ENGINE-ADJUSTMENT/TEST

1. Check Run

   A. Operating Instructions.

   NOTE: Operators are recommended to do the oil pump priming (Ref. 72-60-00, para 3.B.) whenever an engine is installed to make sure that oil gets to the internal bearings.

   Check run the engine in the airframe when the compressor assembly, compressor case, turbine assembly, combustion section, gearbox, fuel control, governor, fuel pump, fuel nozzle, or thermocouple has been removed, repaired or replaced. Operate the engine in accordance with Operating Procedures, para 7, (M250-C20, -C20B, -C20F, -C20J), para 8, (M250-C20S, -C20W), 72-00-00, Engine--Description and Operation. Make note of all incidents of the run such as leaks, abnormal vibration or noises, and/or any irregular functioning of engine equipment. Also note that the following items are within limits (Refer to Operating Limits, para 6., 72-00-00, Engine--Description and Operation):

   (1) Measured gas temperature. (See Table 8 or 9, 72-00-00, Engine--Description and Operation.)

   (2) Output shaft torque. (See Table 10, 11 or 12, 72-00-00, Engine--Description and Operation.)

   (3) Oil pressure. (Refer to Oil Pressure and Temperature, para 6.D., 72-00-00, Engine--Description and Operation.)

   (4) Gas producer N_1 speed. (Refer to Engine Speed, para 6.A., 72-00-00, Engine--Description and Operation.)

   (5) Power turbine N_2 speed. (Refer to Engine Speed, para 6.A., 72-00-00, Engine--Description and Operation.)

   B. Diffuser Vent Orifice Selection

   Select and install the diffuser vent orifice as follows:

   (1) Install a -7 size orifice on the diffuser vent tube. (See Figure 501.)

   (2) Clean the area around the orifice.

   CAUTION: DO NOT INSTALL A SMALLER ORIFICE (LOWER DASH NUMBER) THAN THAT REQUIRED TO STOP SPEWING OR SMOKING AT THE VENT.

   (3) Following the next flight of at least five minutes' duration, inspect the area around the orifice. If there is any evidence of smoking or spewing from the vent, reduce the orifice size by installing the next lower dash number orifice.

   (4) Repeat the flight, inspection, and orifice replacement until no evidence of spewing or smoking is encountered.

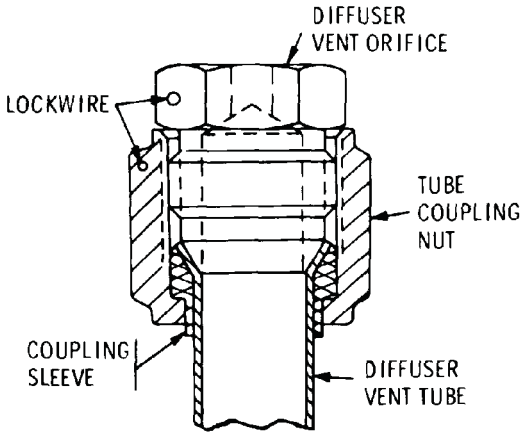
   (5) As an alternate method for obtaining the desired orifice size, start with two -2 size orifices (No. 1 and No. 2).

      (a) Drill out No. 1 orifice to 0.236-0.244 in. (5.994-6.198 mm). No. 1 orifice then becomes a -3 orifice. If No. 1 does not smoke when checked during engine operation, resize No. 2 orifice.

      NOTE: When smoking is encountered, reinstall the previously drilled smaller orifice that did not smoke.

      (b) Drill out the No. 2 orifice to 0.266-0.274 in. (6.76-6.96 mm). No. 2 orifice then becomes a -4 orifice. If No. 2 does not smoke when checked during engine operation, resize No. 1 orifice.

      (c) Drill out the No. 1 orifice to 0.296-0.304 in. (7.52-7.72 mm). No. 1 orifice then becomes a -5 orifice. If No. 1 does not smoke when checked during engine operation, continue alternately enlarging the No. 1 then the No. 2 orifice by one dash number size until the desired orifice is obtained.



ADG092XD

Diffuser Vent Orifice Installation
Figure 501

PARA 1.B. (cont)

(6) Record the size of the finally selected orifice (by dash number) in the Engine Log.

C. Check Run Schedule

Check run the engine in the airframe in accordance with the following schedule:

Setting No.	Condition
1	Start engine and accelerate to Ground Idle. N_1 = 59–65% Observe engine oil pressure. Observe engine for abnormal conditions such as vibration, noise or leakage. Visually inspect all engine oil and fuel fittings to confirm no leaks are present before proceeding. Duration of run need not exceed five (5) minutes.
2	(250–C20, –C20B, –C20F, –C20J) Accelerate to a power setting just short of lift off. (250–C20S, –C20W) Accelerate to 100% N_1 and minimum power. Stabilize for five (5) minutes.
3	Reduce speed to Ground Idle. Check operation of anti–ice valve. Dwell for two (2) minutes.
4	Shut down.

NOTE: Give the engine a thorough visual inspection after shutdown. Repeat the check run if any repairs are necessary as a result of the run or the inspection.

PARA 1. (cont)

D. Propeller Check Run.

(250–C20S) Following removal and replacement of the engine or the propeller, purge trapped air from the propeller oil system. Refer to the Aircraft Maintenance Manual. Purge the prop oil system and subject the propeller to a run cycle during ground operation prior to the first flight using the following check run:

(1) Perform a normal start.

(2) Advance the Power Lever to the highest power attainable during ground operation.

(3) Return the Power Lever to Ground Idle.

(4) Perform a normal shutdown.

(5) Repeat the procedure, steps a. through d., a second time.

2. Vibration Test Procedure

A. Description of Vibration Test Procedure

(1) The vibration test procedure will aid in evaluating vibration, identifying vibration sources and analyzing vibration levels so that corrective action may be taken. Continued engine operation with high vibration levels will cause excessive engine and component wear and can contribute to engine failure and premature engine removal.

(2) Engine vibration may be influenced by factors including aircraft installation, accessories, normal wear, maintenance practices, or unusual operating conditions. By measuring the frequency and magnitude of a vibration, then comparing the measurements with known vibration factors, such data may be used to obtain an indication of the engine area requiring corrective action.

(3) Vibration is a mechanical oscillation or motion about a reference point. Engine–induced vibration is generally observed at frequencies equal to N_1 or N_2 rotor speeds, gear rotational speed, gear mesh frequency, or bearing passage rate. In some instances, the vibration also appears as a harmonic or multiple of the basic frequency.

(4) Vibration pickups (transducers) are used to convert vibration motion to an electrical signal. These pickups may be calibrated in terms of vibration displacement (“mils”), acceleration (“G’s”), or velocity (“IPS”). Velocity is the most meaningful measure of vibration on Model 250 engines.

(5) A vibration signature should be performed on each engine or aircraft using a spectrum analyzer. The signature should be repeated at scheduled intervals, such as 100 hours, and a file should be maintained for each engine–aircraft combination. When a major change in the frequency response is noted, such as the level changing from 0.2 IPS to 0.6 IPS, closer monitoring should be maintained on such engine.

(6) Signatures should be taken with pickups installed in the vertical axis on the compressor, gearbox and turbine. The signatures should be taken at several specified N_1 speeds while the aircraft is on the ground; these N_1 speed points are to be used for each signature. An overall vibration reading can be obtained by using the broad band control on a Chadwick–Helmuth Model 192 analyzer, which is the equipment used in the following procedures.

(7) The test chart (See Vibration Recording Sheet, Figure 502) contains a number of test points. A vibration trend monitoring program can be initiated on an aircraft by using this chart to set the baseline. The monitoring program should be maintained by using points 3, 5 and 6 on Figure 502 at the specified intervals (100, 150, 200 hours, etc.). Any time there is a major variance in charted readings, or whenever high vibrations are indicated, a complete vibration survey should be made prior to initiating troubleshooting.

VIBRATION RECORDING SHEET

AIRCRAFT TYPE: _____
AIRCRAFT SERIAL: _____
ENGINE SERIAL NUMBER: _____
GEARBOX SERIAL NUMBER: _____
COMPRESSOR SERIAL NUMBER: _____
TURBINE SERIAL NUMBER: _____

DATE: _____
TIME SINCE NEW: _____
ENGINE TSN/TSO: _____
GEARBOX TSN/TSO: _____
COMPRESSOR TSN/TSO: _____
TURBINE TSN/TSO: _____

	ALTITUDE	OAT	N_2	N_1 TORQUE	IPS BROAD BAND A/C B/D	NOTES
1					A/C B/D	GROUND IDLE
2			85%		A/C B/D	SEE FIGURE 502 SHEET 2
*3			100%		A/C B/D	FLAT PITCH
4			100%	87%	A/C B/D	
*5			100%	95%	A/C B/D	
*6			100%	95%	A/C B/D	USE GREEN CARD
7			100%		A/C B/D	**SEE NOTE 1
8			100%		A/C B/D	***SEE NOTE 2

* USED FOR ENGINE MONITORING PROGRAM.

** NOTE 1. DO NOT EXCEED ANY ENGINE/TRANSMISSION OR AIRCRAFT FLIGHT LIMITS UTILIZE MAXIMUM ALLOWABLE POWER AND MAINTAIN LEVEL FLIGHT.

*** NOTE 2. CLIMB 3000 FEET ABOVE THE ALTITUDE RECORDED IN CHECK #7 AND PERFORM MAXIMUM ALLOWABLE POWER CHECK (MAINTAIN LEVEL FLIGHT).

-- USE BLUE CARDS ON ALL CHECKS UNLESS OTHERWISE NOTED.

-- DEPRESS BROAD BAND SWITCH AT MAXIMUM RPM AND RECORD READING.

-- USE 10 IPS SIDE OF RECORDING CHART.

-- USE THREE PICKUPS ON THE NORMAL ENGINE VIBRATION PICKUP POINTS.

-- ALL THREE PICKUP POINTS CAN BE ON ONE CARD PROVIDING DIFFERENT COLORED PINS ARE USED AND THEY ARE APPROPRIATELY MARKED.

Vibration Recording Sheet
Figure 502 (Sheet 1)

Series II 3rd Stage Wheel P/N	N2 Speed Avoid Range
23001967	No Limitations*
23065818	75-88%*
23065833	
-With Calibrated N2 Indication	
System (Zero Error)	87-95%*
-A109	85-97%*
-B206L	84.5-97.5%*
-BO105	86.5-95.5%*

*Reference CEB 1400, 72-4095, TP 1343, TP 72-2091

Vibration Recording Sheet
Figure 502 (Sheet 2)

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PARA 2. (cont)

B. Glossary of Terms

The following terms are included in the vibration test procedure:

ACCELERATION	Rate of change of velocity with time along a specified axis. Usually expressed as ‘‘G’s”, or gravitational units.
AVERAGE	Peak value multiplied by 0.637.
CYCLE	An interval of time during which sequence of a recurring succession of events is completed. In the case of vibration, one complete performance of a vibration.
DISCRETE FREQUENCY	A measure of vibration response at one frequency only.
DISPLACEMENT	Specifies change of position in mils. Usually measured from mean position (or position of rest) and applies to linear motion, although it can apply to angular motion.
FREQUENCY	A measure of vibration response expressed in Hertz (Hz).
HERTZ (Hz)	A measurement of the frequency of a vibration. Also, cycles per second (CPS) is sometimes used in association with frequency.
OVERALL	A vibration measurement of all frequencies as read on an average detecting meter.
PEAK	The extreme value of a varying quantity. Measured from zero, or mean value. Peak to peak is 2 times a peak level.
VELOCITY	Refers to rate of change of displacement with time along a specified axis; quickness of motion. Usually measured in Inches Per Second (IPS).

C. Equipment Requirements

(1) Equipment consists of transducers (pickups), brackets, attachment hardware, cables and a spectrum (frequency) analyzer with plotter. The equipment must function as an integrated system capable of vibration measurement over a minimum range of 15 to 1500 Hz (900 to 90,000 rpm); higher ranges are desirable. The system must be capable of measuring vibration levels from at least 0.050 to 5 IPS average velocity.

(2) Currently acceptable equipment is listed below.

(a) Chadwick–Helmuth Model 192, 192A, and 8500 Analyzer/Plotter with Model 7570 High Temperature Velometer Kits

(b) Rotorturner by MCT Helitune

(c) Scientific Atlanta Model 2538

(d) Helitune Quan-Tech 9500 Spectrum Analyzer

(e) GE Aviation Systems Model RADS-AT

(f) Dynamic Solutions Systems, Inc. MicroVibe II

(g) SKF Model Microlog MX, Microlog GX

(h) ACES Systems Model 2015, 2020, and 4040

(3) Other equivalent units may also be utilized.

D. Test Procedure

CAUTION: PERFORMANCE OF THIS PROCEDURE REQUIRES KNOWLEDGE OF BOTH ENGINE AND AIRCRAFT MAINTENANCE PROCEDURES. REFER TO THE RESPECTIVE OPERATION AND MAINTENANCE MANUALS.

CAUTION: SECURE PICKUP LEAD WIRES TO PREVENT ENTANGLEMENT WITH AIRCRAFT CONTROL LINKAGES. ROUTE LEAD WIRE TO PREVENT SURFACE CONTACT WITH ENGINE.

NOTE: The following procedures apply to use of the Chadwick Model 192 analyzer. Operational procedures for other analyzers will be similar.

(1) Install vibration pickups vertically on each engine module as shown in Figure 503 and in the following instructions.

(a) Compressor. Install one vertical vibration pickup on the front side of the compressor-to-inlet housing splitline at the 12 o'clock position. Use a balance "T"-type bracket, such as Rolls-Royce part number 23032992 (see Figure 504) or use the equipment manufacturer's bracket.

(b) Gearbox. Install one vertical vibration pickup on the engine top mounting pad (bottom mounting pad on M250-C20S, -C20W) on the power and accessory gearbox. Use bracket such as Rolls-Royce part number 23032993. (See Figure 505.)

CAUTION: THE TURBINE PICKUP MUST BE A HIGH TEMPERATURE PICKUP IN ORDER TO WITHSTAND THE EXTREME HEAT OF THE TURBINE CASE.

