TELEDYNE CONTINENTAL ® AIRCRAFT ENGINE **CATEGORY 3**

SERVICE BULLETIN

SB03-3

Compliance Will Enhance Safety

FAA APPROVED
SUPERSEDES M84-15

SUBJECT: DIFFERENTIAL PRESSURE TEST AND BORESCOPE INSPECTION PROCEDURES FOR CYLINDERS.

PURPOSE: This bulletin provides differential pressure test and borescope inspection procedures for cylinders to be used as a guide in the determination of their serviceability with respect to these tests.

COMPLIANCE: At each 100 hour interval, annual inspection or when cylinder problems are suspected.

MODELS AFFECTED: All Teledyne Continental Motors (TCM) engine models**.**

GENERAL

F.A.A. Advisory Circular (AC) 43.13-1. Chapter 8, Section 1, paragraph 8-1 states; " Consult the manufacturer's manuals, service bulletins and instruction books regarding the repair and overhaul, inspection, installation, and maintenance of aircraft engines, for that particular make, model and type of engine. This section lists acceptable inspection and repair procedures that may be used in the absence of an engine manufacturer's maintenance information." The following procedures are to be used as the standard for performing a cylinder differential pressure test on all TCM engines. Reference 14 CFR Part 43.13.

A. CYLINDER CONDITION DISCUSSION

The cylinder differential pressure test has become a widely used method of assisting in determining the internal condition of cylinders and cylinder components. As with any test or inspection the cylinder differential pressure test has certain limitations that necessitate its use in conjunction with other non-invasive inspections. TCM requires a cylinder borescope inspection be accomplished in conjunction with the differential pressure test.

In addition to the cylinder differential pressure test and borescope inspection, further inspection of any suspect cylinder is recommended in accordance with the guidelines set forth in this service bulletin. Refer to Tables 1 and 2. The technician should also be cognizant of the engines' oil consumption, the appearance or color of the engine oil and any visual indications of high crankcase pressure (combustion blow-by) such as an oily, wet area on the aircraft belly or lower wing surface. Refer to the latest revision of TCM's Service Bulletin (SB) 96-12 and Service Information Directive (SID) 97-2 for additional inspection items and pilot awareness topics.

The purpose of the cylinder differential pressure test is to IDENTIFY LEAKS and the SOURCE OF LEAKS, with the engine under static conditions (not running), using a regulated pressure source. When performing a cylinder differential pressure test a regulated test pressure of eighty pounds per square inch (80 PSI) is directed into the cylinder with the piston at top dead center at the end of the compression stroke and the beginning of the power stroke. Eighty pounds per square inch (80 PSI) is used as a test pressure for safety reasons and is significantly less than the combustion pressure of 800 to 1000 PSI created during engine operation. Pistons, piston rings, valves and valve seats rely on combustion forces to assist in creating a complete seal during engine operation.

NOTE: This static leak check does not relate directly to cylinder pressures developed during actual engine operations.

The purpose of the cylinder borescope inspection is to provide a visual method of examining the internal cylinder components and must be used in conjunction with the differential pressure test.

Excess cylinder wall or piston ring wear, broken piston rings and burned valves will normally be evidenced by additional conditions that must be taken into consideration when determining cylinder condition. These may include, but may not be limited to:

Excessive cylinder barrel wear and/or piston ring wear:

1. Elevated crankcase pressure; reference the latest revision of TCM Service Bulletin M89-9.
2. Increased oil consumption. See note ② on page 9.
3. Oil becoming discolored within first 10 hours after an oil change.
4. High iron content in oil analysis may be an indication.

Broken piston rings:

1. Scored, grooved cylinder wall, evident via a borescope inspection.
2. Abnormal debris in oil filter or oil screen.
3. High iron content in oil analysis may be an indication.

Burned Valves:

1. Usually results in differential leak test reading in the 0/80 to 40/80 range.
2. Easily identifiable during borescope inspection.

Additionally, many variables affect what a technician sees from a differential pressure test reading. These variables include, but are not limited to:

1. Abnormal amounts of oil in cylinder.
2. Temperature of the engine and the uniformity of cylinder temperature at the time the differential pressure test is performed.
3. Accuracy of the test equipment being used.
4. Capacity and pressure output of the source of compressed air and the techniques used by the technician when performing the test.

