller. Such leakage may be detected at a
compressor outlet sensing line to the controller, at a low-pressure sensing port, or for a duct-mounted controller without a cover, by removing the controller and inspecting the bellows area.

i. If the turbocharger system includes an absolute pressure relief valve, use a noncaustic cleaning solvent and compressed air to remove any accumulation of debris which may tend to restrict bellows or valve motion. Check the bolts and O-Ring on the mounting flange and tighten or replace as needed.

j. Use a noncaustic cleaning solvent and compressed air to remove any accumulated debris from the cooling fins of a poppet-type exhaust bypass valve, or from the linkage of a butterfly-type exhaust bypass valve. Clean the debris from any controller external linkage, but without solvent, to avoid loss of lubricant from self-lubricating bearings.

**WARNING:** Operation of the turbocharger without all normally installed inlet ducts and filters connected can result in injury to personnel and damage to equipment from foreign objects entering the turbocharger.

**CAUTION:** Operation of the engine at any speed faster than idle immediately after start-up can result in “oil lag” failure of turbocharger bearings, especially in cold weather or after a prolonged non-operative period.
k. If feasible, operate the engine at a low partial-power setting and listen for unusual turbocharger noises. If a shrill whine is heard above the normal turbine whine, indicating imminent turbocharger bearing failure, shut down immediately. For such a turbocharger, perform the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000. If the turbocharger fails to pass this inspection, determine the cause of wear by performing the troubleshooting procedure, below, for the condition, “Turbocharger Shaft Bearings, Journals or Bearing Bores Worn,” and overhaul or replace the turbocharger.

l. Remove the air duct from the turbocharger compressor inlet and inspect the compressor wheel and compressor housing for damage to wheel blades, indicating rubbing on the compressor housing, erosion by ingestion of dirt and sand, or impact with foreign objects. Also look for a heavy buildup of oil and dirt, indicating seal leakage; remove any foreign matter. Grasping shaft end, rotate the wheel by hand while pressing the rotating assembly toward the turbine end of the turbocharger. Rock shaft up and down. There should be no binding, rubbing, or other interference with free rotation. If none of the above defects is found, securely reconnect the air duct to the compressor inlet.

m. Disconnect the exhaust ducting from the turbine outlet and examine the turbine wheel blades for damage. Grasping shaft end, rotate the wheel by hand while pressing the rotating assembly toward
the compressor end of the turbocharger; also rock shaft up and down. Look for oil in the turbine wheel and its housing indicative of seal leakage, and check for evidence of the wheel rubbing on the housing. Remove any foreign matter. If none of the above defects is found, securely reconnect the exhaust duct to the turbine outlet.

n. If any listed conditions were found in steps 1 and m, above, see the troubleshooting procedures for the conditions, as applicable, of “Turbocharger Seal Leakage at Compressor End,” or “Turbocharger Seal Leakage at Turbine End,” or “Turbocharger Rotating Assembly Binding or Dragging.” Also perform the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000. If the bearings do not pass this inspection, determine the cause of wear by performing the troubleshooting procedure “Turbocharger Shaft Bearings, Journals or Bearing Bores Worn,” as described below, and overhaul or replace the turbocharger.

o. If the compressor wheel or turbine wheel has suffered foreign object damage, clean or repair the air induction system or engine exhaust system, as needed, before installing a replacement or overhauled turbocharger.

p. If there was turbocharger seal leakage, troubleshooting the condition “Turbocharger Seal Leakage at Compressor End,” or “Turbocharger Seal Leakage at Turbine End,” as applicable.
TROUBLESHOOTING ENGINE SYMPTOMS:

Each of the engine troubles named under “Listing Engine Troubles,” above, has a troubleshooting chart to match, and is further explained below. Neither the text nor the charts, however, should be regarded as covering every possible cause. Rather, this information is primarily representative of the approach to be employed in troubleshooting a turbocharged engine malfunction. Those troubleshooting operations which can be performed most quickly and easily should be accomplish first. Removal or disassembly should be postponed, for the most part, until all in-place inspections have been performed. Table 18 is a list of troubleshooting procedure notes which are referred to in the troubleshooting charts as supplementary information.
Table 18 - Troubleshooting Procedure Notes

A. A new turbocharger may smoke for a short period of perhaps 30 minutes, until factory oil coatings are consumed.

B. Check for oil leakage past the seal of the controller internal poppet; at a compressor outlet air sensing line to the controller; at other air-sensing lines or ports; or, for a duct-mounted controller without a cover, by removing the controller and inspecting the bellows area. Repair or replace.

C. Examine engine operating and maintenance procedures to detect departures from accepted practices and standards. Review the applicable portions of the airframe/engine manufacturer maintenance publications, AFM/POH, and refer to KAPS SB 023 “Turbocharger System Operational Tests” latest revision.

D. Inspect the interior of the turbocharger center housing by removing the oil drain and looking in through the oil drain opening. When a sludged or coked condition exists, sludge builds up heavily on the shaft, between the bearing journals, on the walls of the housing from the oil drain opening back to the turbine end, and on the turbine-end piston ring seal.

E. Detect abnormal wear in the turbocharger shaft bearings, journals, or bearing bores by performing the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000.

F. With the air inlet and exhaust outlet ducting separated from the turbocharger, look for blade damage to the compressor wheel or turbine wheel. Examine the outer blade tip edges for evidence of rubbing on adjacent housing surfaces, using a light to see the turbine wheel blade tips from the housing outlet. Exerting uniform pressure, rotate the wheels by hand while pressing the rotating assembly toward each end. There should be no binding, rubbing, or other interference with free rotation.