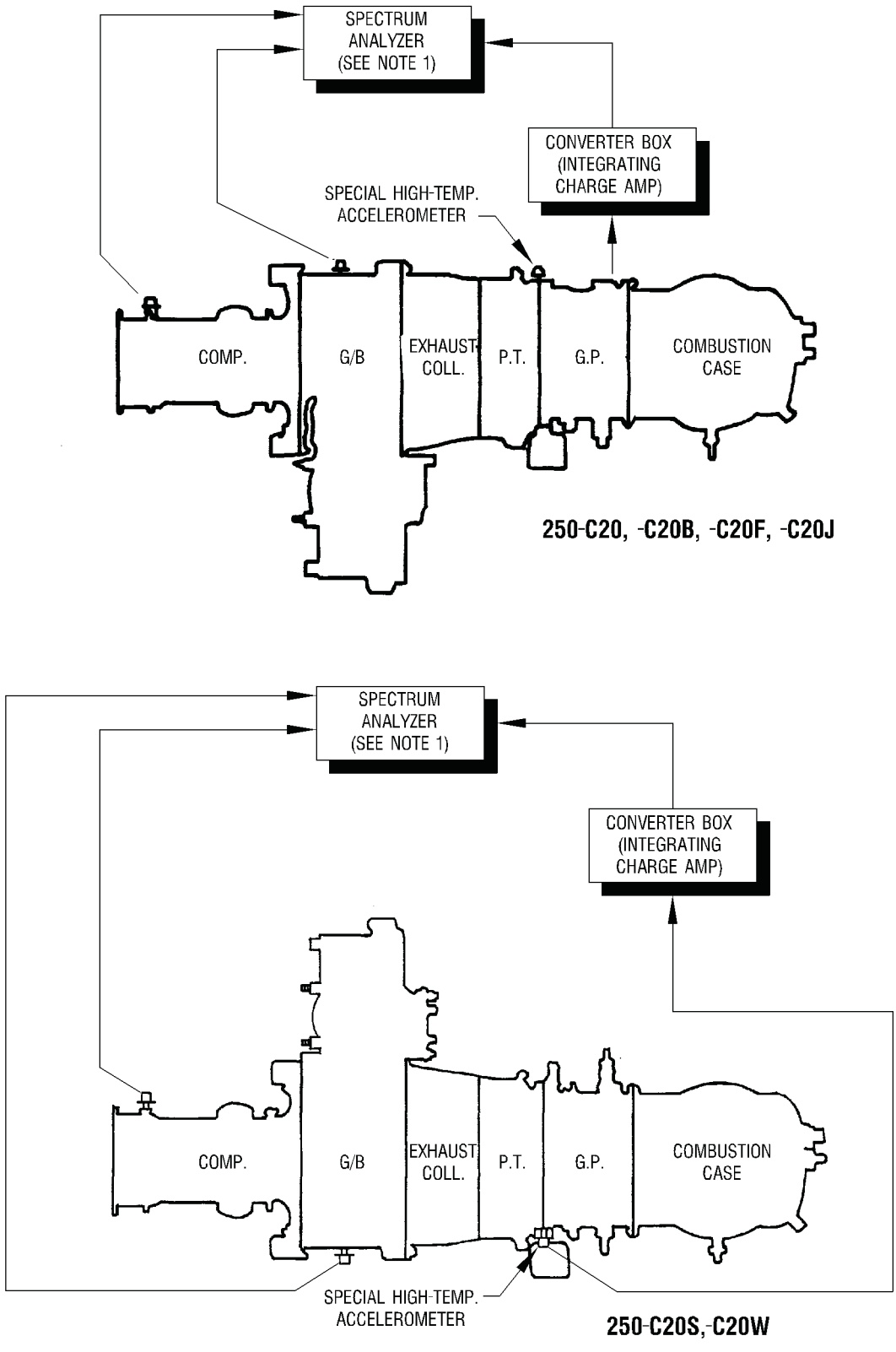
NOTE: The bracket below fastens on the forward side of the splitline.

(c) Turbine (M250-C20, -C20B, -C20F, -C20J). Install one vertical vibration pickup on the forward side of the gas producer-to-power turbine support splitline at the 12 o'clock position. Use a balance "T"-type bracket such as Rolls-Royce part number 23032992 (see Figure 504) or use the equipment manufacturer's bracket.

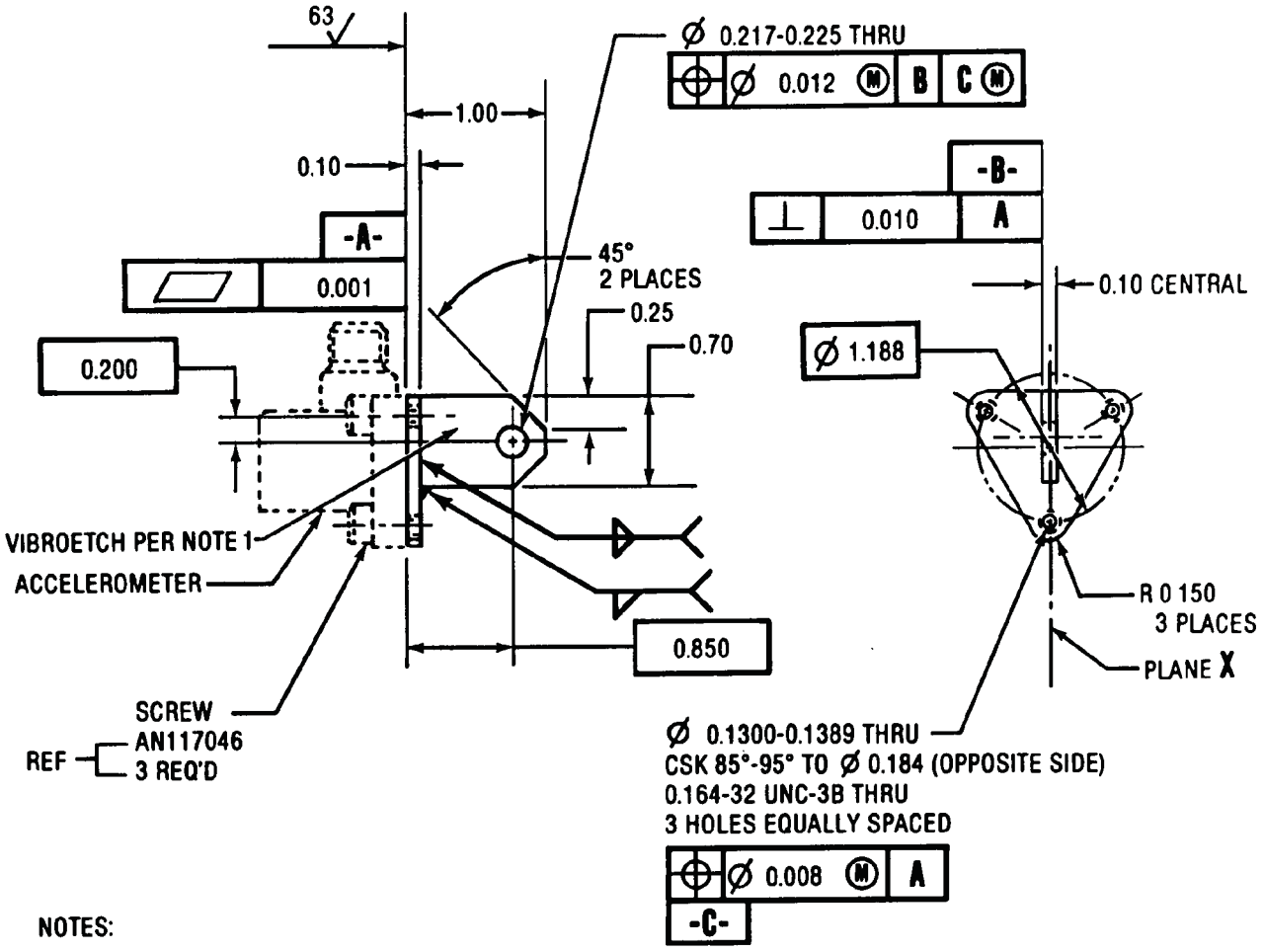
(d) Turbine (M250-C20S, -C20W). Install one vertical vibration pickup on the forward side of the gas producer-to-power turbine support splitline at the 6 o'clock position. Use a balance "T"-type bracket such as Rolls-Royce part number 23038047 (see Figure 506) or use the equipment manufacturer's bracket.

CAUTION: BE SURE THAT THE SPECTRUM ANALYZER AND VIBRATION PICKUPS ARE PROPERLY CALIBRATED. REFER TO MANUFACTURER CALIBRATION EQUIPMENT AND PROCEDURES. IT IS RECOMMENDED THAT PICKUPS BE CALIBRATED BEFORE EACH USE OR WHENEVER OUT-OF-NORMAL VIBRATION LEVELS ARE DETECTED, WITH MINIMUM CALIBRATION TIME EVERY SIX MONTHS.

(2) Using the blue card (10 IPS side) in the spectrum analyzer, measure the frequency range desired at any test point except test point 6. (See Figure 507.)



Installing Vibration Pickups
Figure 503



NOTES:

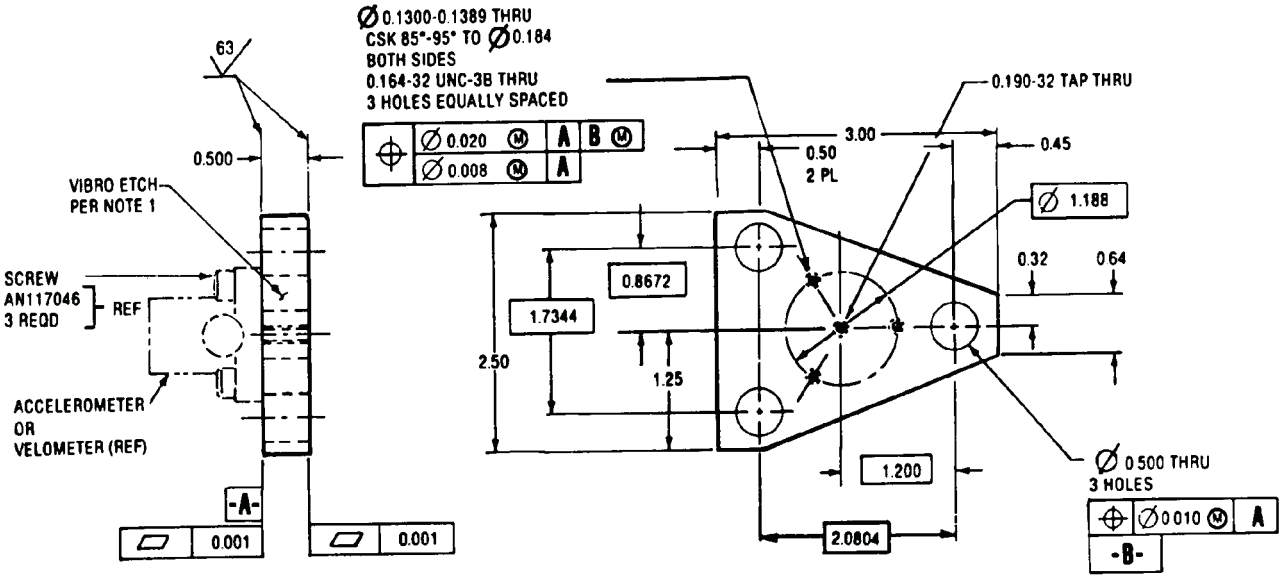
1. MARK AS SPECIFIED IN LOCATION SHOWN WITH 1/8-3/16 HIGH FIGURES THE FOLLOWING:
   a) THE NAME "ALLISON" FOLLOWED BY THE TOOL NUMBER 23032992
   b) VENDOR NAME OR TRADEMARK
2. BREAK SHARP EDGES 0.020 UOS
3. SURFACE FINISH 125 UOS
4. MATERIAL-300 SERIES STAINLESS STEEL
5. TOL ON 3 PLACE DECIMALS ± 0.010
6. TOL ON 2 PLACE DECIMALS ± 0.02

ACCELEROMETER CONNECTOR MUST LIE IN PLANE X

VIBRATION RESONANCE WITH PICKUP MOUNTED IS:	
DIRECTION	FREQ. - HERTZ
NORMAL TO SURFACE B	1120 - 1150
NORMAL TO SURFACE A	ABOVE 2000
PARALLEL TO SURFACES A AND B	245 - 290

AEY004XA

Accelerator Mounting Bracket P/N 23032992
Figure 504



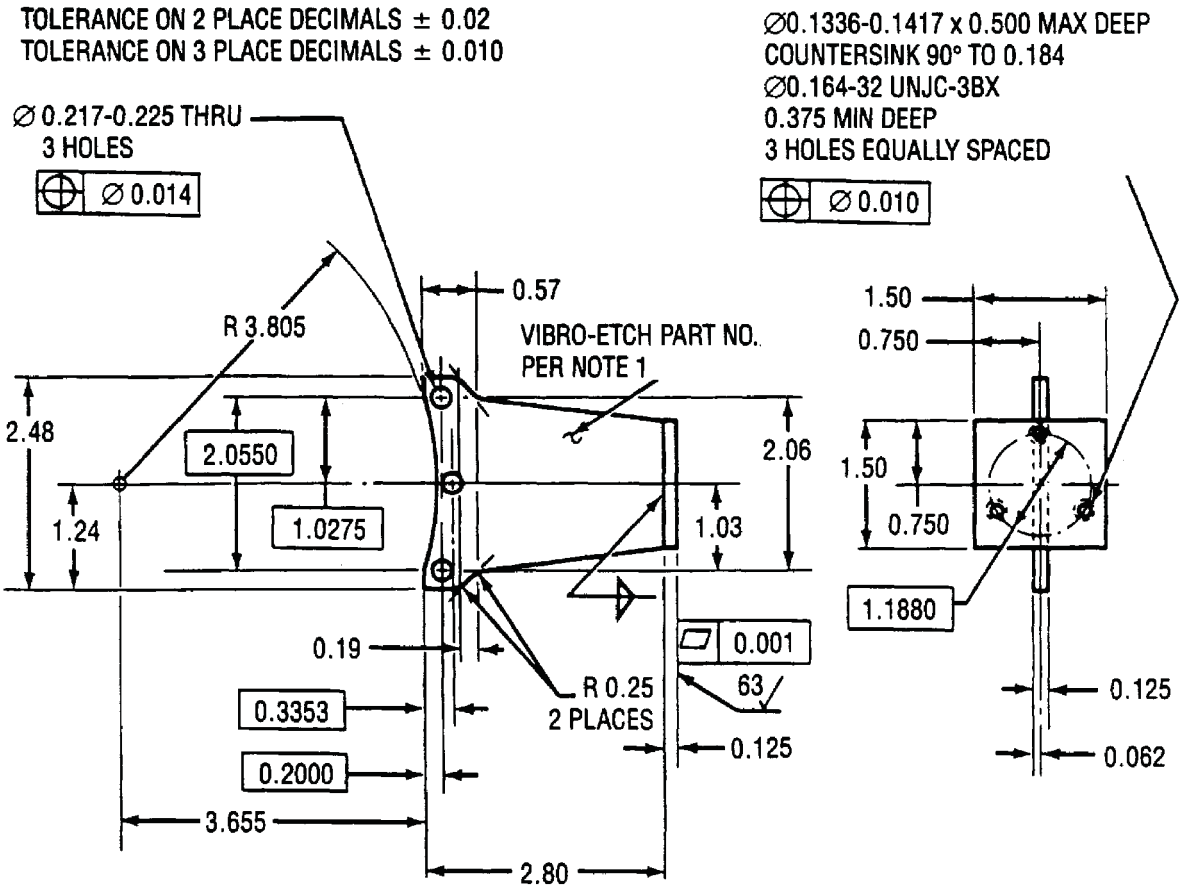
NOTES:

1. MARK AS SPECIFIED IN LOCATION SHOWN WITH 1/8-3/16 HIGH FIGURES THE FOLLOWING:
   a) THE NAME "ALLISON" FOLLOWED BY TOOL NUMBER 23032993
   b) VENDOR NAME OR TRADEMARK
2. BREAK SHARP EDGES 0.020 UOS
3. SURFACE FINISH 125 UOS
4. MATERIAL - 300 SERIES STAINLESS STEEL
5. TOL ON 3 PLACE DECIMALS ± 0.010
6. TOL ON 2 PLACE DECIMALS ± 0.02

NOTE: BRACKET MOUNTING HOLE PATTERN IS INTENTIONALLY SLOPPY ENOUGH TO ALLOW THE USE OF THIS BRACKET ON ALL SERIES ENGINES.

AEY005XF

Accessory Gearbox Mounting Pad P/N 23032993
Figure 505



NOTES:

1. MARK AS SPECIFIED IN LOCATION SHOWN
   WITH 1/8"-3/16" HIGH FIGURES THE FOLLOWING:
   a) THE NAME "ALLISON" FOLLOWED BY TOOL NUMBER 23038047
   b) VENDOR NAME OR TRADEMARK
2. REMOVE BURRS AND SHARP EDGES UOS
3. MACHINED SURFACES MAY BE 250 UOS
4. MATERIAL 300 SERIES STAINLESS STEEL
5. ATTACH PICKUP TO BRACKET WITH 3 AN 117046 (#8-32 x 0.50 LG) SCREWS SAFETY WIRE
6. USE 3 MS 9432-10 TEE HEAD BOLT FOR MOUNTING BRACKET TO SPLITLINE FLANGE
7. WELD SYMBOLS PER ANSI/AWSA 2.4

ADG094XA

Accelerometer Bracket, 250–C20S, –C20W, Turbine Vertical, P/N 23038047
Figure 506

PARA 2.D. (cont)

(3) Using the green–border card (10 IPS side) in the spectrum analyzer, measure the frequency range desired at test point 6. (See Figure 508.)

(4) Secure cowlings as required by aircraft flight manual for safe ground and flight operation.

CAUTION: ENSURE THAT ENGINE AND TRANSMISSION LIMITS ARE NOT EXCEEDED ON THE GROUND OR IN FLIGHT DURING THE TEST SEQUENCE. REFER TO APPLICABLE ENGINE/AIRFRAME MANUALS.

(5) Start engine to idle. Operate engine as necessary to bring oil system to normal operating temperature range.

(6) Record data indicated below:

(a) Ground Operation:

Record applicable vibration data. (See Figure 502.) Record as many test points as possible before flying.

CAUTION: PRIOR TO OPERATION IN FLIGHT, BE SURE THAT ALL EQUIPMENT AND CABLES ARE SECURED AND DO NOT INTERFERE WITH THE OPERATION OF THE ENGINE OR AIRCRAFT FLIGHT CONTROL SYSTEM.

(b) Flight Operation:

Fly the aircraft and record the remaining test points.

NOTE: Current average limits for discrete frequencies are 1.0 IPS, with an overall average of 1.5 IPS.

(7) Determine if maintenance action is indicated by comparing the newly acquired data with previously recorded data and with maximum allowable limits. (See Figure 509.)

E. Interpretation of Data

The first step is to determine if the vibration is airframe or engine related. Any rotational speed below 6000 rpm (100 Hz) is usually airframe related, because the slowest rotational speed of the engine is the power output shaft at 6000 rpm (except for some accessory drives).

Typical engine vibration signature cards are shown in Figures 507 and 508. These curves represent the peak vibration velocity for frequencies between 5,000 and 900,000 rpm. Analysis of this signature is accomplished as follows:

(1) Determine the vibration frequencies (rpm) and vibration velocity amplitude (IPS peak) of the major vibration peaks on the plot cards. Then convert these values to inches per second (IPS) average velocity.

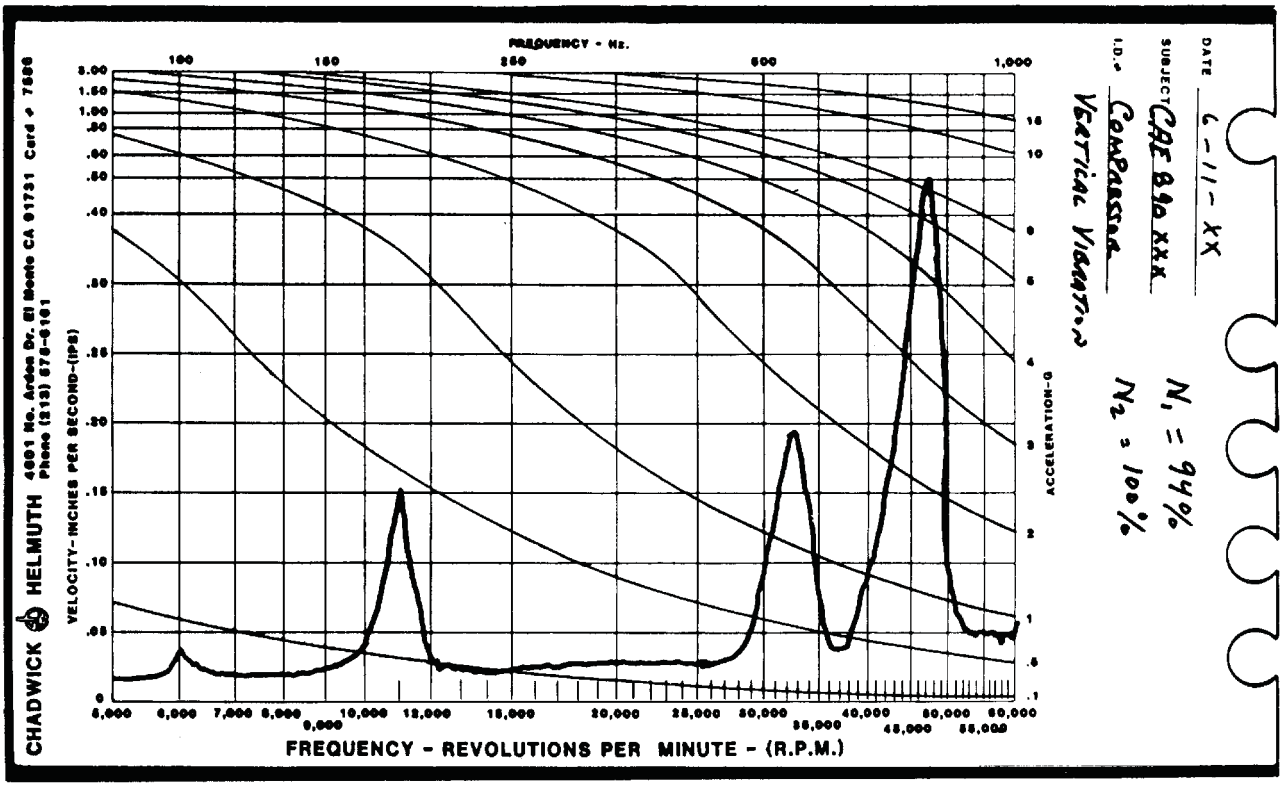
Conversion Factors:

(a) IPS Peak multiplied by 0.637 = IPS Average Velocity

(b) RPM divided by 60 = Hertz (cycles per second)

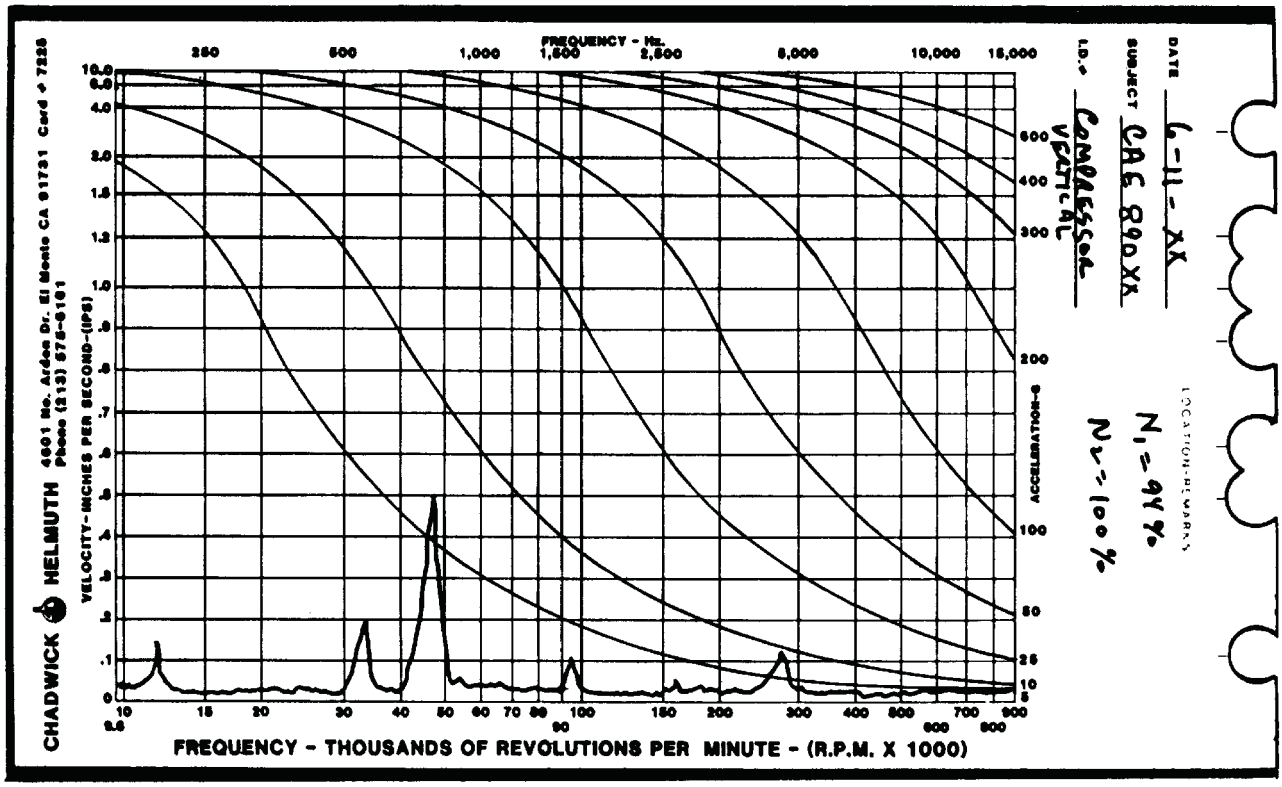
(c) Gear rpm multiplied by the number of gear teeth = gear mesh frequency

NOTE: The vibration card used in the following example is for the frequency range 5,000 to 60,000 rpm only. The vibration level of the engine should be checked over the entire required range of frequencies (5,000 to 900,000 rpm).