B. CYLINDER DIFFERENTIAL PRESSURE TEST:

(a) Required Tools and Equipment:

In addition to the standard complement of tools required to perform maintenance and repairs on aircraft engines the following tools and equipment are required to perform a cylinder differential pressure test.

1. Source of dry, compressed air capable of providing a minimum line pressure of 125 P.S.I. with a minimum flow capability of 15 Cubic Feet per Minute.

2. Cylinder differential pressure tester. Select one of the following units listed below or equivalent.

   - Eastern Technology Corporation Model E2M①. See Figure 1. **Recommended by TCM.**

     This differential pressure tester incorporates the Master Orifice Tool.

     Eastern Technology Corporation
     180 Roberts Street
     East Hartford, CT 06108
     Phone: 860-528-9821

   - Eastern Technology Corporation Model E2A①. See Figure 2.

     This differential pressure tester requires you to purchase separately the Master Orifice tool P/N 646953.

     Eastern Technology Corporation
     180 Roberts Street
     East Hartford, CT 06108
     Phone: 860-528-9821

3. Master Orifice Tool P/N 646953A.

   This tool is available in limited supply.

   SPX Corp. - Kent Moore Tool Division
   28635 Mound Road
   Warren, MI 48092
   Phone: 800-345-2233

NOTE: Differential pressure test equipment must be certified and calibrated. Failure to properly maintain and calibrate test equipment may result in false cylinder differential compression readings.

① Eastern Technology Corporation offers calibration and repair service on these items.

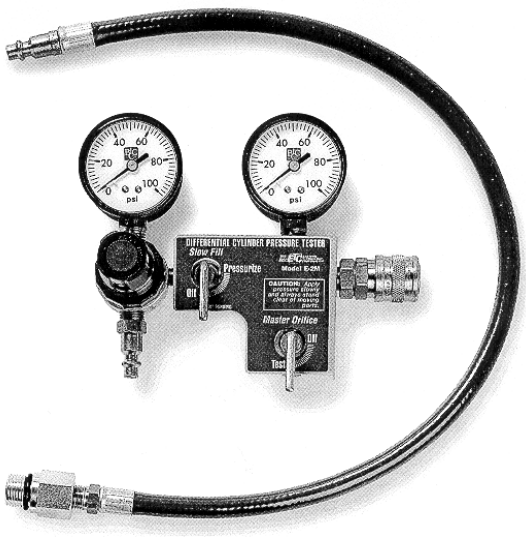


FIGURE 1
Eastern Technology Corp. Model E2M

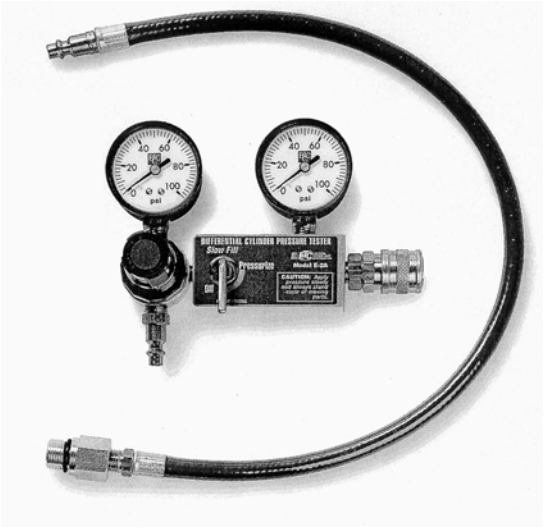


FIGURE 2

Eastern Technology Corp. Model E2A

(b) Establishing the Acceptable Pressure Leakage Limit:

The "Master Orifice" is a calibration standard that must be used prior to performing the cylinder differential pressure test. The "Master Orifice" establishes the **Acceptable Cylinder Pressure Leakage Limit** for the **test equipment** being used and the **atmospheric conditions** at the time of the test. The Acceptable Cylinder Pressure Leakage Limit reading must be recorded along with the individual cylinder readings in the engine logbook and the inspection work order.