G. Thoroughly clean the air induction and exhaust system following compressor wheel damage by foreign object impact. Change the air cleaner element so that any metal pieces embedded in the air cleaner element are not drawn into the replacement turbocharger.

H. Whenever oil contamination is indicated or suspected, Hartzell Engine Technologies recommends a thorough flushing of the oil system per the engine manufacturer’s maintenance publications.
**Figure 17 - Troubleshooting - Manifold Pressure Low or Fluctuating or Aircraft Cannot Reach Critical Altitude**

**Possible Causes and Remedies**

- **Symptom or Trouble**
  - Manifold Pressure Low or Fluctuating
  - Aircraft Cannot Reach Critical Altitude

- **Restriction in Duct Between Air Cleaner & Engine Intake Manifold**
  - Yes: Remove Restriction or Replace Damaged Parts As Needed
  - No: See Troubleshooting Chart For This Condition

- **Restriction in Engine Exhaust System After Turbocharger**
  - Yes: Remove Restriction or Replace Damaged Parts As Needed
  - No: See Troubleshooting Chart For This Condition

- **Restriction in Engine Intake or Exhaust Manifold**
  - Yes: Refer to Engine Manufacturer Maintenance Publications
  - No: See Troubleshooting Chart For This Condition

- **Pressure Relief Valve Opens at Too Low a Pressure**
  - Yes: See Troubleshooting Chart For This Condition
  - No: Replace Damaged Parts As Needed

- **Engine Malfunction, Ignition or Fuel System**
  - Yes: Refer to Engine Manufacturer Maintenance Publications
  - No: See Troubleshooting Chart For This Condition

- **Turbocharger Output Low or Operates Sluggishly**
  - Yes: See Troubleshooting Chart For This Condition
  - No: Refer to Engine Manufacturer Maintenance Publications

- **Engine Oil Pressure Low**
  - Yes: Refer to Engine Manufacturer Maintenance Publications
  - No: Clean or Replace As Necessary

- **Controller or Wastegate Dirty and/or Sticking**
  - Yes: Clean or Replace As Necessary
  - No: Refer to Engine Manufacturer Maintenance Publications

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17.
Manifold Pressure Low or Fluctuating, or Aircraft Cannot Reach Critical Altitude
(See Figure 17):

Any of the symptoms listed together here can indicate that not enough compressed air is consistently reaching the engine from the turbocharger to maintain required manifold pressure. Some of the possible causes and remedies are as follows:

a. Loose connections or other leakage in the exhaust system would reduce the energy available to drive the turbine which turns the compressor wheel. Leakage in the air induction system downstream of the compressor would reduce the mass of air actually getting to the combustion chamber. Either of these types of leakage should have been detected in carrying out the “Pre-Troubleshooting Inspection” procedure.

b. Restrictions in the air ducting or in the exhaust system, either upstream or downstream of the turbocharger, obviously must affect the compression and flow of air to the engine. The “Pre-Troubleshooting Inspection” procedure includes a check of the air cleaner for restriction. As the troubleshooting chart indicates, the air ducts between the air cleaner and the compressor, and between the compressor and the engine intake manifold, as well as the exhaust system downstream of the turbocharger, must be examined for restrictions. Remove any restrictions and repair or replace damaged parts as needed. Correct any
restrictions in the engine intake or exhaust manifold per the engine manufacturer maintenance publications.

c. Manifold pressure will not reach required levels if the system includes a pressure relief valve which opens at too low a pressure. See the troubleshooting procedure for this condition.

d. Malfunctions in the engine ignition for fuel system can, of course, also affect the efficiency of the air-fuel combustion. Correct them per the engine manufacturer maintenance publication.

e. If the troubleshooting procedure eliminates the other possible causes, it may be that the turbocharger is just not supplying a sufficient mass of air, for some reason apart from the causes already eliminated. See the troubleshooting procedure for “Turbocharger Output Low or Operates Sluggishly,” which examines causes which include possible defects in the turbocharger system as well as other sources of trouble.

**Oil Leakage (See Figure 18):**

The Turbocharger system is a possible source of oil leaks because it is connected to the engine lubricating oil system for lubricant/coolant in the turbocharger directly, and for power fluid in the exhaust bypass valve and controller(s). “Pre-Troubleshooting Inspection” includes checks for oil leakage at oil supply and drain lines and connections, and eliminates several possible defects which can help to cause oil leakage from the...
Figure 18 - Troubleshooting - Oil Leakage

Symptom or Trouble

Possible Causes and Remedies*

- At Too Slow Idle, Turbocharger Won’t Turn, Compressor Seal Leaks Oil Seen As Blue Smoke (See Note A**)
  - No
  - Try Faster Idle to Clear Up Smoking
  - Yes

- Engine Oil Wrong Type or Viscosity, or Unauthorized Oil Additives
  - No
  - Service Per Engine Manufacturer Maintenance Publications
  - Yes

- Engine Crankcase Improperly Vented
  - No
  - Refer to Engine Manufacturer Publications
  - Yes

- Restriction in Duct Between Air Cleaner and Turbocharger
  - No

- Restriction or Faulty Check Valve in Turbocharger Oil Drain Line
  - No
  - Turbocharger Seal Leakage at Compressor End
  - No
  - See Troubleshooting Chart For This Condition
  - Yes

- Turbocharger Seal Leakage at Turbine End
  - Yes

- Controller Leaking Oil Past Seal of Internal Poppet
  - No

- Engine Malfunction Allowing Oil in Exhaust (Rings, Pistons, Valves, Etc.)
  - Yes

- Refer to Engine Manufacturer Maintenance Publications

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17.