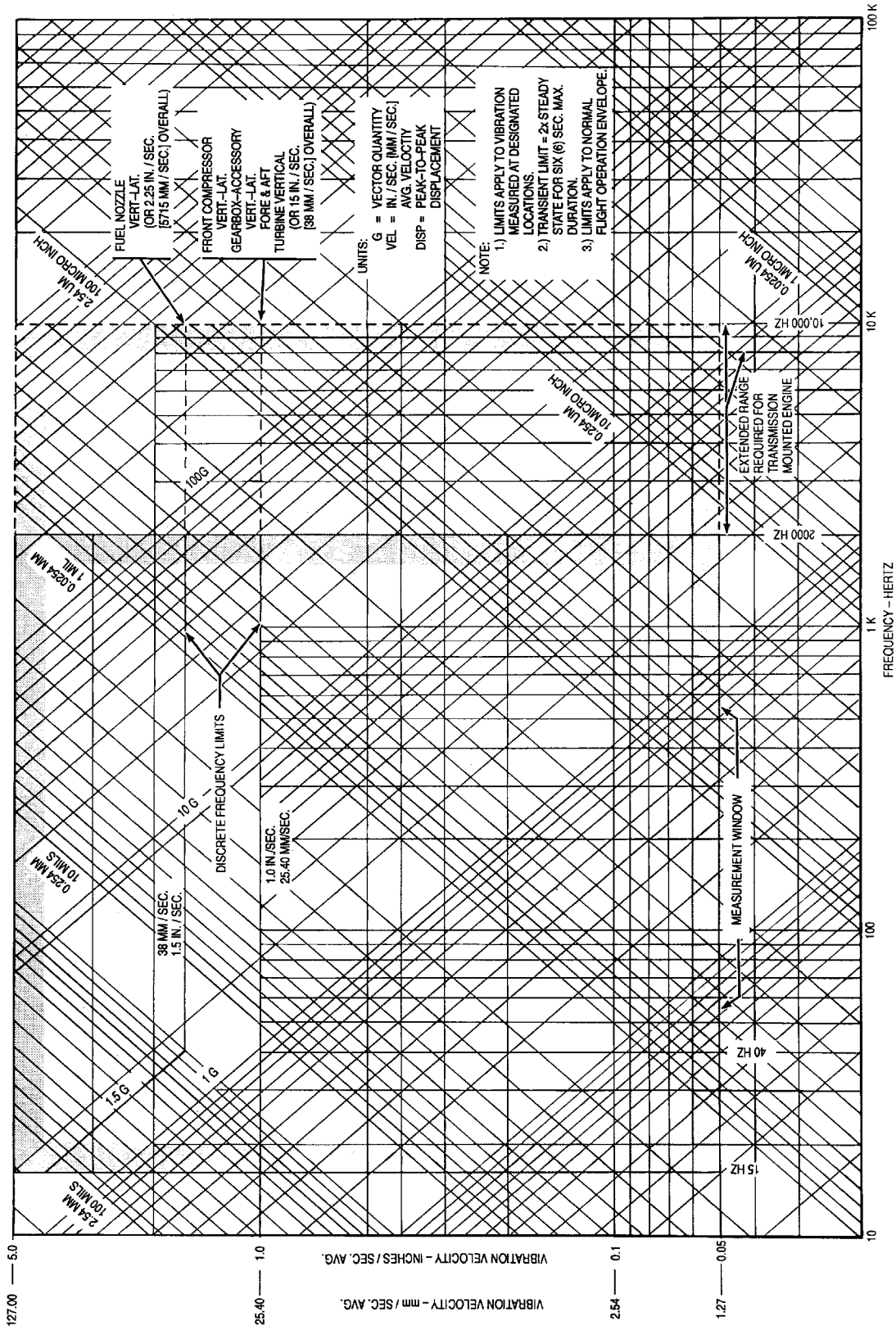
APS043XF

Typical Chadwick Vibration Analysis Card 5,000 to 60,000 rpm
Figure 507



APS044XF

Typical Chadwick Vibration Analysis Card 10,000 to 900,000 rpm
Figure 508



Installed Engine Vibration Limits Normal Operation Range and Limits
Figure 509

PARA 2.E. (cont)

(2) Example (Normal Vibration Range): The upper end of the normal vibration range for one discrete vibration frequency is 1.0 IPS (Avg.). Therefore, the engine in the following example is well within Rolls–Royce normal vibration range (normal vibration range is specified in Figure 509).

Frequency RPM	Frequency Hz	Velocity IPS (Peak)	Velocity IPS (Avg.)
11,300	188	0.15	0.10
33,000	550	0.19	0.121
48,000	800	0.50	0.319

(3) Normal Operating Range: Compare IPS average velocities shown below to the normal operating range shown in Figure 509. In this case, the vibration is within normal operating range.

Measured Frequency	Measured Velocity	Maximum Allowable Vibration Limits
188 Hz	0.10 IPS (Avg.)	1.0 IPS (Avg.)
550 Hz	0.121 IPS (Avg.)	1.0 IPS (Avg.)
800 Hz	0.319 IPS (Avg.)	1.0 IPS (Avg.)

(4) Sources of Engine Vibration: If vibration is not within normal operating limits, the source of vibration should be identified. Many possible sources of vibration exist, but the highest engine–related vibration levels normally occur at rotational speeds of the major engine components which are as follows:

(a) N_1 gas producer rotational speed

(b) N_2 power turbine rotational speed

(c) Starter generator rotational speed

(d) Output shaft rotational speed

(e) Rotational speeds of special engine–powered accessories

(5) Sources of Airframe Vibration: The most frequent sources of airframe vibration are as follows:

(a) Main rotor or propeller rotational speed

(b) Main rotor or propeller blade passage speed (and multiples of this speed)

(c) Tail rotor drive shaft speed

(d) Tail rotor rotational speed

(e) Tail rotor blade passage speed (and multiples of this speed)

(6) Identifying Engine–Related Vibrations.

(a) To identify engine–related vibrations, N_1 and N_2 rotational speeds should be determined first. Referring to Figure 507. N_1 was recorded as 94%, and N_2 was recorded as 100%. These speeds may be determined by analyzing the vibration signature.

(b) For example, to find N_1, look for a major peak in the measured frequency range between 510–850 Hz; this corresponds to 30,600–51,000 rpm, or 60%–100% N_1. Refer to the major peak occurring at 800 Hz (48,000 rpm) in Figure 507. By interpolating from the known 100% factor 850 Hz = 51,000 rpm, it can be determined that 800 Hz = 48,000 rpm, or 94.1%, which confirms the recorded N_1 speed of 94%.

PARA 2.E. (cont)

(c) Similarly, N_2 can be found as a major peak between 330–550 Hz; this corresponds to 19,800–33,000 rpm, or 60–100% N_2. Refer to the major peak occurring at 550 Hz in Figure 507. The peak at 550 Hz – 33,000 rpm (which is the 100% factor), confirming the recorded N_2 speed of 100%.

(d) The remaining major peaks can be identified by using speed charts to help determine potential vibration sources. These charts list gear ratios and rotating shaft speeds for engine–driven components. Matching the vibration peak frequency (rpm) with a speed on the chart will indicate the most likely source for that vibration.

(7) Speed Chart Calculations.

(a) Shaft speeds on the speed charts were computed using 100% N_1 and N_2. If measured N_1 and N_2 are not at 100%, the vibration peak frequency (speed) at which the vibration would occur if N_1 and N_2 were 100% must be determined. The resulting speed is matched to a shaft speed in the chart.

(b) For example, the remaining major peak in Figure 507 occurs at 11,300 rpm. The notation on Figure 507 chart indicates N_1 = 94% and N_2 = 100%. Since N_1 is not 100%, the equivalent rpm for 100% N_1 must be found:

$$\frac{11{,}300 \text{ rpm}}{0.94\ N_1} = 12{,}021 \text{ rpm}$$

(c) Therefore, the 100% N_1 equivalent of 94% N_1 at 11,300 rpm is 12,021 rpm. It is not necessary to convert N_2, since N_2 is at 100%. However, both speeds (N_1 and N_2) are needed for charts since it is not known if the vibration is from the N_1 or N_2 gear trains.

(d) Examination of the speed chart (Figure 510) shows a starter generator gearshaft speed of 12,034 rpm in the N_1 gas producer and power turbine gear trains, which is close to the 12,021 calculated vibration frequency. This result indicates a vibration problem in the area of the N_1 starter generator gearshaft.

(e) Rule out the possibility that the vibration is from N_2 by comparing the 11,300 rpm 100% N_2 vibration with the speed chart (Figure 510). No shaft speeds are close to the 11,300 rpm peak on Figure 507.

(f) The actual starter generator gearshaft speed at 94% N_1 (0.94 x 12,034) is 11,312 rpm, and this gearshaft has caused the 11,300 rpm vibration frequency peak in Figure 507.

F. Limits

(1) Limits on Separate, Individual Vibrations. The discrete frequency guidelines apply to measurement of a particular frequency, such as 48,000 rpm (800 Hz). If tests reveal vibrations above the normal operating range (Figure 509) or above 1.0 IPS average velocity, action should be taken to determine the source of the vibration and perform corrective action.

(2) Overall Vibration Limits. The overall vibration guidelines apply when test equipment reads all vibration contributions over a broad band, such as 15 to 2,000 Hz. If overall limits are exceeded, analysis of each vibration must be made.

G. Maintenance Action. There are many potential causes of vibration. Suggested areas for possible corrective action are:

(1) N_1 Frequency Vibration

PARA 2.G. (1) (cont)

(a) Check cables, spectrum analyzer and pickups to ensure that all test components are in proper working order and are calibrated properly.

(b) Inspect for foreign object damage.

(c) Check compressor and turbine attaching hardware. Retighten per applicable Operation and Maintenance Manual instructions.

(d) Inspect for main shaft bearing failure or impending failure. Such failure should generate metal particles and enable the chip indicator light. Check oil filter and magnetic chip detectors for evidence of metal contamination.

(e) Check for sources of N_1 internal engine vibration such as:

1 No. 1 bearing

2 Compressor or impeller imbalance

3 No. 2 bearing

4 N_1 system rubs including:

Axial stages to plastic coating

Impeller to shrouds

Labyrinth seal knives

5 Foreign Object Damage (FOD) to compressor (usually vibration with noise)

6 No. 1 seal

7 Alignment:

Front support

Compressor to gearbox

8 Spur adapter gearshaft

9 Loose turbine assembly tie bolt

10 No. 8 bearing

11 No. 7 bearing

12 N_1 turbine–to–compressor coupling shaft indexing

13 Gas turbine rotor

(2) N_2 Frequency Vibration. Check for sources of N_2 vibration frequency such as:

(a) Turbine balance

(b) Loose power turbine inner or outer nuts

(c) Improper gearbox–to–turbine shims

(d) No. 3, 4, 5, or 6 bearings

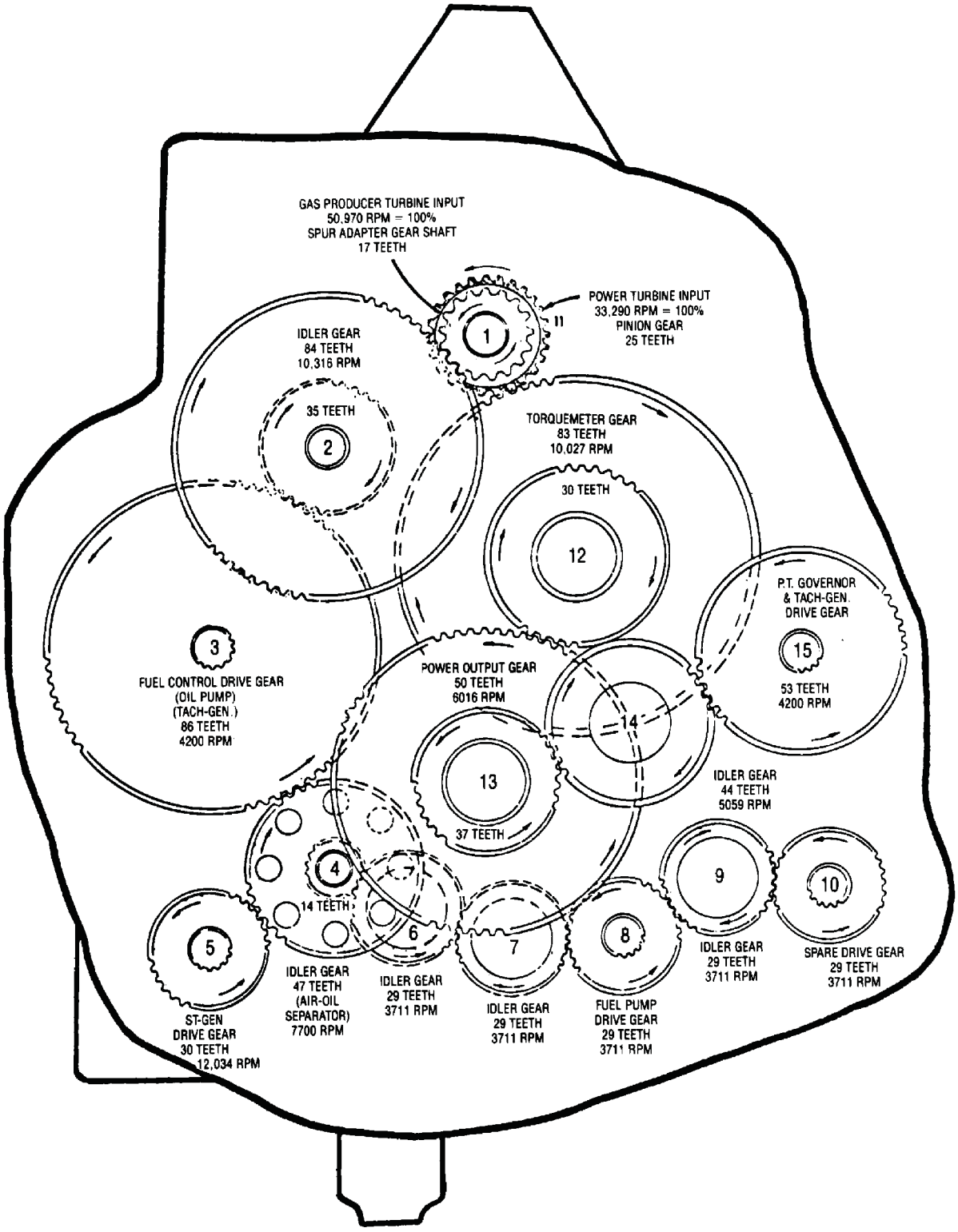
(3) Check output shaft frequency vibration:

(a) Check output shaft flex couplings and shaft balance

(b) Check alignment of engine to aircraft

(c) Check power takeoff gear

(d) Check freewheeling unit (if installed)



Schematic – Gas Producer and Power Turbine Gear Trains
Figure 510

AES019XA

PARA 2.G. (cont)

(4) Check high gearbox vibrations:

(a) Loose compressor studs

(b) No. 2–1/2 bearings

(c) No. 3 and 4 bearings

(d) Alignment:

1 Pinion gear

2 Case or cover

(5) Check main rotor blade passage vibration:

(a) Vibration may be in main rotor rpm times number of blades, main rotor rpm, or multiples of these. Align, balance and track main rotor. Refer to appropriate airframe manual for procedures.

(b) Check engine to airframe mounts. Inspect and retighten per aircraft manual instructions.

(c) Check main rotor transmission mounts for condition and security per airframe manual instructions.

(6) Check starter generator frequency vibration:

(a) Replace unit

H. Manufacturer Assistance

If suspected airframe and engine components have been inspected, repaired, or replaced per the appropriate manufacturer's instructions as indicated by this vibration test data, and vibration symptoms still persist, contact Rolls–Royce for further assistance.

3. Engine Trend Check Analysis

The trend check analysis provides a method for the operator to monitor engine performance. The trend check will also allow the operator to more effectively predict when preventative maintenance is required and schedule some maintenance actions that were formerly unscheduled.