1) Eastern Technology Corporation Model E2M:

This test is accomplished with no connections to the female quick connector.

a) Set the ***Master Orifice Valve*** to the **OFF** position; handle horizontal and directly over the OFF label.

b) Set the ***Slow Fill Valve*** (next to the pressure regulator) to the **OFF** position; handle vertical and pointing down.

c) After making sure the ***Slow Fill Valve*** is **OFF**, connect your air source to the tester at the male quick connection fitting.

d) Adjust pressure regulator so left hand gauge reads 80 PSI.

e) Set the ***Master Orifice Valve*** to the **TEST** position; handle vertical and pointing down.

f) Open the ***Slow Fill Valve*** completely; handle horizontal and over the **PRESSURIZED** label.

g) If necessary, adjust the regulator to maintain 80PSI indication on the left-hand gauge.

h) Record the pressure reading on the right hand gauge. This reading is the **Minimum Acceptable Cylinder Pressure Leakage Limit**.

i) Close the ***Slow Fill Valve*** completely; handle vertical and pointing down.

j) Set the ***Master Orifice Valve*** to the **OFF** position; handle horizontal and directly over the **OFF** label.

You are now ready to perform the cylinder differential pressure test.

2) Standard Differential Pressure Tester and Master Orifice Tool P/N 646953:

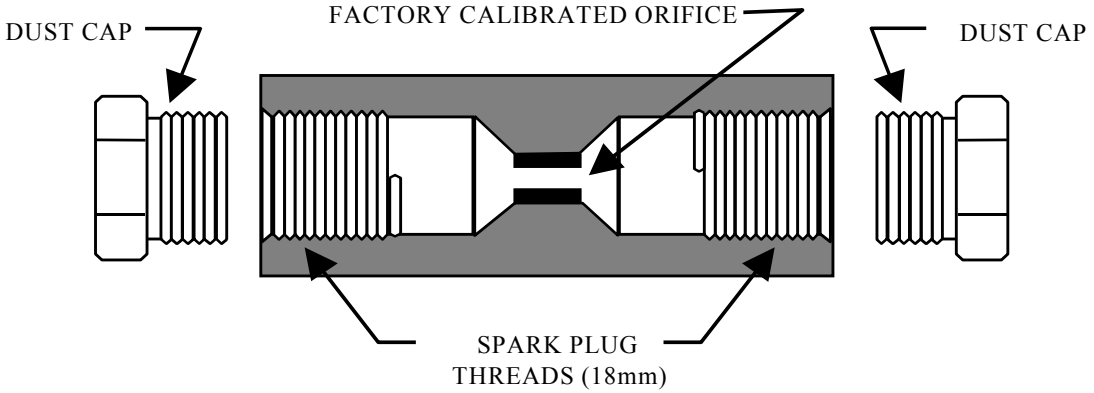


FIGURE 3
MASTER ORIFICE P/N 646953

a) Make sure the ***Regulator Pressure Valve*** is backed all the way **OUT.**

b) Make sure the ***Cylinder Pressure Valve*** is **OFF or Closed.**

c) Remove the protective caps from both ends of the Master Orifice and install the Master Orifice onto the threaded end of the cylinder adapter and tighten hand tight.

d) Connect the cylinder adapter with Master Orifice attached to the female quick connection on the supply hose from the differential test unit.

e) Connect your air source to the tester at the male quick connection fitting.

f) Adjust pressure regulator so regulator pressure gauge reads 80 PSI.

g) Turn the cylinder pressure valve to the **ON** or **OPEN** position.

h) If necessary, adjust the pressure regulator to maintain a reading of 80 PSI on the regulator pressure gauge.