** Troubleshooting Procedure Notes, Table 18.

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turbocharger system components: a clogged air cleaner, loose connections on the duct from the compressor to the intake manifold, and leakage at the intake manifold. Some other possible causes and remedies are as follows:

a. If the engine idles too slowly, the turbocharger may not turn, allowing oil to leak past the compressor seal during idle and appear as blue smoke in the exhaust. Increase idle speed slightly to stop smoking. A new turbocharger may smoke for perhaps 30 minutes until factory oil coatings are consumed.

b. If the wrong type or viscosity of oil, or unauthorized oil additives, are being used in the engine lubrication system, service the system per the engine manufacturer maintenance publications.

c. If the engine crankcase is improperly vented, correct per engine manufacturer maintenance publications.

d. The “Pre-Troubleshooting Inspection” procedure checks for air cleaner restriction, which can cause oil to be drawn past the turbocharger seal at the compressor end. Also remove any restriction in the duct between the air cleaner and the turbocharger, and replace damaged parts as needed.

e. Restrictions in oil drainage may raise the oil level in the turbocharger center housing and cause seal leakage. As the troubleshooting chart suggests, check for a restriction or a faulty check valve in the turbocharger oil drain line. Remove such a restriction or replace damaged parts as needed.
f. If there is turbocharger seal leakage at either the turbine end or compressor end even after other possible causes mentioned in steps a, b, and c have been eliminated, see the troubleshooting chart for the seal leakage condition.

g. If a controller is discovered to be constantly leaking oil past the seal of the internal poppet, overhaul or replace the controller. Detect such leakage at a compressor outlet sensing line to the controller, at a low-pressure sensing port, or, for a duct-mounted controller without a cover, by removing the controller and inspecting the bellows area.

h. Oil in the exhaust system upstream of the turbocharger indicates an engine malfunction such as problems with rings, pistons, or valves. Correct these conditions per the engine manufacturer maintenance publications.

Engine Overboosts (See Figure 19):

Overboost, or excessive manifold pressure, can result if the control system malfunctions, and continues until the pilot takes corrective action or the malfunction is overcome.

**WARNING:** If engine is known to have overboosts, consult engine manufacturer’s instructions for inspection(s) required before engine may be operated again.
a. Some engines include a pressure relief valve in the turbocharger system, preset to crack open when compressor discharge pressure reaches a value slightly above the rated manifold pressure. If this relief valve fails to open, overboost can occur. See the troubleshooting chart for “Pressure Relief Valve Fails to Open.”

b. In some systems, a safeguard against overboost is the rate controller, or the rate section of a rate/absolute dual controller, which opens the exhaust bypass valve when there is an excessive rate of increase in compressor discharge pressure, as during a too-rapid throttle advance. If the exhaust bypass valve has failed to open, the troubleshooting chart “Exhaust Bypass Valve Fails To Open” may possibly point the way to a malfunctioning rate controller.

Cabin Loses Pressure at Altitude and Partial Power (See Figure 20):

If the aircraft cabin loses pressure at altitude but manifold pressure is adequate, then the aircraft controls for cabin pressure may have malfunctioned, and may require repair per the manufacturer’s instructions. Insufficient cabin pressure at partial power, however, can indicate that the turbocharger may not be supplying air at sufficient pressure for the cabin pressure system. The troubleshooting chart “Turbocharger Output Low or Operates Sluggishly” helps to pinpoint possible causes and remedies for this condition. One such cause may be an exhaust bypass valve which fails to close properly because its controller is out of adjustment.
Figure 19 - Troubleshooting - Engine Overboost

Symptom or Trouble

Possible Causes and Remedies*

Pressure Relief Valve Fails To Open

Yes

 Exhaust Bypass Valve Fails To Open

No

See Troubleshooting Chart For This Condition

See Troubleshooting Chart For This Condition

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17.

Figure 20 - Troubleshooting - Cabin Loses Pressure at Altitude and Partial Power

Symptom or Trouble

Possible Causes and Remedies*

Aircraft Cabin Pressure Controls Malfunction

Yes

Refer to Engine Manufacturer Maintenance Publications

Turbocharger Output Low or Operates Sluggishly

No

See Troubleshooting Chart For This Condition

Yes

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17.
TROUBLESHOOTING TURBOCHARGER

SYMPTOMS:

Turbocharger Output Low or Operates Sluggishly (See Figure 21):

The condition of “Turbocharger Output Low or Operates Sluggishly” is listed as a possible cause in two engine troubleshooting procedures, each of which includes “Pre-Troubleshooting Inspections,” so that a number of possible causes of turbocharger insufficiency may be investigated and eliminated. These causes include: loose connections or other leaks in the air induction or engine exhaust systems; restriction in the air cleaner; observable damage to, or foreign material lodged in, the compressor wheel or turbine wheel; and discernible binding or dragging of the turbocharger rotating assembly. Other possible causes and remedies are as follows:

a. Turbocharger output may be low because the exhaust bypass valve fails to close, and instead allows too much of the exhaust gas to bypass the turbine. Early detection of this condition and troubleshooting under “Exhaust Bypass Valve Fails to Close or Operates Sluggishly,” below, can save much troubleshooting time and effort.