Rolls–Royce strongly encourages all operators on a voluntary basis to utilize performance trending to supplement their regular maintenance program. It should be noted that the use of performance trending does not change the requirement to operate the engine within established limits and according to applicable publications. Aircraft manufacturer engine trending procedures that are published in the applicable FAA approved flight manuals can be used in lieu of the procedure given in this manual if they are Rolls–Royce approved. (Refer to Aircraft Manufacturer Trend Check–Alternate Procedure, para 4.D. this section.)

The analysis given in the Engine Trend Check Procedure, para 4, this section, provides the necessary guidance, procedures, check lists, correction tables and graphic examples required to set up an engine trend check program. A trend check program can be initiated at any point in an engine's life. The effectiveness of the trending program is dependent on the quality of the uncorrected data. Anything that causes the inflight data to be in error will reflect adversely on the effectiveness of the program.

Consideration should be made for tolerances on the accuracy of aircraft installed instruments. Instrument error could affect measured performance by approximately:

A. 4% below actual power available for every + 5°C error in outside air temperature (OAT).

(1) Use a precision mercury type thermometer in the immediate vicinity of the OAT probe. Shade both thermometers for a minimum of 15 minutes before taking a reading. Compare accuracy of installed OAT gauge.

B. 1% below actual power available for every 300 feet error in pressure altitude.

(1) Determine pressure altitude by averaging the readings of altimeters of known accuracy with flight deck reading.

PARA 3. (cont)

C. 2% below actual power available for every + 6°C error in TOT.

(1) Check calibration of TOT system and gauge.

D. 2% below actual power available for every + 2% error in torquemeter. (Check accuracy or torquemeter).

4. Engine Trend Check Procedure

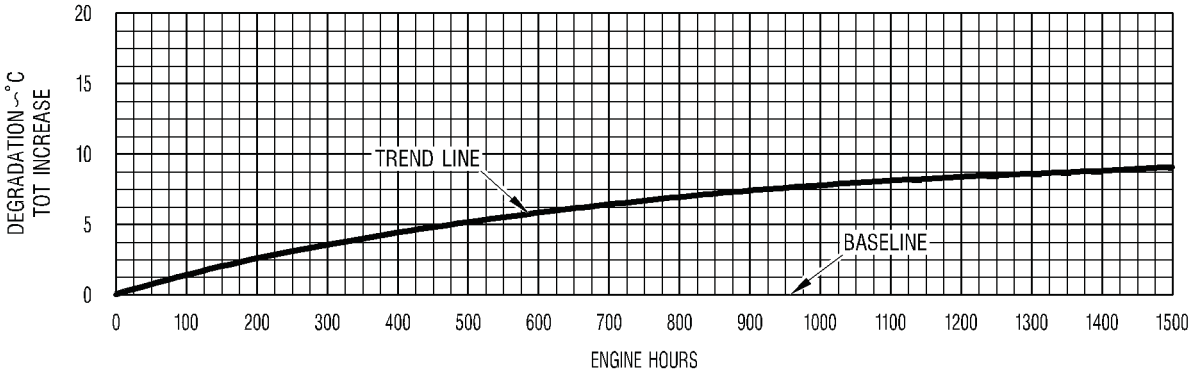
A. Description

(1) Trend checks can be used to monitor the health of the engine on a day to day basis. However, trending is best used to determine engine health over longer periods of sustained operation. The key to interpreting the data is a basic understanding of the engine characteristics. Turbine engines normally degrade or lose power through engine operation. If normal degradation is plotted against accumulated engine hours, the trend line of increased turbine outlet temperature (TOT) could appear as in Figure 511.

NOTE: Figures 511 through 515 and Figure 525 are for a typical engine. The degradation trend plotted for a specific engine should follow the general pattern of these curves; but, need not duplicate the illustrated values.

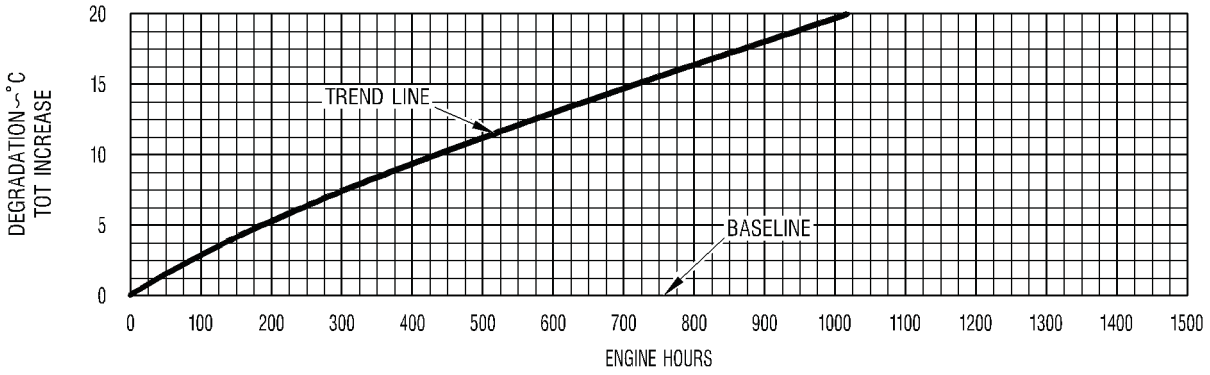
(2) Degradation is also affected by operation in erosive environments, excessive operation at high temperature or overtemperature conditions, and other abnormal conditions. The more erosive the environment, the longer the high temperature was maintained or the higher the overtemperature, the faster performance will degrade. Degradation due to this type of abnormal operation could appear as the trend line depicted in Figure 512.

(3) When engine performance degrades beyond the limits allowed in applicable aircraft publications, maintenance should be performed. Each time that engine maintenance is performed, some measure of performance may be recovered. Normally, following this maintenance, the engine will not recover to the power level experienced when the engine was new or overhauled, without the replacement or rework of components to like new condition. Figure 513 shows a typical performance recovery resulting from regular engine washes. Note that engine performance does not return to the original baseline power available when the engine was new or overhauled.



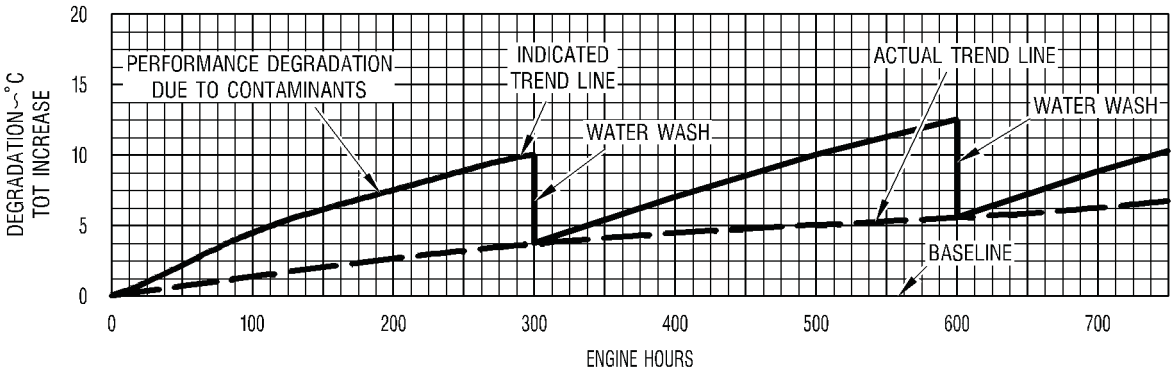
Normal Engine Degradation
Figure 511

APS026XD



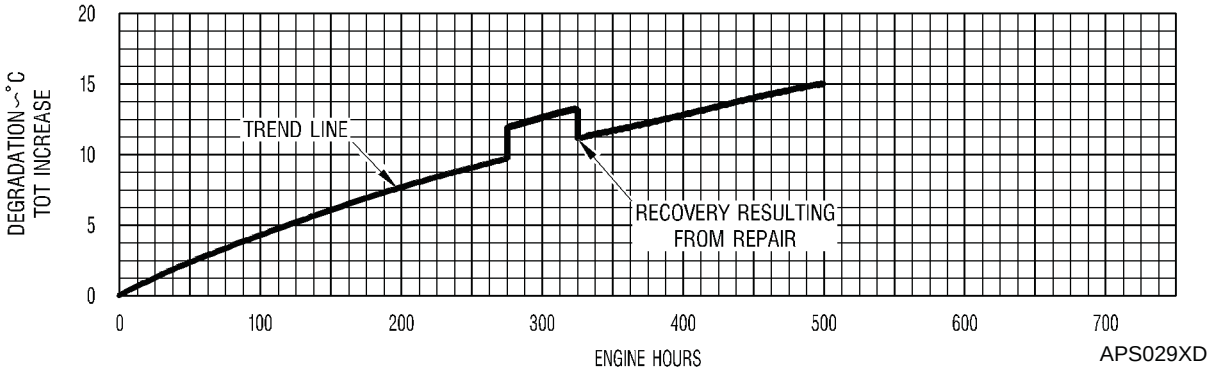
Abnormal Operation Engine Degradation
Figure 512

APS027XD



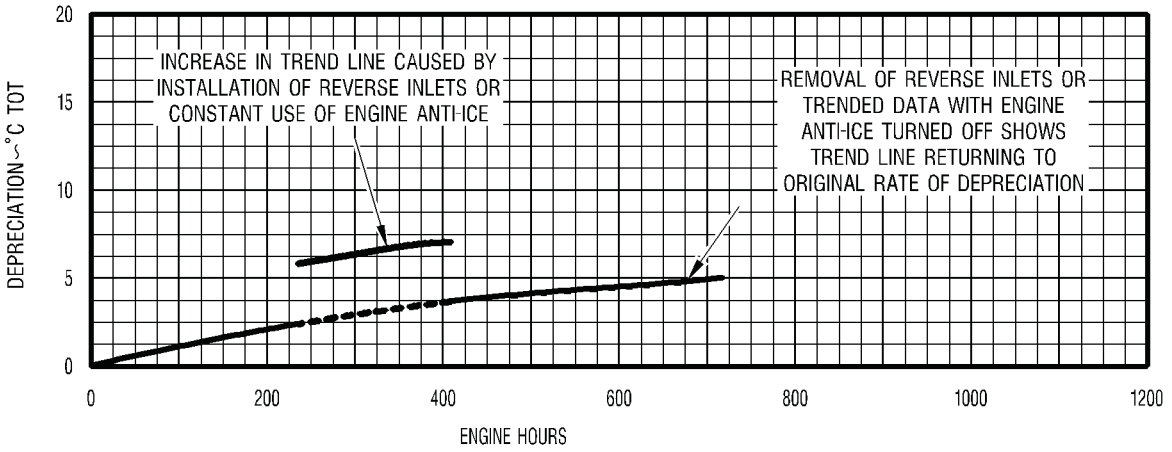
Performance Recovery Due to Engine Wash
Figure 513

APS028XD



APS029XD

Engine Degradation with Component Failure/Repair
Figure 514



Engine Degradation Baseline Change
Figure 515

ADS034XD

PARA 4.A. (cont)

(4) Short term degradation can be caused by operating the engine in contaminated atmospheric conditions. Dust, smoke and other industrial contaminants can cause this type of power loss. Aircraft oil leaks, when they mix with the air entering the engine, can also result in a loss of power. This type of degradation can take place in minutes or hours and is generally corrected by rinsing or washing the engine. Following the engine rinse or wash, it is normal that power would return to the previous base line. If power is not recovered following a rinse or wash of a dirty engine, another problem is indicated.

(5) Engine components that are in the process of failing can also appear as short term degradation. When engine performance degrades over a short period of time, and rinsing or washing the engine doesn't recover the performance loss, a component failure or misadjustment should be investigated and corrected. Following maintenance, it would be normal to expect that trend line power would be recovered. This type of component failure or loss of adjustment could appear as in Figure 514.

(6) Figures 511 through 514 represent some of the typical data plots that can result when attempting to analyze or trend data. There are numerous combinations of these graphs that when properly analyzed can provide the operator useful information to determine that maintenance is, or soon will be, required. However, interpreting the data is not always a straight forward process. There are a number of factors that occur to confuse or mask both normal and abnormal readings.

WARNING: DO NOT EXCEED SPECIFIED AIRCRAFT OR ENGINE LIMITATIONS DURING PERFORMANCE OF THIS CHECK.

(7) Data scatter and pilot procedure can be a common source of inaccuracy in the trend procedure. It can result from the normal instrumentation error caused by allowable inaccuracy/readability or omission/change of a trend check procedure step. Following the daily flight trend check, the recorded data should be corrected and plotted. When the corrected TOT readings are more than plus or minus 20°C from the existing trend line, maintenance personnel should make sure no obvious failures have occurred before repeating the trend check to determine whether the variation was due to data scatter or pilot procedure. If, upon repeating the trend check, the newly plotted data returns to within plus or minus 20°C from the existing trend line without further action by the pilot or maintenance personnel, the problem was probably due to data scatter. Neither the aircraft nor engine should have to be operated beyond established limitations to perform the trend check procedure. If aircraft or engine limitations are encountered during performance of the trend check procedure, it is an indication that the check has either been improperly performed or that there is an aircraft or engine problem.

PARA 4.A. (cont)

NOTE: Prior to initiating a trend check program, operators should assure that the aircraft instrumentation is properly calibrated.

(8) If repeated checks continue to give corrected plotted readings in excess of plus or minus 20°C corrected TOT change from the existing trend line, the cause can also be due to pilot procedure. Each step of the procedure should be reviewed to assure that all switches were properly positioned and instruments were read correctly. One of the most common causes for inaccuracy is leaving the anti–ice, bleed air heater, environmental control unit or other engine air–operated component turned on during the check. Also, be sure to allow the engine at least 1 minute to stabilize prior to taking any readings. If the procedure was performed correctly and the plus or minus 20°C corrected TOT change continues to result, then an aircraft or engine problem should be investigated.