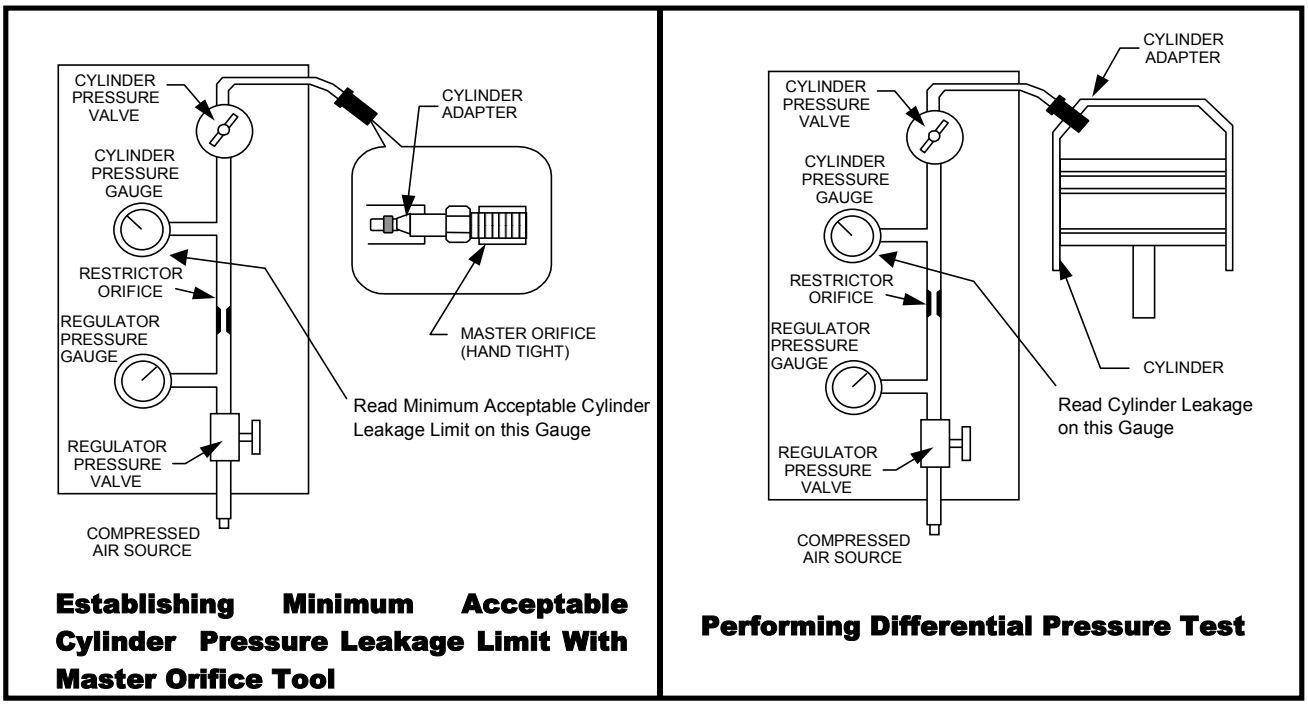
i) Record the pressure reading on the cylinder pressure gauge. This reading is the **Minimum Acceptable Pressure Leakage Limit**.

j) Turn the cylinder pressure valve to the **CLOSED** or **OFF** position.

k) Remove the cylinder adapter and Master Orifice from the female quick connection on the supply hose from the differential test unit.

l) Remove the Master Orifice from the cylinder adapter.

You are now ready to perform the cylinder differential pressure test.



Establishing Minimum Acceptable Cylinder Pressure Leakage Limit With Master Orifice Tool

Performing Differential Pressure Test

FIGURE 4
Differential Pressure Test Equipment

(c) Performing The Cylinder Differential Pressure Test:

Ideally, perform the cylinder differential pressure test as soon as possible after the aircraft has been flown. If the aircraft cannot be flown prior to performing the cylinder differential pressure test, it must be operated on the ground, with the cowling installed until a minimum cylinder head temperature (CHT) of 300 to 350 degrees Fahrenheit is observed on the aircraft gauge. For aircraft fitted with constant speed propellers operate the engine at a high enough power setting to allow the cycling of the aircraft propeller. For aircraft with fixed pitched propeller, operate the engine to full static RPM.

WARNING

Magnetos must be grounded and fuel must be shut off prior to test to make certain that the engine cannot accidentally start. Take necessary precautions to prevent accidental rotation of the propeller while performing the differential pressure leak test. Differential Pressure tests are best performed with two people, one to adjust the pressure regulator and one to hold the aircraft propeller.

NOTE: The 360 series, 470 series and 520/550 Sandcast engines utilize a starter adapter design that results in an increased resistance in turning force when the propeller is turned in the opposite direction of normal rotation. The technician may, if he desires, reduce the amount of resistance by removing the starter motor from the starter adapter when performing this test.

1. Perform the test as soon as possible after the engine is shut down to ensure that the piston rings, cylinder walls, and other engine parts are well lubricated and at operating clearance.
2. Remove the most accessible spark plug from each cylinder. Identify the cylinder number and position of the removed spark plugs. Examination of the spark plugs will aid in diagnosing engine and cylinder conditions. Reference spark plug manufacturers' technical data.
3. Turn the crankshaft by hand in the direction of rotation until the piston (in the cylinder being checked) is coming up on its compression stroke.
4. Install the cylinder adapter in the spark plug hole and connect the differential pressure tester to the adapter. (NOTE: Cylinder pressure valve is in the CLOSED position). Slowly open the cylinder pressure valve and pressurize the cylinder to 20 PSI.
5. Continue rotating the engine in the normal direction of rotation, against this pressure, until the piston reaches top dead center (TDC). TDC is indicated by a sudden decrease in the force required to turn the crankshaft. If the crankshaft is rotated too far, back up at least one-half revolution and start over again to eliminate the effect of backlash in the valve operating mechanism and to keep the piston rings seated on the piston ring lands.