b. Restrictions in the air ducting between the air cleaner and the turbocharger would reduce the volume of air entering the compressor, and
restrictions in the duct between the compressor and the engine intake manifold would hinder the delivery of compressed air to the engine. Also, any restriction in the engine exhaust system downstream of the turbocharger turbine would affect the flow of exhaust gas through the turbine to drive the compressor. For any of the restrictions listed in this step, remove the restriction and replace damaged parts as needed.

c. In the case of restrictions in the engine intake or exhaust manifolds, correct the condition per the engine manufacturer maintenance publications.

d. A heavy buildup of carbon deposits behind the turbine wheel can be a hindrance to rotation, and requires disassembly and overhaul or replacement of the turbocharger. The condition is also a good reason to review engine operation and maintenance procedures, if they result in excessive unburned hydrocarbons in the exhaust or oil in the turbine housing.

e. Faulty operation or poor maintenance of the engine can also cause heavy sludging or coking in the turbocharger center housing, with hindrance of rotation and added wear on bearings among its negative effects. Inspect the interior of the center housing by removing the oil drain and looking in through the oil drain opening, removing the turbocharger if necessary. When a sludged or coked condition exists, sludge builds up heavily on the shaft between the bearing journals, on the wall of the housing from the oil drain opening back to the
* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17 (page 84).

** Troubleshooting Procedure Notes, Table 18 (page 90).
turbine end, and on the turbine-end piston ring seal. This condition requires overhaul of the turbocharger as needed and a complete servicing of the engine lubricating oil system components supplying and draining the turbocharger center bearing housing assembly.

f. If there is suspicion of abnormal wear in the turbocharger bearings, perform the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000. Failure to pass this inspection calls for overhaul or replacement of the turbocharger after seeking causes of wear in the troubleshooting procedure, “Turbocharger Shaft Bearings, Journals or Bearing Bores Worn.”

**Turbocharger Rotating Assembly Binding or Dragging (See Figure 22):**

Binding or dragging of the turbocharger rotating assembly may be detected visually, by removing the air duct from the compressor inlet or the exhaust duct from the turbine outlet, and looking for wheel damage or rubbing. This symptom may also be detected by hearing the sound, or by feeling the drag while manually turning the rotating assembly. Possible causes and remedies are as follows:

a. To detect hindrances to rotation in the compressor or turbine housings, remove the air duct from the turbocharger compressor inlet, and the exhaust duct from the turbine outlet and inspect the compressor wheel and turbine wheel, and their housings, and proceed as follows:
Symptom or Trouble

Possible Causes and Remedies*

Compressor Wheel Damaged by Foreign Object. (See Note F, G, *)

No

Yes

Clean and Repair Air Induction System As Needed, Overhaul Turbo.

Turbine Wheel Damaged by Foreign Object. (See Note F, *)

No

Yes

Clean and Repair Exhaust System As Needed, Overhaul Turbo.

Compressor Wheel or Turbine Wheel Rubbing on Housing. (See Note F, *)

No

Yes

See “Turbocharger Shaft Bearings, Journals or Bearing Bores Worn.”

Heavy Carbon Buildup Behind Turbine Wheel. (See Note C, *)

No

Yes

Overhaul Turbocharger As Needed

Heavy Sludge or Coking in Center Housing. (See Notes C, D, *)

Yes

Overhaul Turbocharger, Service Engine, Lube System

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17 (page 84).

** Troubleshooting Procedure Notes, Table 18 (page 90).
1. If there is compressor wheel or turbine wheel damage from a foreign object, clean and repair the air induction system or engine exhaust system respectively, as needed, and try to determine the source of the foreign object to prevent a recurrence. Overhaul or replace the turbocharger.

2. If there is evidence of the compressor wheel or turbine wheel rubbing on the housing, perform the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000. If the bearings do not pass this inspection, determine the cause of wear by troubleshooting the condition, “Turbocharger Shaft Bearings, Journals or Bearings Bores Worn,” and overhaul or replace the turbocharger.

3. If there is heavy carbon buildup behind the turbine wheel, overhaul the turbocharger as needed, and examine the engine operation and maintenance procedures for departures from accepted practices and standards.

b. To detect heavy sludge or coking in the turbocharger, remove the oil drain from the center housing and look in through the oil drain opening, removing the turbocharger if necessary. When a sludged or coked condition exists, sludge builds up heavily on the shaft between the bearing journals, on the wall of the housing from the oil drain opening back to the turbine end, and on the turbine-end piston ring seal. For this condition, overhaul or replace the turbocharger and completely service the
engine lubricating oil system. Also examine the engine operation and maintenance procedures for departures from accepted practices and standards.

**Turbocharger Shaft Bearings, Journals or Bearing Bores Worn (See Figure 23):**

Suspected abnormal wear in the turbocharger shaft bearings, journals, or bearing bores can be readily confirmed by performing the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000. It is imperative to detect and eliminate the cause of such failure before a replacement turbocharger is installed. Abnormal wear in the bearings results from abrasives in the oil, or from an insufficient supply of oil. Examine engine operation and maintenance procedures for departures from accepted practices and standards. These are some of the possible causes of bearing wear, and their remedies:

a. If there is a restriction or faulty check valve in the oil supply line to the turbocharger, remove the restriction or replace damaged parts, as needed.

b. If the engine oil is contaminated or of improper grade or type, or if the engine oil filter is clogged, provide service for the engine lubricating oil system in accordance with the manufacturer maintenance publications.

c. If a malfunction of the engine lubricating oil system causes an insufficient oil supply to the turbocharger, correct the condition per engine manufacturer maintenance publications.
Symptom or Trouble