(9) To assure accurate trend checks, the aircraft configuration must remain the same during the first and each subsequent check. For example, some aircraft have bleed air operated components such as pumps that cannot be turned off. Since each trend check would be made with these systems operational, it will have no visible effect on the trended data. Additionally, if an engine operated subsystem was usually required for safe flight during the period the trend check was normally performed, the first and each subsequent check should be performed with that system operational. For example, in some areas of the world, engine anti–ice is frequently required for normal operation and should therefore be operated during each trend check. Furthermore, when a new or overhauled engine, or an aircraft or engine component that may affect performance is installed, a new baseline trend must be established. A change in the trend line could appear as in Figure 515.

B. Example

(1) This example is provided to illustrate data tabulation, correction and graphing.

(a) Aircraft flight condition: 2,000 feet pressure altitude, 20°C outside air temperature, 100 knots airspeed with the following engine instrument indications: N_1 = 98%, N_2 = 100%, Torque = 80%, TOT = 720°C, Oil Pressure = 110 psig, Oil Temperature = 95°C.

(b) The maintenance or operations section shall record aircraft S/N, engine S/N, date and engine time on the 250 Trend Check Record. (See Figure 516.)

(c) After departure, the pilot notes the correct altimeter reading, sets the altimeter to 29.92 in. Hg and continues to climb the aircraft to 2000 ft pressure altitude.

NOTE: Any 1,000 foot increment in pressure altitude up to 10,000 feet can be selected for the check. However, data reduction is simplified when the same pressure altitude is used for each subsequent check.

NOTE: Any baseline torque that provided an indicated N_1 speed greater than 95% can be utilized. The indicated torque setting required will be obtained from the torque correction chart by entering the chosen base line torque and pressure altitude to be flown.

(d) The pilot now adjusts the engine power for cruise flight at 80% torque, checks that the N_1 is above 95% and waits for one minute to allow the engine to stabilize. The pilot now records PA = 2000 ft, TOR = 80%, OAT + 20°C, N_1 = 98% and TOT = 720°C on the 250 Trend Check Record. (See Figure 517.) Since light to moderate turbulence was experienced throughout the procedure, the pilot has noted “turbulence” in the remarks block to indicate that the data might be affected. The pilot then resets the altimeter to the correct reading.

250 TREND CHECK RECORD

AIRCRAFT S/N N12345 ENGINE S/N 88888

DATE	ENGINE TIME	PRESSURE ALTITUDE	TORQ.	OAT	N_1	TOT		REMARKS
1/15/82	646.0							

Example — Data Filled in by Maintenance/Operations
Figure 516

APS051XD

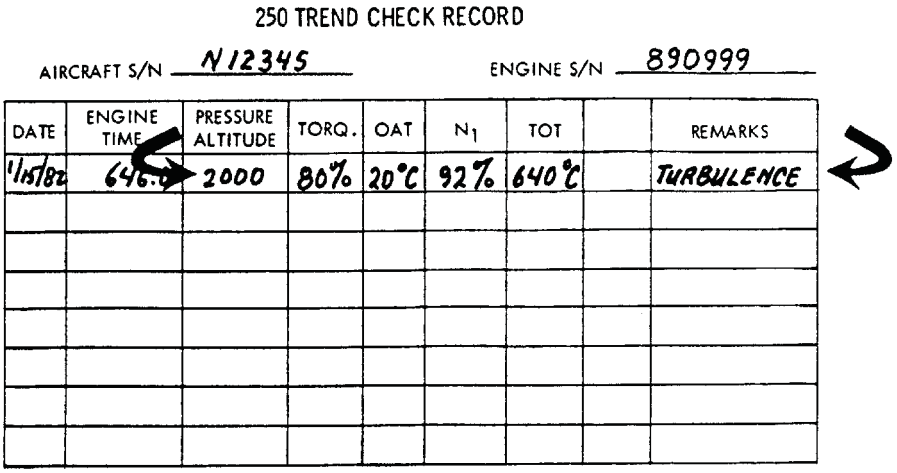
PARA 4.B.(1) (cont)

(e) Following flight, the recorded data can be corrected and trended. The baseline parameters for the graphed data are 2,000 feet pressure altitude and 80% indicated torque. After determining that these baseline parameters have been used, the resulting data can be corrected and graphed. Using Figure 518, determine the corrected N_1 speed value. Find the indicated OAT on the left vertical scale and the indicated N_1 speed on the top horizontal scale. Moving right and down, you will intersect at the corrected N_1 speed of 97%. Graph this speed as indicated in Figure 520.

NOTE: If the pilot cannot utilize the same baseline pressure altitude for each trend check, the trend procedure must be modified. The use of a nonstandard altitude described in step (h) will allow the pilot to perform the trend check at various altitudes.

(f) Using Figure 519, determine the corrected TOT. Find the indicated OAT on the left vertical scale and indicated TOT on the top horizontal scale. Moving right and down, you will intersect at the corrected TOT value of 703°C. For indicated TOT values under 650°C, consult the first page of Table 503. Graph this data as indicated in Figure 520.

(g) It should be noted that the data graphed in Figure 520 cannot always be directly compared to the background data depicted in Figures 511 through 515. The background data are for illustration purposes only, to show long term degradation of a typical engine. Actual graphed N_1 and TOT data can vary from the example. The important thing to remember is that the overall trend should be gradual. Step changes in the trend are significant and their causes should be determined.



250 TREND CHECK RECORD

AIRCRAFT S/N N12345 ENGINE S/N 890999

DATE	ENGINE TIME	PRESSURE ALTITUDE	TORQ.	OAT	N_1	TOT		REMARKS
1/15/82	646.0	2000	80%	20°C	92%	640°C		TURBULENCE

Example — Data Added By the Pilot
Figure 517

APS052XD

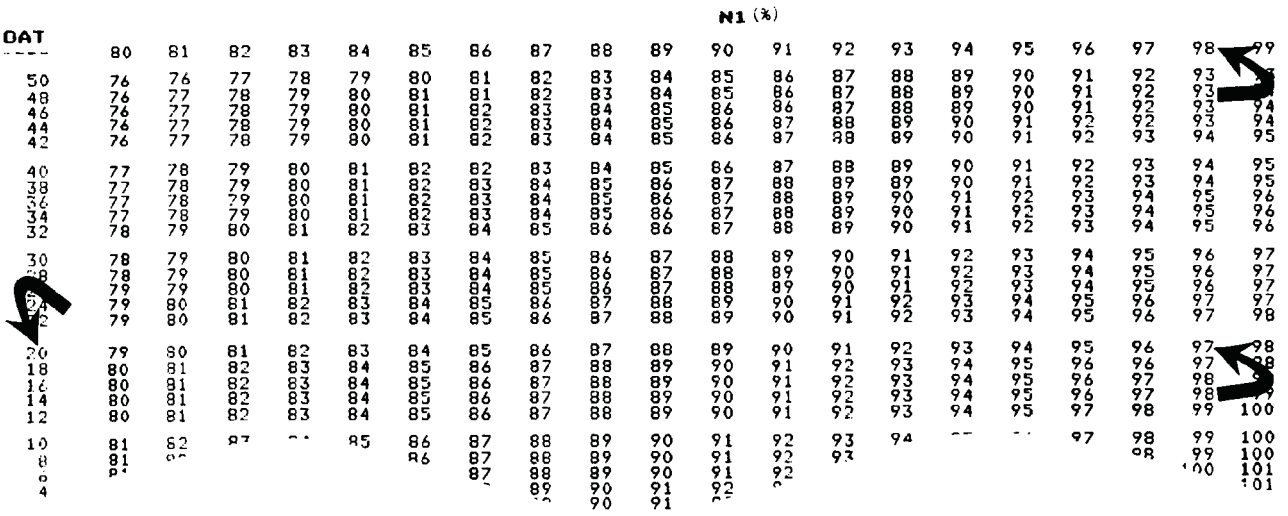
PARA 4.B.(1) (cont)

(h) If a baseline pressure altitude for performing the daily trend check procedure cannot be established, the check can still be completed by correcting the torque input value to sea level conditions prior to performing the check. (See Figure 521.) For example, if flight clearance is to climb and maintain 3000 feet, enter the chart at the baseline torque value of 80% torque, move right to intersect the 3000 foot pressure altitude value and read 72% torque as depicted. Accordingly, for this flight set the 72% on the aircraft torque gage, record the readings, correct the data and plot the values as described earlier. The use of a different baseline altitude for each check will require the torque correction chart depicted in Figure 521 to be carried in the aircraft for reference.

(i) Reduced torque values may be required at high altitudes to remain within engine or aircraft limitations. This can result in N_1 readings below 95% speed that will allow the engine bleed valve to open. If this data is plotted, it will erroneously appear as a step change increase in the TOT trend. Step change increases in the TOT trend must be compared to the trended N_1 to assure the bleed valve is closed. Data taken while the bleed valve is fully open or modulating will not be accurate.

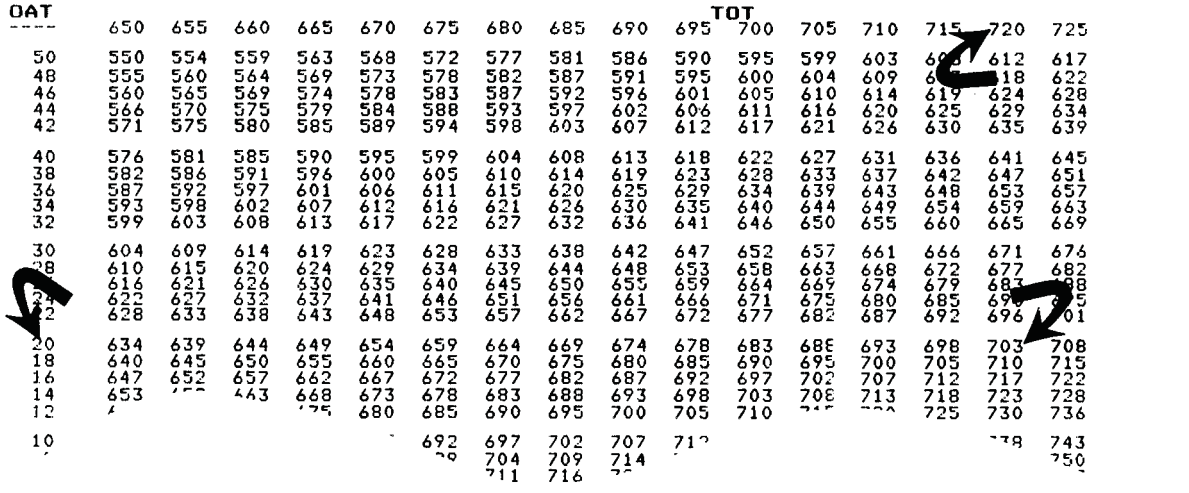
(j) Step change variations in TOT or other graphed parameters should be investigated to determine their cause. Step changes that result from aircraft configuration changes, engine maintenance or other known causes are permissible and result in a new trend line as illustrated in Figure 514 or 515. Step changes resulting from unknown causes should be investigated systematically using the recommendations provided in the troubleshooting section of this manual. (See Table 101, Engine–Troubleshooting, 72–00–00.)

(k) The maximum amount of deterioration allowed is determined by the limits stated in the aircraft flight manual and in accordance with the aircraft manufacturer's FAA approved power assurance check procedure.



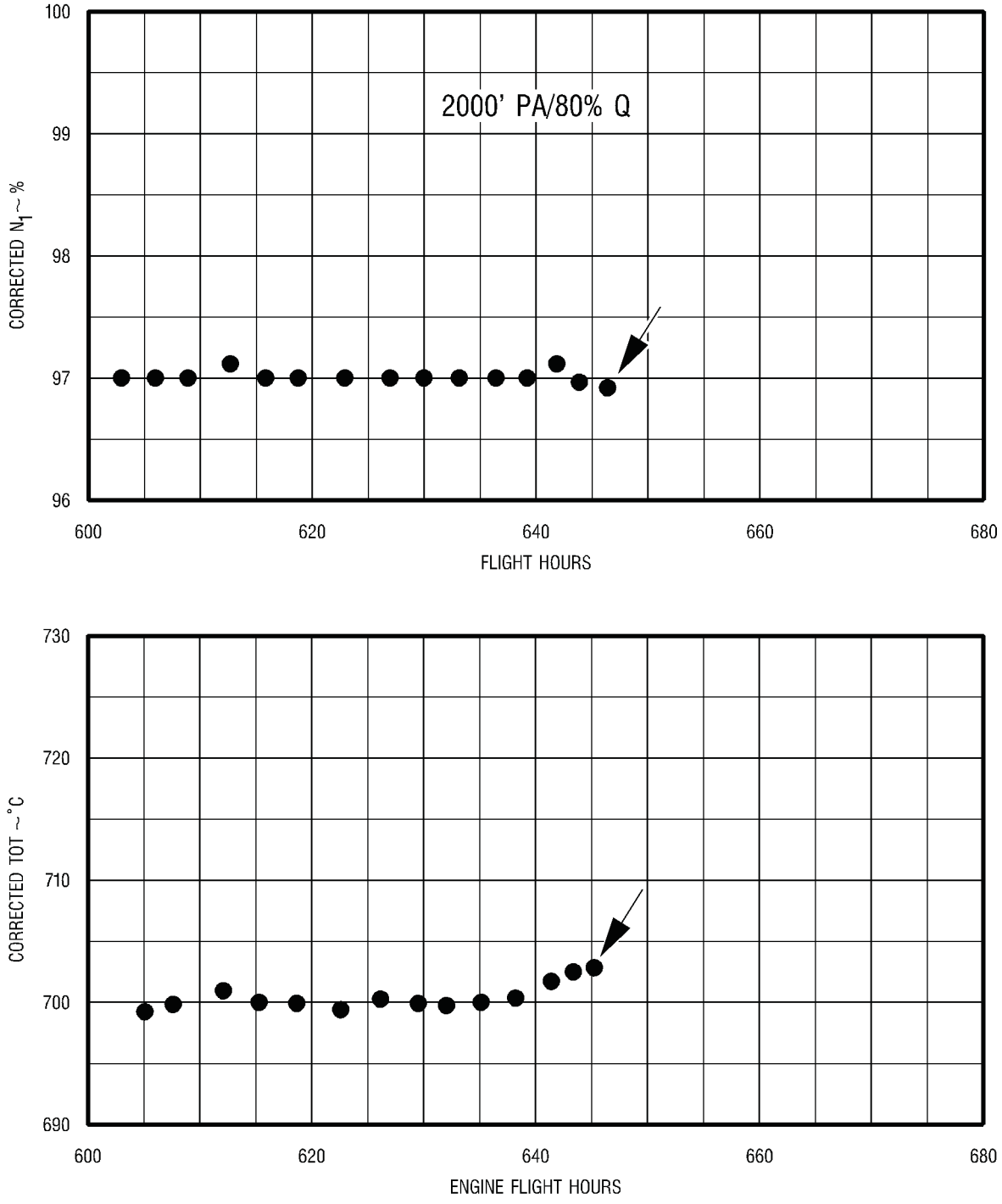
ADS030XD

N_1 Correction Chart
Figure 518



TOT Correction Chart
Figure 519

ADS031XD



Trend Check Graph
Figure 520

ADS035XA

BASELINE TORQUE(%)	PRESSURE ALTITUDE (FT) SEA LEVEL	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
	INDICATED TORQUE (%)										
60	60	58	56	54	52	50	48	46	45	43	41
65	65	63	60	58	56	54	52	50	48	46	45
70	70	68	65	63	60	58	56	54	52	50	48
75	75	72	70	67	65	62	60	58	56	54	52
80	80	77	74	72	69	67	64	62	59	57	55
85	85	82	79	76	73	71	68	66	63	61	58
90	90	87	84	81	78	75	72	69	67	64	62
95	95	92	88	85	82	79	76	73	71	68	65
100	100	96	93	89	86	83	80	77	74	71	69