WARNING

Care must be exercised in opening the cylinder pressure valve, since sufficient air pressure will be built up in the cylinder to cause it to rotate the crankshaft if the piston is not at TDC.

6. With the piston at top dead center, open the cylinder pressure valve completely. Check the regulator pressure gauge and adjust, if necessary, to 80 PSI.
7. To assure that the piston rings are seated and the piston is square in the cylinder bore, move the propeller slightly back and forth with a rocking motion, while applying the regulated pressure of 80 PSI, to obtain the highest indication. Adjust the regulator as necessary to maintain a pressure gauge reading of 80 PSI.

8. Record the pressure indication on the cylinder pressure gauge. The difference between this pressure and the pressure shown by the regulator pressure gauge is the amount of leakage through the cylinder. Record individual cylinder readings as; $^{(\text{pressure reading})}/_{80\ \text{PSI}}$.
9. Note any leakage source (air discharge) and determine serviceability. Refer to Table 1.
10. Proceed to the next cylinder and repeat Step 3 through 9 until all cylinders have been checked.
11. After all cylinder pressure indications have been recorded, proceed with a borescope inspection of each cylinder in accordance with Table 2, section C.

TABLE 1

DIFFERENTIAL PRESSURE TEST RESULTS

AIR DISCHARGE SOURCE	PRESSURE TEST VALUE	SYMPTIONS AND OBSERVATIONS	RECOMMENDED ACTION
Air discharge at oil filler/crankcase breather.	Cylinder differential pressure test reading above leakage limit.	Normal Borescope Indications. Oil Consumption stable, no excessive oil discharge out engine breather.	Continue engine in service. Repeat differential pressure test at next 100-hour/annual inspection.
Air discharge at oil filler/crankcase breather.	Cylinder differential pressure test reading below leakage limit.	Normal Borescope Indications. Oil Consumption stable, no excessive oil discharge out engine breather.	Fly Aircraft at Cruise Power setting ① and repeat cylinder differential pressure test
	Cylinder differential pressure test reading below leakage limit **after re-check**	N/A	Remove cylinder for repair
	Cylinder differential pressure test reading above or below leakage limit.	Oil Consumption abnormal ②, with oil discharge out engine breather. Borescope inspection reveals heavy carbon deposits in combustion chamber and on piston crown with excessive oil puddling in cylinder barrel	Remove cylinder for repair

TABLE 1 (continued)

DIFFERENTIAL PRESSURE TEST RESULTS

AIR DISCHARGE SOURCE	PRESSURE TEST VALUE	SYMPTIONS AND OBSERVATIONS	RECOMMENDED ACTION
Little to no air discharge at oil filler/crankcase breather.	Cylinder differential pressure test reading abnormally high	Oil Consumption abnormal ② with oil discharge out engine breather. Borescope inspection reveals heavy carbon deposits in combustion chamber and on piston crown. Excessive oil puddling in cylinder barrel.	Remove cylinder for repair.
Air discharge into induction system	Cylinder differential pressure test reading above leakage limit.	Normal cylinder borescope inspection results.	Continue engine in service.
	Cylinder differential pressure test reading below leakage limit.	Normal cylinder borescope inspection results.	Fly aircraft at cruise power ① and repeat cylinder differential pressure test.
	Cylinder differential pressure test reading below leakage limit **after re-check.**	N/A	Remove cylinder for repair.
Air discharge into exhaust system	Cylinder differential pressure test reading above leakage limit.	Normal cylinder borescope inspection results.	Continue engine in service.
	Cylinder differential pressure test reading below leakage limit.	Normal cylinder borescope inspection results.	Fly aircraft at cruise power ① and repeat cylinder differential pressure test.
	Cylinder differential pressure test reading below leakage limit **after re-check.**	N/A	Remove cylinder for repair
Air escaping at spark plug spot face	Cylinder differential pressure test readings N/A	Dye check of area reveals cracks.	Remove cylinder for replacement.
Air discharge at cylinder head to barrel juncture or between barrel fins	Cylinder differential pressure test readings above leakage limit	First cylinder head fin above cylinder barrel wet with oil or baked on oil residue. See also latest revision of SB96-12 for additional test to be performed.	Remove cylinder for replacement.