Possible Causes and Remedies*

- Turbo, Shaft Bearings, Journals or Bearing Bores Worn (See Note E, *)
  - Restriction or Faulty Check Valve In Oil Supply Line To Turbo. Yes
  - Contaminated or Improper Grade Or Type of Engine Lube Oil Yes
  - Insufficient Oil Supply To Turbo, Due To Engine Lube System Malfunction Yes

- No
  - Remove Restriction Or Replace Damaged Parts As Needed
  - Service Per Engine Manufacturer Maintenance Publications
  - Refer To Engine Manufacturer Maintenance Publications

- Insufficient Oil Supply To Turbo Due To Oil Lag (See Note C, **) Yes
  - Abrasive Wear From Coked Particles in Center Housing Yes
  - Service Lube System Per Engine Manufacturer Maintenance Publications

- Clogged Engine Oil Filter
  - Refer To Engine Manufacturer Maintenance Publications

- Yes

* Chart assumes that “Pre-Troubleshooting Inspection” has been performed as summarized in Table 17 (page 84).
** Troubleshooting Procedure Notes, Table 18 (page 90).
d. Check whether the turbocharger was properly prelubricated at installation, or at the most recent servicing of the engine lubricating system. See Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000 for the procedure, “Prelubricating Turbocharger on Engine.”

e. If engine speed and load is increased above idle before oil pressure has built up to at least the minimum level prescribed by the engine manufacturer, the “oil lag” may damage the turbocharger. See the engine operating precautions under “Special Operating Procedures” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000.

f. Improper operation, especially overheating, may produce carbonized or “coked” particles in the oil, abrasive enough to cause direct wear of the turbocharger bearing surfaces. The lubricating system must be serviced per engine manufacturer maintenance publications before installing a replacement turbocharger.
Turbocharger Seal Leakage at Compressor End
(See Figure 24):

Several conditions can cause turbocharger seal leakage at the compressor end of the rotating assembly by drawing or forcing oil past this seal. Higher-than-normal pressure outside the housing, or an increase in the level of oil within the housing will contribute to oil loss past the seal. A worn or damaged compressor wheel and/or worn turbocharger shaft bearings may also cause motion and wear at the seal. These are some possible causes and remedies:

a. If the engine air cleaner element is clogged, inspect and service the air cleaner per the engine manufacturer maintenance publications.

b. If there is a restriction or faulty check valve in the turbocharger oil drain line, remove the restriction or replace damaged parts as needed.

c. If there is a restriction in the duct between the air cleaner and the turbocharger compressor intake, remove the restriction or replace damaged parts as needed.

d. A malfunction in the oil scavenge pump or the drain sump may cause oil backup in the turbocharger center housing. Correct such conditions per the engine manufacturer maintenance publications.

e. If there is a restriction in the engine crankcase breather, detect and eliminate the condition per the engine manufacturer maintenance publications.
Figure 24 - Troubleshooting - Turbocharger Seal Leakage at Compressor End

Symptom or Trouble: Turbocharger Seal Leakage at Compressor End

Possible Causes and Remedies:

- Air Cleaner Element Clogged
  - Yes: Service Per Engine Manufacturer Maintenance Publications
  - No: Restriction or Faulty Check Valve In Turbo, Oil Drain Line
    - Yes: Remove Restriction or Replace Damaged Parts As Needed
    - No: Restriction in Duct Between Air Cleaner and Turbocharger
      - Yes: Remove Restriction or Replace Damaged Parts As Needed
      - No: Malfunction In Oil Scavenge Pump Or Drain Sump
        - Yes: Refer To Engine Manufacturer Maintenance Publications
- Restriction in Engine Crankcase Breather
  - Yes: Refer to Engine Manufacturer Maintenance Publications
  - No: Worn or Damaged Compressor Wheel (See Note F and G, *)
    - Yes: Clean and Repair Air Induction System As Needed, Overhaul Turbo.
    - No: Turbo, Shaft Bearings, Journals or Bearing Bores Worn (See Note E, *)
      - Yes: See Troubleshooting Chart For this Condition
      - No: Engine Malfunction, Piston Blowby or High Internal Crankcase Pressure
        - Yes: Refer To Engine Manufacturer Maintenance Publications

* Troubleshooting Procedure Notes, Table 18 (page 90).
f. If compressor wheel damage or wear is present to contribute to seal leakage, clean and repair the air induction system, as needed, and overhaul or replace the turbocharger.

g. If the turbocharger shaft bearings, journals, or bearing bores are worn (to the extent of not passing the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000, determine the cause of wear by troubleshooting this condition before overhauling or replacing the turbocharger.

h. If there is an engine malfunction such as piston blowby or too high internal crankcase pressure, correct the condition per the engine manufacturer maintenance publications.

**Turbocharger Seal Leakage at Turbine End**
(See Figure 25):

Most of the possible causes considered here for turbocharger seal leakage at the turbine end of the rotating assembly tend to raise the level of the oil within the turbocharger center housing, or to affect the relative pressures on the internal and external sides of the seal. There is also the possibility of seal damage or wear if the turbine wheel is worn or damaged, or shaft bearings have worn abnormally. These are some possible causes and remedies:

a. Check whether the turbocharger was prelubricated excessively, and follow the instructions for “Prelubricating Turbocharger on Engine” found in
Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000.

b. If there is a restriction in the engine crankcase breather, detect and eliminate the condition per the engine manufacturer maintenance publications.

c. If there is a restriction or faulty check valve in the turbocharger oil drain line, remove the restriction or replace damaged parts as needed.