APS055XD

Torque Correction Chart
Figure 521

PARA 4. (cont)

C. Procedure

(1) Set the aircraft altimeter to 29.92 in. Hg and fly the aircraft at a pressure altitude convenient to normal flight and in increments of 1000 feet from sea level. The maximum altitude for the check is 10,000 ft. Assure the following conditions exist:

WARNING: DO NOT TURN OFF SYSTEMS OR COMPONENTS REQUIRED FOR SAFE FLIGHT. IF ANTI–ICE IS FREQUENTLY REQUIRED FOR SAFE FLIGHT, IT SHOULD BE OPERATED DURING EACH TREND CHECK.

(a) Anti–ice air — off

(b) Environmental control unit — off

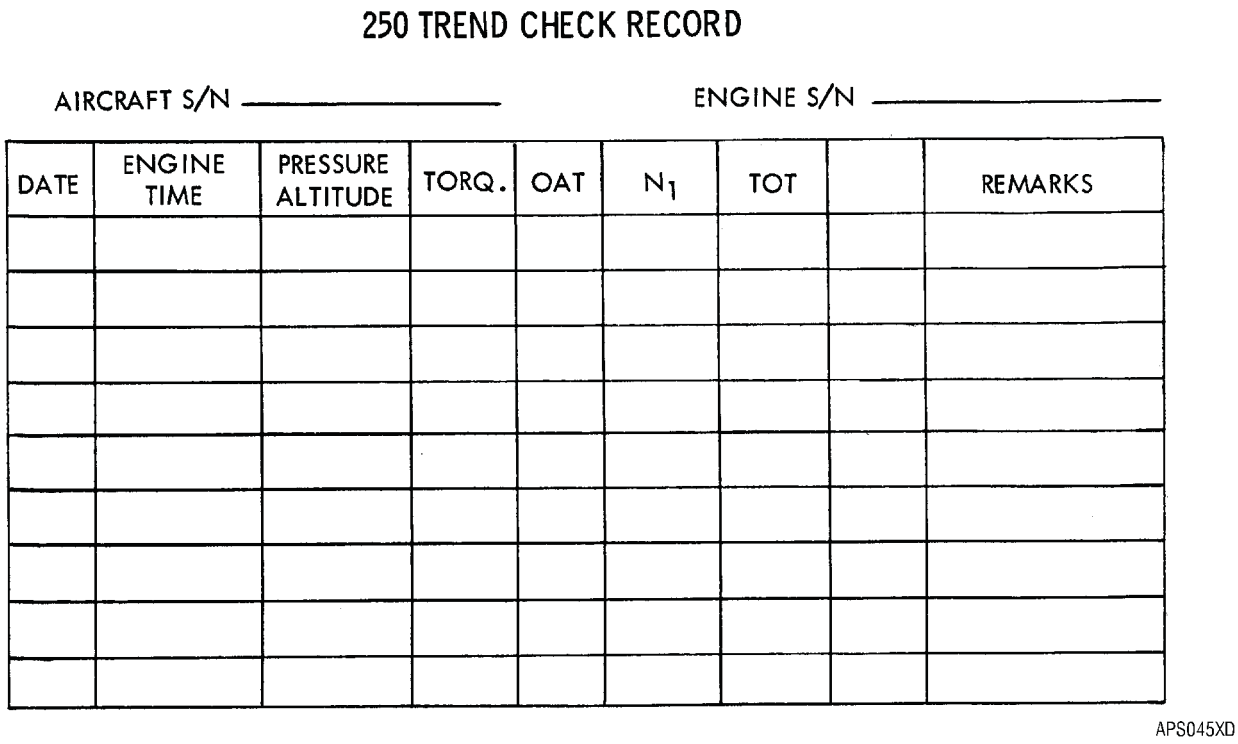
(c) Bleed air heater — off

(d) Generator load is less than 20%

(2) Set engine N_2 speed at Normal Cruise rpm. This speed should remain constant on all subsequent checks.

NOTE: If N_2 rpm is changed for subsequent checks, a new baseline trend will be established.

(3) Keep the aircraft in a level cruise flight when this trend check is performed. Do not perform the check while in a climb or descent flight mode.



250 TREND CHECK RECORD

AIRCRAFT S/N _____ ENGINE S/N _____

DATE	ENGINE TIME	PRESSURE ALTITUDE	TORQ.	OAT	N_1	TOT		REMARKS

APS045XD

Trend Check Data Recording Form
Figure 522

PARA 4.C. (cont)

(4) Set the engine power to a baseline torque value that provides at least 95% N_1 speed to be sure the engine bleed valve is closed and to ensure a valid trend check. If a nonstandard baseline altitude is used, determine the indicated torque requirement from the torque correction chart. (See Table 501.) If N_1 is not 95% or more, step (3) should be repeated at a higher torque value which will also establish a new trend line. Hold cruise power for one minute to allow the engine to stabilize prior to recording the data listed in step (5).

(5) Record the following values on the trend check record form provided as Figure 522.

(a) Pressure altitude

(b) OAT (C)

(c) N_1 — Gas Producer rpm

(d) Torque

(e) Turbine Outlet Temperature — TOT

(6) Following flight, correct N_1, TOT, and torque values using the charts provided in Tables 501 through 503. Record corrected values on the trend check graph provided in Figure 523.

NOTE: Refer to Figure 524 for a reference outline of the trend check procedure which can be conveniently carried in the aircraft.

Table 501

Torque Correction Chart

Baseline Torque (%)	Pressure Altitude (ft)										
	Sea Level	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
	Indicated Torque %										
60	60	58	56	54	52	50	48	46	45	43	41
65	65	63	60	58	56	54	52	50	48	46	45
70	70	68	65	63	60	58	56	54	52	50	48
75	75	72	70	67	65	62	60	58	56	54	52
80	80	77	74	72	69	67	64	62	59	57	55
85	85	82	79	76	73	71	68	66	63	61	58
90	90	87	84	81	78	75	72	69	67	64	62
95	95	92	88	85	82	79	76	73	71	68	65
100	100	96	93	89	86	83	80	77	74	71	69

NOTE: Depending on aircraft gross weight and ambient conditions, performance of the trend check may not be possible using some of the above indicated torques if the trended torque figure selected produces an indicated torque value that is so low that an accurate trend check is not possible. Therefore, an increased baseline torque value may be required.

Table 502

N_1 Correction Chart

OAT	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
50	76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	93	94	95	96	97	98
48	76	77	78	79	80	81	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
46	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91	92	93	94	95	96	97	98	99
44	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	92	93	94	95	96	97	98	99
42	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	98	99
40	77	78	79	80	81	82	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
38	77	78	79	80	81	82	83	84	85	86	87	88	89	89	90	91	92	93	94	95	96	97	98	99	100
36	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	98	99	100
34	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
32	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
30	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	97	98	99	100	101
28	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
26	79	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
24	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	97	98	99	100	101	102
22	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
20	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
18	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	96	97	98	99	100	101	102	103
16	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
14	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
12	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	97	98	99	100	101	102	103	104	105
10	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
8	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
6	81	82	83	84	85	86	87	88	89	90	91	92	93	94	96	97	98	99	100	101	102	103	104	105	106
4	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
2	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
0	82	83	84	85	86	87	88	89	90	91	92	93	94	96	97	98	99	100	101	102	103	104	105	106	107
–2	82	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107
–4	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	105	106	107	108
–6	83	84	85	86	87	88	89	90	91	92	93	95	96	97	98	99	100	101	102	103	104	105	106	107	108
–8	83	84	85	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
–10	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	102	103	104	105	106	107	108	109
–12	84	85	86	87	88	89	90	91	92	93	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
–14	84	85	86	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	107	108	109	110
–16	85	86	87	88	89	90	91	92	93	94	95	96	97	98	100	101	102	103	104	105	106	107	108	109	110
–18	85	86	87	88	89	90	91	92	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	111
–20	85	86	87	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	105	106	107	108	109	110	111
–22	86	87	88	89	90	91	92	93	94	95	96	97	99	100	101	102	103	104	105	106	107	108	109	110	111
–24	86	87	88	89	90	91	92	94	95	96	97	98	99	100	101	102	103	104	105	106	108	109	110	111	112
–26	86	87	89	90	91	92	93	94	95	96	97	98	99	100	102	103	104	105	106	107	108	109	110	111	112
–28	87	88	89	90	91	92	93	94	95	96	98	99	100	101	102	103	104	105	106	107	108	110	111	112	113
–30	87	88	89	90	91	93	94	95	96	97	98	99	100	101	102	103	105	106	107	108	109	110	111	112	113
–32	87	89	90	91	92	93	94	95	96	97	98	99	101	102	103	104	105	106	107	108	109	110	112	113	114
–34	88	89	90	91	92	93	94	96	97	98	99	100	101	102	103	104	105	106	108	109	110	111	112	113	114
–36	88	89	90	91	93	94	95	96	97	98	99	100	101	103	104	105	106	107	108	109	110	111	112	114	115
–38	89	90	91	92	93	94	95	96	97	99	100	101	102	103	104	105	106	107	108	110	111	112	113	114	115