① Fly the aircraft at a cruise power setting between 65 and 75 percent power, as specified in the aircraft Pilots Operating Handbook/Aircraft Flight Manual (POH/AFM), for a duration that will allow the engine oil and cylinder head temperatures to stabilize, or at least 45 minutes. Perform an additional differential compression test on the suspect cylinder(s).

② A sudden increase in oil consumption from the established or normal trend for the engine or an oil consumption rate that exceeds 1/2 quart (liter) per hour during normal engine operation.

C. CYLINDER BORESCOPE INSPECTION

(a) Required Equipment:

In addition to the standard complement of tools required to perform maintenance and repairs on aircraft engines the following tools and equipment are required to perform a cylinder borescope inspection.

1. Borescope.

    - AUTOSCOPE™ – Lenox Instrument Company. See Figure 5. **Recommended by TCM.**

      Q. A. Technologies
      PO Box 61085
      Savannah, GA 31420
      Phone: 912-330-0500
      Fax: 912-330-0104
      E-mail: sales@qatek.com
      Web-site: qatek.com

      Note: TCM customers receive a special discount when ordering from Q. A. Technologies.

FIGURE 5

(b) Performing the Inspection:

CAUTION

Take preventative measures to avoid burns when performing a borescope inspection on a hot engine.

1. If not already removed for differential pressure test, remove the upper spark plug from each cylinder.
2. Position piston at bottom dead center on the power stroke. The exhaust valve will be open with the piston in this position.
3. Insert the borescope probe through the upper spark plug hole and inspect the internal surfaces of each cylinder, including the exhaust valve and exhaust valve seat in accordance with Table 2.
4. After completing inspection steps 1,2 and 3; position piston at bottom dead center at the end of the intake stroke.
5. Insert the borescope probe through the upper spark plug hole and inspect the intake valve and intake valve seat in accordance with Table 2.

TABLE 2

Borescope Inspection Objectives And Corrective Actions

ITEM	Objective	If Abnormality Noted
Combustion chamber.	Inspect: 1. Valve seat inserts for erosion, burning. 2. Sparkplug heli-coils for protrusion into combustion chamber. 3. Heavy carbon deposits/presence of excessive oil.	 1. Remove cylinder for repair 2. Remove cylinder for repair 3. Remove cylinder for repair.
Exhaust valve face	Inspect for signs of leakage or damage, indicated by: 1. Localized discoloration on the valve face circumference. See Figure 7 page 12 2. Minute cracks. 3. Erosion (missing material).	 1. Repair or replace cylinder. 2. Repair or replace cylinder. 3. Repair or replace cylinder.
Intake valve face.	Inspect for signs of leakage or damage, indicated by: 1. Localized discoloration on the valve face circumference. 2. Erosion (missing material)	 1. Repair or replace cylinder. 2. Repair or replace cylinder.
Cylinder Bore.	Inspect exposed surface of bore for: 1. Heavy scoring/piston rub. See Figure 10 on page 13. 2. Piston pin rub (wide ban pattern in horizontal plane at 3 o'clock and/or 9 o'clock position). 3. Upper portion of cylinder bore has no visible hone pattern. See Figure 11 &12 on page 13 and 14. 4. Corrosion. See Figure 9, on page 12. 5. Excessive oil in cylinder/heavy deposits of carbon in combustion chamber	 1. Repair or replace cylinder. 2. ① 3. Normal indication for in service cylinders 4. ② 5. Remove cylinder for repair
Piston Head.	Inspect for: 1. Piston crown for erosion, missing material 2. Visible damage from foreign debris.	 1. Remove cylinder for repair 2. Remove cylinder for repair

Experience and expertise in borescope examination requires the aviation technician to perform borescope inspection on a consistent basis. It is especially important that the technician perform borescope inspections prior to removal of a cylinder for any reason so that they may validate by visual indications viewed through the borescope, the actual conditions.