d. A malfunction in the oil scavenge pump or the drain sump may cause oil backup in the turbocharger center housing; correct such conditions per the engine manufacturer maintenance publications.

e. If turbine wheel damage or wear is present to contribute to seal leakage, clean and repair the exhaust system, as needed, and overhaul or replace the turbocharger.

f. To detect heavy sludge or coking in the turbocharger, remove the oil drain from the center housing and look in through the oil drain opening. Remove the turbocharger if necessary. When a sludge or coked condition exists, sludge builds up heavily on the shaft, between the bearing journals, on the walls of the housing from the oil drain opening back to the turbine end, and on the turbine-end piston ring seal. For this condition, overhaul the turbocharger and completely service the engine lubricating oil system. Also review engine operation and maintenance procedures for departures from accepted practices and standards.
**Symptom or Trouble**

**Possible Causes and Remedies**

**Excessive Prelube of Turbocharger**
- Yes: Follow Prelube Instructions, Vol. 1, Section 2 of Manual

**Restriction in Engine Crankcase Breather**
- Yes: Refer to Engine Manufacturer Maintenance Publications

**Restriction or Faulty Check Valve in Turbo, Oil Drain Line**
- Yes: Remove Restriction or Replace Damaged Parts As Needed

**Malfunction In Oil Scavenge Pump Or Drain Sump**
- Yes: Refer to Engine Manufacturer Maintenance Publications

**Worn or Damaged Turbine Wheel**
- Yes: Clean and Repair Exhaust System As Needed, Overhaul Turbo.

**Heavy Sludge or Coking in Center Housing**
- Yes: Overhaul Turbocharger, Service Engine Lube System

**Turbo, Shaft Bearings, Journals or Bearing Bores Worn**
- Yes: See Troubleshooting Chart For this Condition

**Engine Malfunction, Piston Blowby or High Internal Crankcase Pressure**
- Yes: Refer to Engine Manufacturer Maintenance Publications

* Troubleshooting Procedure Notes, Table 18.
g. If the turbocharger shaft bearings, journals, or bearings bores are worn (to the extent of the not passing the “Bearing Clearance Inspection” found in Chapter 2 of the latest revision of the HET Aircraft Turbocharger Overhaul Manual P/N 400600-0000, determine the cause of wear by troubleshooting this condition before overhauling or replacing the turbocharger.

h. If there is an engine malfunction such as piston blowby or too high internal crankcase pressure, correct the condition per the engine manufacturer maintenance publications.

TROUBLESHOOTING VALVE AND CONTROLLER:

Pressure Relief Valve Does Not Open (See Figure 26):

If the absolute pressure relief valve in a turbocharger system does not open to prevent overboost, it must be removed and disassembled. If testing of the valve (Chapter 2 of the latest revision of HET Aircraft Valves and Controls Overhaul Manual P/N 400999-0000) indicates a malfunctioning aneroid bellows, overhaul or replace the valve. If testing shows that the valve is out of calibration, recalibrate or replace the valve.
Figure 26 - Troubleshooting - Pressure Relief Valve Does Not Open

Possible Causes and Remedies

Symptom or Trouble
Pressure Relief Valve Does Not Open

Relief Valve Aneroid Bellows Malfunctioning

Yes

Overhaul or Replace Relief Valve

No

Relief Valve Out of Calibration

Recalibrate or Replace Relief Valve

Figure 27 - Troubleshooting - Pressure Relief Valve Opens at Too Low a Pressure

Possible Causes and Remedies

Symptom or Trouble
Pressure Relief Valve Opens At Too Low Pressure

Relief Valve Head or Mounting Flange Fretted or Worn

Yes

Replace Valve Head And/Or Mounting Flange

Attaching Bolts Loose or O-Ring Blown

Yes

Replace O-Ring and Tighten Bolts

Relief Valve Out of Calibration

Recalibrate or Replace Relief Valve

Yes

Attached Bolts Loose or O-Ring Blown

Replace O-Ring and Tighten Bolts

Recalibrate or Replace Relief Valve
Pressure Relieve Valve Opens At Too Low a Pressure (See Figure 27):

The absolute pressure relief valve in a turbocharger system may open at too low a pressure. Here are some possible causes and remedies for this malfunction:

a. If the spring (if accessible), valve head and/or the mounting flange are fretted, broken or worn, replace the part(s) as needed.

b. If the attaching bolts for the valve are loose, tighten them. If the O-Ring at the attaching surface has blown, replace it.

c. If the testing shows that the relief valve is out of calibration, recalibrate or replace the valve.

Exhaust Bypass Valve Does Not Close Or Operates Sluggishly (See Figure 28):

An exhaust bypass valve normally stays open until oil pressure builds up in its hydraulic cylinder to actuate its closing. Not closing must be traced to a hydraulic problem in building up oil pressure, or to a mechanical problem in closing the poppet-type or butterfly-type valve. Some of the possible causes and remedies are as follows:
a. The engine oil system may be operating at a pressure too low to actuate the exhaust bypass valve. Check and correct for such a condition per the engine manufacturer maintenance publications.

b. If there is a restriction in the oil supply line to the exhaust bypass valve actuator, remove the restriction or replace the line, as needed.

c. If the wrong poppet-type exhaust bypass valve has been installed, with a poppet size not matching the seat to which it must mate, replace with the correct unit as listed in the manufacturer’s publications.

d. If the inlet port of the actuator is obstructed, clear the orifice or capillary tube in the port, or replace the capillary tube if damaged.

e. In a poppet-type exhaust bypass valve, if the poppet is stuck in the open position, overhaul or replace the unit.