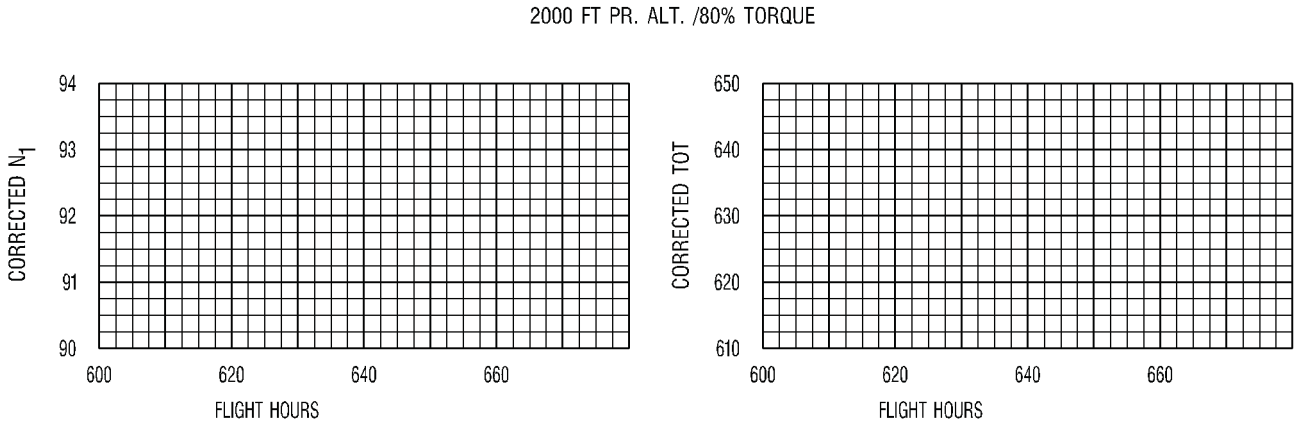
Table 503

TOT Correction Chart

OAT	530	535	540	565	550	555	560	565	558	575	580	585	590	595	600	605	610	615	620	625	630	635	640	645	650
50	443	447	452	456	461	465	470	474	479	483	488	492	496	501	505	510	514	519	523	528	532	537	541	546	550
48	447	452	456	461	465	470	474	479	483	488	483	497	801	506	510	515	519	524	528	533	537	542	546	551	555
46	452	456	461	466	470	475	479	484	488	493	497	502	506	511	515	520	524	529	533	568	572	577	551	556	560
44	457	461	466	470	475	479	484	488	493	497	502	507	511	516	520	525	529	534	538	543	547	552	556	561	566
42	461	466	470	475	479	484	489	493	498	502	507	511	516	521	858	560	537	569	543	548	553	557	562	566	571
40	466	470	475	480	484	489	493	498	503	507	512	516	521	526	530	535	539	544	549	553	558	562	578	572	576
38	471	475	480	485	489	595	598	806	508	512	517	522	526	531	535	540	545	459	554	559	563	568	572	577	582
36	475	480	485	489	494	499	503	508	513	517	522	527	531	536	541	545	550	555	559	564	569	573	578	583	587
34	480	485	490	494	499	504	508	513	518	523	527	532	537	541	546	551	555	560	565	569	674	579	583	588	593
32	485	490	495	499	504	509	514	518	523	528	532	537	542	547	551	556	561	566	570	575	580	584	589	594	599
30	490	495	500	505	509	514	519	524	528	533	538	543	547	552	557	562	566	571	576	581	585	590	595	600	604
28	495	500	505	510	514	519	524	529	534	538	543	548	553	558	562	567	572	577	581	586	591	596	601	605	610
26	500	505	510	515	520	525	529	534	539	544	549	553	558	563	568	573	578	582	587	592	597	602	606	611	616
24	506	511	515	520	525	530	535	540	544	549	554	559	564	569	574	578	583	588	593	598	603	607	612	617	622
22	511	516	521	526	530	535	540	545	550	555	560	565	570	574	579	584	589	594	599	604	609	613	618	623	628
20	516	521	526	531	536	541	546	551	556	561	565	570	575	580	585	590	595	600	605	610	615	620	624	629	634
18	522	527	532	537	542	546	551	556	561	566	571	576	581	586	591	596	601	606	611	616	621	626	631	636	640
16	527	532	537	542	547	552	557	562	567	572	577	582	587	592	597	602	607	612	617	622	627	632	637	642	647
14	533	538	543	548	553	558	563	568	573	578	583	588	593	598	603	608	613	618	623	628	633	638	643	648	653
12	538	544	549	554	559	564	569	574	579	584	589	594	599	604	609	614	619	624	629	634	640	645	650	655	660
10	544	579	554	559	565	670	575	480	585	490	595	600	605	610	615	621	626	631	636	641	646	651	656	661	666
8	550	555	560	565	571	576	581	586	591	596	601	606	611	617	622	627	632	637	642	647	652	658	663	668	673
6	556	561	566	571	577	582	587	592	597	602	608	613	618	623	628	633	638	644	649	654	659	664	669	675	680
4	562	578	572	577	583	588	593	598	603	609	614	619	624	629	635	640	645	650	655	661	666	671	676	681	687
2	568	573	578	584	589	594	599	605	610	615	620	626	631	636	641	647	652	657	662	667	673	689	683	688	694
0	574	579	585	590	595	600	606	611	616	622	627	632	637	643	648	453	659	664	669	674	680	685	690	695	701
–2	580	586	591	596	602	607	612	618	623	628	634	639	644	649	655	660	665	671	676	681	687	692	697	703	708
–4	587	592	597	603	608	613	619	624	630	635	640	646	651	656	662	667	672	678	683	688	694	699	704	710	715
–6	593	599	604	609	615	620	626	631	636	642	647	652	658	663	669	674	679	685	690	696	701	706	712	717	723
–8	600	605	611	616	621	627	632	638	643	649	654	659	665	670	676	681	687	692	698	703	708	714	719	725	730
–10	606	612	617	623	628	634	639	645	650	656	661	667	672	678	683	688	694	699	705	710	716	721	727	732	738
–12	613	619	624	630	635	641	646	652	657	663	668	674	679	685	690	696	701	707	712	718	723	729	734	740	745
–14	620	625	631	637	642	648	653	659	664	670	676	681	687	692	698	703	709	714	720	726	731	737	742	748	753
–16	627	632	638	644	649	655	660	666	672	677	683	688	694	700	705	711	717	722	728	733	739	745	750	756	761
–18	634	640	645	651	657	662	668	673	679	685	690	696	702	707	713	719	724	730	736	741	747	753	758	764	769
–20	641	647	652	658	664	670	675	681	687	692	698	704	709	715	721	726	732	738	744	749	755	761	766	772	778
–22	648	654	660	666	671	677	683	689	694	700	706	711	717	723	729	734	740	746	752	757	763	769	775	780	786
–24	656	662	667	673	679	685	690	696	702	708	714	715	725	731	737	743	748	754	760	766	771	777	783	789	795
–26	663	669	675	681	687	692	698	704	710	716	722	727	733	739	745	751	757	762	768	774	780	786	792	797	803
–28	671	677	683	689	694	700	706	712	718	724	730	736	741	747	753	759	765	771	777	783	788	794	800	806	812
–30	679	685	691	696	702	708	714	720	726	732	738	744	750	756	762	768	774	779	785	791	797	803	809	815	821
–32	687	693	699	705	711	716	722	728	734	740	746	752	758	764	770	776	782	788	794	800	806	812	818	824	830
–34	695	701	707	713	719	725	731	737	743	749	755	761	767	773	779	785	791	797	803	809	715	821	827	833	839
–36	703	709	715	721	727	733	739	745	751	757	764	770	776	782	788	794	800	806	812	818	824	830	836	843	849
–38	711	717	723	729	736	742	748	754	760	766	772	779	785	791	797	803	809	815	821	828	834	840	846	852	858

Table 503
TOT Correction Chart (cont)

OAT	650	655	660	665	670	675	680	685	690	695	700	705	710	715	720	725	730	735	740	745	750	755	760	765	770
50	550	554	559	563	568	572	577	571	586	590	595	599	603	608	612	617	621	626	630	635	639	644	648	653	657
48	555	560	564	569	573	578	582	587	591	595	600	304	609	613	618	622	627	631	636	640	645	649	654	658	663
46	560	565	569	574	578	583	587	592	596	604	605	610	614	619	624	628	633	637	642	646	651	655	660	664	669
44	566	570	575	579	584	588	593	597	602	606	611	616	620	625	629	634	638	643	647	652	656	661	665	670	675
42	571	575	580	585	589	594	598	603	607	612	617	621	626	630	635	639	644	649	653	658	662	667	671	676	681
40	576	581	585	590	595	599	604	608	613	618	622	627	631	636	641	645	650	654	659	664	668	673	677	682	687
38	582	586	591	596	600	605	610	614	619	623	628	633	637	642	647	651	656	660	665	670	674	679	684	688	693
36	587	592	597	601	606	611	615	620	625	629	634	639	643	648	653	657	662	666	671	676	680	685	690	694	699
34	593	598	602	607	612	616	621	626	630	635	640	644	649	654	689	663	668	673	677	682	687	691	696	701	705
32	599	603	608	613	617	622	627	632	636	641	646	650	655	660	665	669	674	679	684	688	693	698	702	707	712
30	604	609	614	619	623	628	633	638	642	647	652	657	661	666	671	676	680	685	690	695	699	704	709	714	718
28	610	615	620	624	629	634	639	644	648	653	658	663	668	672	677	682	687	691	696	701	706	711	715	720	725
26	616	621	626	630	635	640	645	650	655	659	664	669	674	679	683	688	693	698	703	718	712	717	722	727	732
24	622	627	632	637	641	646	651	656	661	666	671	675	680	685	690	695	700	704	709	714	719	724	729	734	738
22	628	633	638	643	648	653	657	662	667	672	677	682	687	692	696	701	706	711	716	714	726	731	735	740	745
20	634	639	644	649	654	659	664	669	674	678	683	688	693	698	703	708	713	718	723	728	733	737	742	747	752
18	640	645	650	655	660	665	670	675	680	685	690	695	700	705	710	715	720	725	730	735	739	744	749	754	759
16	647	652	657	662	667	672	677	682	687	692	697	702	707	712	717	822	727	732	736	741	746	751	756	761	766
14	653	658	663	668	673	678	683	688	693	698	703	708	713	718	723	728	733	739	744	749	754	759	764	769	774
12	660	665	670	675	680	685	690	695	700	705	710	715	720	725	730	736	741	746	751	756	761	766	771	776	781
10	666	671	676	682	687	692	697	702	707	712	717	722	727	732	738	743	748	753	757	763	768	773	778	783	788
8	673	678	683	688	693	699	704	709	714	719	724	729	734	740	745	750	755	760	765	770	775	781	786	791	796
6	680	685	690	695	700	706	711	716	721	726	731	737	742	747	752	757	762	768	773	778	783	788	793	798	804
4	687	692	697	702	707	713	718	723	728	733	739	744	749	754	759	765	770	775	780	785	791	796	801	806	811
2	694	699	704	709	715	720	725	730	736	741	746	751	756	762	767	772	777	783	788	793	798	804	809	814	819
0	701	706	711	717	722	727	732	738	743	748	753	759	764	769	775	780	785	790	796	801	806	811	817	822	827
−2	708	713	719	724	729	734	740	745	750	756	761	766	772	777	782	788	793	798	804	809	814	819	825	830	835
−4	715	721	726	731	737	742	747	753	758	763	769	774	779	785	790	795	801	806	812	817	822	828	833	838	844
−6	723	728	733	739	744	750	755	760	766	771	777	782	787	793	798	803	809	814	820	825	830	836	841	847	852
−8	730	736	741	746	752	757	763	768	774	779	784	790	795	801	806	812	817	822	828	833	839	844	850	855	861
−10	738	743	749	754	760	765	771	776	782	787	792	798	803	809	814	820	825	831	836	842	847	853	858	864	869
−12	745	751	757	762	768	773	779	784	790	785	801	806	812	817	823	828	834	839	845	850	856	861	867	872	878
−14	753	759	764	770	776	781	787	792	798	803	809	815	820	826	831	837	842	848	853	859	865	870	876	881	887
−16	761	767	773	778	784	789	795	801	806	812	817	823	829	834	840	845	851	857	862	868	873	879	885	890	896
−18	769	775	781	786	792	798	803	809	815	820	826	839	837	843	849	854	860	865	871	877	882	888	894	899	905
−20	778	783	789	795	800	806	812	818	823	829	835	840	746	852	857	863	869	874	880	886	892	897	903	909	914
−22	786	792	798	803	809	815	820	826	832	838	843	849	855	861	866	872	878	884	889	895	901	907	912	918	924
−24	795	800	806	812	818	823	829	835	841	847	852	858	864	870	876	881	887	893	899	904	910	916	922	958	933
−26	803	809	815	821	827	832	838	844	850	856	862	867	873	879	885	891	896	902	908	914	920	926	931	937	943
−28	812	819	824	830	836	841	847	853	859	865	871	877	883	888	894	900	906	912	918	924	930	935	941	947	853
−30	821	827	833	839	845	851	856	862	868	874	880	886	892	898	904	910	916	922	928	934	939	945	951	957	963
−32	830	836	842	848	854	860	866	872	878	884	890	896	902	908	914	920	926	932	938	944	950	955	961	967	973
−34	839	845	851	857	863	869	875	881	887	593	899	906	912	918	924	930	936	942	948	954	960	966	972	978	984
−36	849	855	861	867	873	879	885	891	897	903	909	915	922	928	934	940	946	952	958	964	970	976	982	988	994
−38	858	864	870	877	883	889	895	901	907	913	919	926	932	938	944	950	956	962	968	975	981	987	993	9991005	



250 Trend Check Graph
Figure 523

PARA 4. (cont)

D. Aircraft Manufacturer Trend Check — Alternate Procedure

Most aircraft manufacturer power checks generate percent torque as part of the aircraft In–flight Power Assurance — Daily Trend Check. This procedure trends power or torque with appropriate corrections for ambient flight conditions and aircraft installation characteristics. The result of this procedure is Delta percentage of specifications torque. This Delta percentage of specification torque can be used for trend monitoring by plotting the observed torque margin on a daily basis. This plot would appear similar to Figure 525.

ENGINE TREND CHECK PROCEDURE

WARNING: DO NOT EXCEED ENGINE/AIRCRAFT LIMITS.

1. Note altimeter pressure; set to 29.92 in. Hg and fly baseline torque and altitude for one minute.

   NOTE: Correct the torque setting if a non–standard baseline altitude is used.

   WARNING: ACCESSORIES REQUIRED FOR SAFE FLIGHT SHOULD BE OPERATED DURING EACH CHECK.

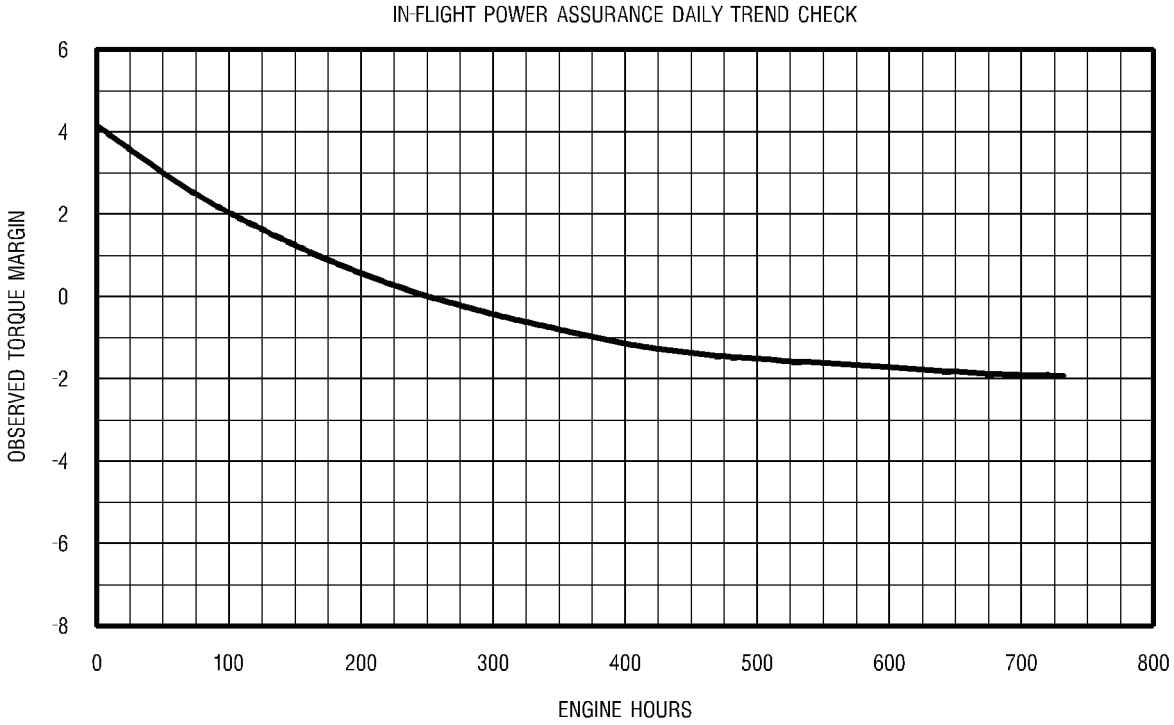
2. Turn off bleed air operated accessories (see WARNING); stabilize generator load below 20% and set full N_2 operating speed.

   NOTE: Be sure engine settings/configuration are identical for each check.

3. Record pressure altitude, OAT, N_1, torque and TOT.

4. Reset altimeter.

In–flight Check List
Figure 524



APS032XA

In–Flight Power Assurance Daily Trend Check
Figure 525