The following photographs are provided as a guide to the aviation technician when performing borescope examinations. Teledyne Continental Motors welcomes inquiries and comments from the aviation technician. We urge you to call your Regional Service Representative or Teledyne Continental Motors Technical Support at (888) 826-5465.

① Remove cylinder for repair or replacement. Perform complete inspection of connecting rod bushing for correct installation and finishing. Refer to latest revision of TCM SB 00-3.

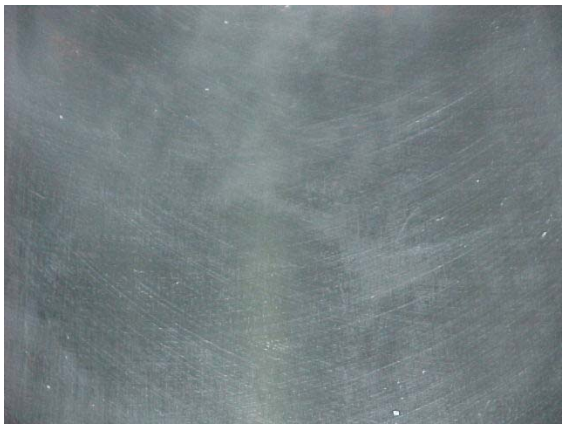
② Refer to the latest revision of TCM Service Information Directive (SID) 97-2. See Figure 9.

Normal Combustion Chamber. Exhaust valve has reddish combustion deposit in center with dark outer edge. Intake valve has light brown combustion deposits. Combustion chamber has light brown deposits.

FIGURE 6

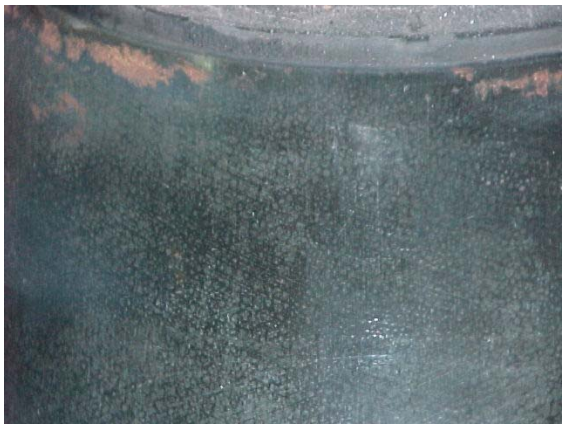
Burned exhaust valve. Note edge of valve face that has lost all combustion residue and striations moving toward center of valve.

FIGURE 7



New Phosphate coated cylinder bore with revised cylinder bore hone pattern. Phosphate coating provides increase corrosion protection during the initial hours of engine operation.

FIGURE 8



Phosphated cylinder bore. Note phosphate coating remaining in valleys of cylinder bore hone pattern. Light corrosion at top of cylinder bore, above piston ring travel limit. Presence of light corrosion in this area is normal.