f. On a butterfly-type exhaust bypass valve, if the external linkage from the actuator to the butterfly valve is binding, correct the cause of the binding. If the butterfly itself cannot move because the bearings are tight, perhaps from carbon deposits, try freeing the shaft by spraying with carbon solvent lubricant. Otherwise, overhaul or replace the valve housing assembly.

g. Check butterfly clearance in the “fully closed” position against the valve in the “Reassembly” procedure for the specific exhaust bypass valve in Chapter 2 of the latest revision of the HET
Figure 28 - Troubleshooting - Exhaust Bypass Valve Does Not Close or Operates Sluggishly

Symptom or Trouble

Possible Causes and Remedies

Exhaust Bypass Valve Does Not Close or Operates Sluggishly

- Engine Oil Pressure Too Low To Actuate Bypass Valve
  - Yes
  - No
  - Refer To Engine Manufacturer Maintenance Publications
  - Yes

- Restriction In Oil Supply Line To Bypass Valve
  - Yes
  - No
  - Remove Restriction Or Replace Line As Needed
  - Yes

- Wrong Poppet-Type Bypass Valve Installed (Wrong Dia. Poppet)
  - Yes
  - No
  - Replace With Correct Bypass Valve
  - Yes

- Actuator Inlet Port Obstructed
  - Yes

In Poppet-Type Bypass Valve, Poppet Sticking Open

- Yes

- Overhaul or Replace Bypass Valve

- Actuator Linkage Binding
  - Yes

- Correct Cause of Binding

- Butterfly Valve Bearings Tight (Carbon Deposits)
  - Yes

- Spray With Carbon Solvent Lubricant or Overhaul Valve Housing Assembly
  - Yes

- Butterfly “Fully Closed” Position Out of Adjustment
  - Yes

- Readjust Per Ch. 3 of the Valve & Controls Overhaul Man. 400999-000

Actuator Piston Packing Leaking Excessively or Cylinder Walls Scored

- Yes

- Replace Packing or Overhaul Bypass Valve As Needed
  - Yes

- Controller Fails To Close Oil Flow or Operates Sluggishly
  - Yes

- See Troubleshooting Chart For This Condition

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h. If disassembly and inspection of the actuator shows that the piston packing has worn, fretted, or cracked to allow excessive oil leakage, replace the packing. If the actuator cylinder walls are scored, overhaul or replace the exhaust bypass valve.

i. Oil pressure cannot build up if a controller located between the actuator outlet and the engine crankcase fails to close off the oil flow. See the troubleshooting procedure, “Controller Fails to Close Oil Flow,” Figure 30.

Exhaust Bypass Valve Does Not Open
(See Figure 29):

If an exhaust valve, which is normally open, does not open, this must be due to either a hydraulic problem which prevents relief of the oil pressure which actuates the valve to close, or a mechanical problem which interferes with opening. Some of the possible causes and remedies are as follows:

a. If there is a restriction in the oil line from the exhaust bypass valve actuator to the controller(s), remove the restriction or replace the line, as needed.

b. In a poppet-type exhaust bypass valve, if the poppet is stuck in the closed position, overhaul or replace the bypass valve.
Figure 29 - Troubleshooting - Exhaust Bypass Valve Does Not Open

**Symptom or Trouble**

Exhaust Bypass Valve Does Not Open

Possible Causes and Remedies

- Restriction In Oil Line From Actuator To Controller
  - No
  - Yes
  - Remove Restriction Or Replace Line As Needed

- In Poppet-Type Bypass Valve, Poppet Sticking Closed
  - No
  - Yes
  - Overhaul Or Replace Bypass Valve

- Actuator Linkage Binding
  - No
  - Yes
  - Correct Cause of Binding

- Butterfly Valve Bearing Tight (Carbon Deposits)
  - No
  - Yes
  - Spray With Carbon Solvent Lubricant Or Overhaul Valve Housing Assembly

- Butterfly Valve Jams Closed In Warmup, Then Releases At Operating Temp.
  - No
  - Yes
  - Center Butterfly In Valve Housing

- Butterfly “Fully Open” Position Out of Adjustment
  - No
  - Yes
  - Readjust Per Section 5 of Manual

- Controller Does Not Open Oil Flow
  - No
  - Yes
  - See Troubleshooting Chart For This Condition

- Controller Does Not Open Oil Flow
  - No
  - Yes
  - See Troubleshooting Chart For This Condition

- Controller Does Not Open Oil Flow
  - No
  - Yes
  - See Troubleshooting Chart For This Condition

- Controller Does Not Open Oil Flow
  - No
  - Yes
  - See Troubleshooting Chart For This Condition
c. On a butterfly-type exhaust valve, if the external linkage from the actuator to the butterfly valve is binding, correct the cause of binding. If the butterfly itself if stuck in the closed position, or cannot move because the bearings are tight, perhaps from carbon deposits, try freeing the shaft by spraying with carbon solvent lubricant. Otherwise, overhaul or replace the valve housing assembly.

d. Check butterfly clearance in the “fully open” position against the valve given in the “Reassembly procedure for the specific exhaust bypass valve in Chapter 2 of the latest revision of the HET Aircraft Valves and Controls Overhaul Manual P/N 400999-0000. If necessary, adjust to the correct clearance.

e. If the controller located between the actuator outlet and the engine crankcase which is supported to relieve oil pressure to open the bypass does not do so, see the troubleshooting procedure, “Controller Fails To Open Oil Flow.”

**Controller Does Not Close Oil Flow or Operates Sluggishly (See Figure 30):**

Each controller is designed so that its internal poppet valve is nearly closed, within what is senses as “normal” conditions. This partially closes off oil flow through the controller from the exhaust bypass valve to the engine crankcase. Some of the possible causes of controller not closing off oil flow consistently, and their remedies, are as follows:
Figure 30 - Troubleshooting - Controller Does Not Close Oil Flow Or Operates Sluggishly

Symptom or Trouble: Controller Does Not Close Oil Flow Or Operates Sluggishly

Possible Causes and Remedies:

1. Leak In Low Pressure Sensing Line, If Any, To Controller
   - Yes: Repair Leak Or Replace Line As Needed
   - No: Controller Leaking Oil Past Seal Of Internal Poppet (See Note pg 122)

2. Controller Leaking Oil Past Seal Of Internal Poppet (See Note pg 122)
   - Yes: Overhaul Or Replace Controller
   - No: Variable Absolute Pressure Controller External Cam Worn

3. Variable Absolute Pressure Controller External Cam Worn
   - Yes: Overhaul Or Replace Controller
   - No: Variable Absolute Pressure Controller Linkage To Throttle Incorrect

4. Variable Absolute Pressure Controller Linkage To Throttle Incorrect
   - Yes: Refer To Engine Manufacturer Maintenance Publication

5. Controller Out Of Calibration
   - Yes: Recalibrate Or Replace Controller
   - No: Controller Internal Poppet Held Open By Foreign Particles In Oil

6. Controller Internal Poppet Held Open By Foreign Particles In Oil
   - Yes: Flush Controller Or Overhaul As Needed
   - No: Controller Internal Poppet Sticking Open

7. Controller Internal Poppet Sticking Open
   - Yes: Overhaul Or Replace Controller
   - No: Controller Internal Damage

8. Controller Internal Damage
   - Yes: Overhaul Or Replace Controller
a. If there are air pressure sensing lines to the controller, inspect the lines for leaks or restrictions and repair or replace the line, as needed.

b. Check for significant oil leakage past the seal of the controller internal poppet. Look for this leakage at the compressor outlet air sensing line to the controller, at the other air sensing lines or ports, or, for a duct-mounted controller without a cover, remove the controller and inspect the bellows area. If there is such leakage, overhaul or replace the controller.

c. If the controller is a variable absolute pressure type which has been in service for some time, it is possible that some of the external mechanisms have become worn, especially the cam. If so, overhaul or replace the controller.

d. On a variable absolute pressure controller, the linkage to the engine throttle may be incorrectly assembled, loose or out of adjustment. If so, reassemble, tighten or readjust per the engine manufacturer maintenance publications.

e. If testing (in Chapter 2 of the latest revision of the HET Aircraft Valves and Controls Overhaul Manual P/N 400999-0000) shows that the controller is out of calibration, recalibrate or replace the controller.

f. If inspection shows that the controller internal poppet is held open by foreign particles in the oil, flush the controller with clean engine oil. If
flushing alone does not cure the trouble, overhaul or replace the controller.

g. If there is other internal damage to the controller, such as a torn diaphragm or broken spring, overhaul or replace the controller.

Controller Does Not Open Oil Flow
(See Figure 31):

Each controller is designed so that its internal poppet valve is normally closed until it senses those conditions in which it is to open and permit oil flow from the exhaust bypass valve to the engine crankcase, permitting the exhaust bypass valve to open. Some possible causes of controller not permitting oil flow, and their remedies, are as follows:

a. If the engine oil is too cold for the controller to operate properly, allow time for the oil to warm up.

b. If there is a restriction in the oil line from the controller back to the engine crankcase or oil sump, remove the restriction or replace the line, as needed.

c. If there is an air pressure sensing line to the controller, inspect the line for leaks, or restrictions, and repair or replace the line, as needed; if present, check for tears or holes in the diaphragm. If so, replace diaphragm.
d. On a variable absolute pressure controller, the linkage to the engine throttle may be incorrectly assembled or out of adjustment. If so, reassemble or readjust per the engine manufacturer maintenance publications.

e. If testing (in Chapter 2 of the latest revision of the HET Aircraft Valves and Controls Overhaul Manual P/N 400999-0000.) shows that the controller is out of calibration, recalibrate or replace the controller.

f. In a rate controller, if the capillary is clogged, clear the capillary or overhaul the controller.

g. If inspection of the controller shows that the internal poppet is stuck closed, or the controller is otherwise damaged, overhaul or replace the controller.
Controller Does Not Open Oil Flow

Possible Causes and Remedies

- Engine Oil Too Cold
  - No
  - Yes: Allow Oil To Warm

- Restriction In Oil Drain Line
  - No: Remove Restriction Or Replace Line As Needed
  - Yes

- Leak In High Pressure Air Sensing Line, If Any, To Controller
  - No: Repair Leak Or Replace Line As Needed
  - Yes

- Variable Absolute Pressure Controller Linkage To Throttle Incorrect Or Loose
  - No
  - Yes: Refer To Engine Manufacturer Maintenance Publication

- Controller Out of Calibration
  - No
  - Yes: Recalibrate Or Replace Controller

- Main Bellows Lost Vacuum
  - No
  - Yes: Overhaul Or Replace Controller

- Rate Controller Capillary Clogged
  - No
  - Yes: Clear Capillary Or Overhaul Controller

- Controller Internal Poppet Sticking Closed
  - No
  - Yes: Overhaul Or Replace Controller

- Controller Internal Damage
  - No
  - Yes: Overhaul Or Replace Controller
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