FIGURE 9

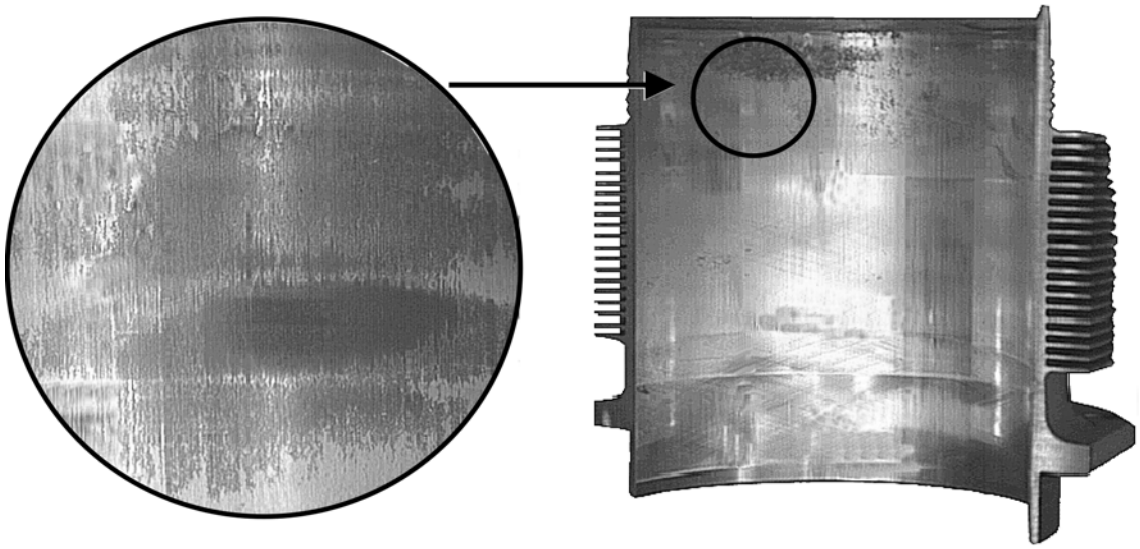


FIGURE 10
CYLINDER BARREL SCORING / PISTON RUB

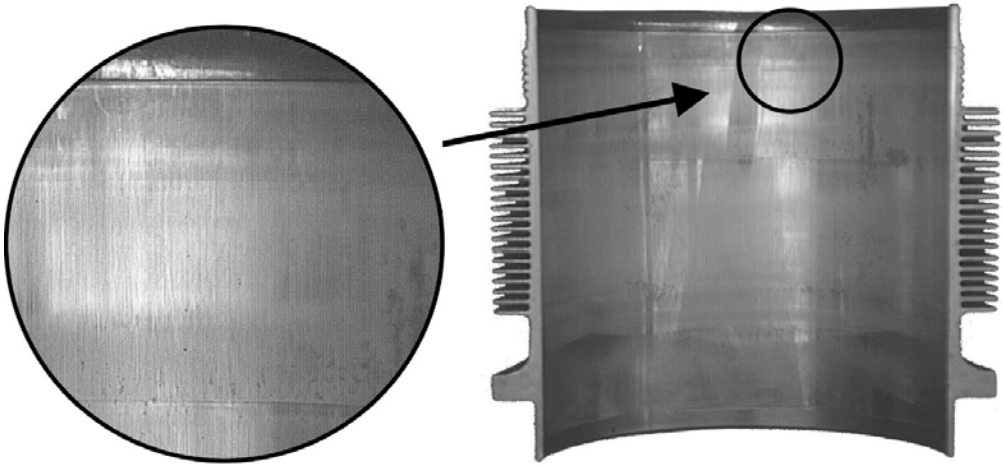


FIGURE 11
UPPER RING TRAVEL AREA
TYPICAL IN SERVICE CYLINDER BARREL

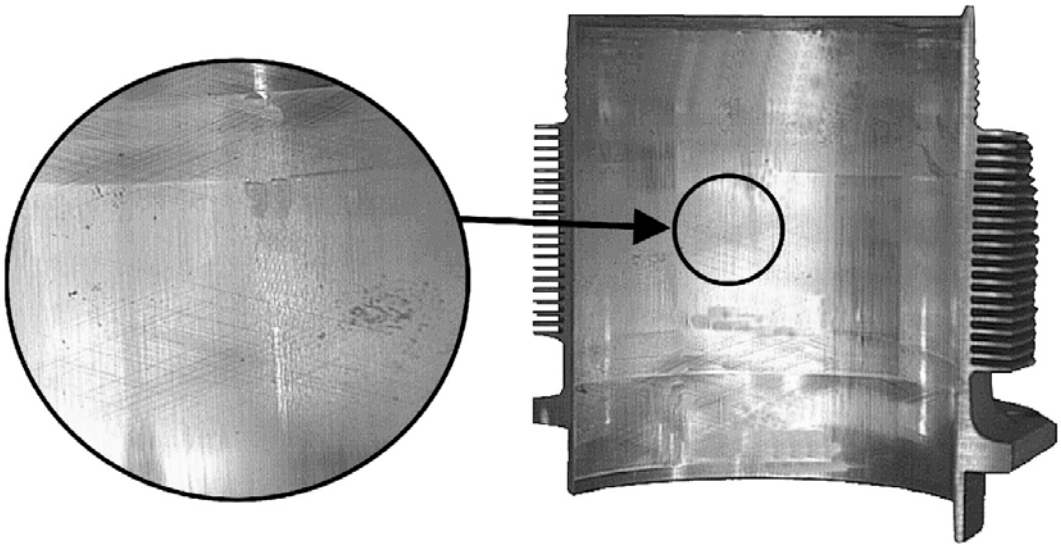


FIGURE 12
TYPICAL IN SERVICE CYLINDER BARREL