CHAPTER 18 — VIBRATION AND NOISE ANALYSIS

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VIBRATION AND NOISE ANALYSIS

18-1. GENERAL

Bell Helicopter has tested and supports the following equipment for main rotor tracking and balancing and main driveshaft balancing. The primary diagnostic equipment is the Rotor Analysis and Diagnostic System Model AT (RADS AT) with procedures included in the BHT-212-MM. Also usable is the analog Model 177M Vibrex equipment.

For convenience, balancing of the tail rotor and main driveshaft are also included in this chapter. Maintenance procedures for these components will be found in the appropriate chapters.

ROTOR SMOOTHING AND VIBRATION ANALYSIS

18-2. VIBRATION ANALYSIS

18-3. GENERAL

NOTE

Refer to Chapter 62 for the complete field maintenance instructions for the main rotor and rotating control components.

Most vibrations are always present in the helicopter at low magnitudes. The main problem is deciding when a vibration level has reached the point of being unacceptable. The only sources of any frequency are rotating or moving parts on the helicopter. Other parts vibrate only in sympathy with an existing vibration. Extreme low, low frequency, and most medium frequency vibrations are caused by the rotor or dynamic controls. Various malfunctions in stationary components can affect absorption or damping of existing vibrations and increase overall level felt by the pilot. A number of vibrations are present, and are considered a normal characteristic of the machine. Two per revolution (2/rev) vibration is the most prominent of these, with 4/rev or 6/rev the next most prominent. There is always a small amount of high frequency present. Flight experience is necessary to learn normal vibration levels. Even experienced pilots sometimes make the mistake of concentration on feeling one specific vibration and conclude that the vibration level is higher than normal, when actually it is not. For simplicity and standardization, vibrations are arbitrarily divided in general frequencies as follows:

Extremely low frequency	Less than 1/rev pylon rock
Low frequency	1/rev or 2/rev type vibration
Medium frequency	Generally 4/rev, 5/rev, or 6/rev
High frequency	Tail rotor or faster (buzz)

18-4. Extreme Low Frequency

Extreme low frequency vibration is limited to pylon rock. Pylon rocking two to three cycles per second is inherent with the rotor, mast, and transmission system. To keep vibration from reaching noticeable levels, transmission mount dampening is incorporated to absorb the rocking. Malfunctions in the dampening system will allow rocking to start and continue until it can be felt by the pilot. A quick check of the dampening system may be made by the pilot while in a hover. Moving cyclic fore and aft at about one movement per second will start the pylon rocking. The length of time required for the rocking to die out after motion of the cyclic is stopped is indicative of the quality of the dampening. An abnormal continuation of rock during the normal flight is an indication that something is wrong with the transmission mounts or dampers. This may be due to wear, parts loosening up, breakage, incorrect installations, or wrong type parts installed.

18-5. Low frequency.

Low frequency vibrations, 1/rev and 2/rev, are caused by the rotor. 1/rev vibrations are of two basic types; vertical or lateral. A 1/rev vertical is caused by one blade developing more lift at a given point than the other blade develops at the same point. A lateral vibration is caused by a spanwise imbalance of the rotor due to a weight difference between blades, alignment of the CG of the blades with respect to spanwise axis (which affects chordwise balance), or imbalance of hub or stabilizer bar. Rigidly controlled manufacturing processes and techniques eliminate all but minor differences between blades, resulting in blades which are virtually identical. The minor differences which remain will affect flight but are compensated for by adjustments of trim tabs and pitch settings. Initially, the rotor is brought into ground track by normal tracking procedures, using the pitch change link (rolling the grip) to make a blade fly higher or lower to bring both blade tips into the same tip path plane. A track is taken using a higher operating rpm to determine if one blade is climbing (developing more lift) more than the other as its speed increases. This climbing tendency is overcome by adjusting the trim tabs after a flight check is made, then flying again to determine the effect. Because of the physical differences in blades, it is sometimes necessary to roll a blade out of track slightly in order to get both blades developing the same amount of lift. Generally, verticals felt predominantly in low power descent at moderate airspeeds (60-70 knots) are caused by a basic difference in blade lift and can be corrected by rolling the grip slightly out of track. Verticals felt mostly in forward flight which get worse as airspeed increases are usually due to one blade developing more lift with increased speed than the other (a climbing blade). This condition is corrected by adjustment of the trim tabs. Smoothing of 1/rev verticals is essentially a trial and error process. A basic straight forward procedure is used but the outcome of any adjustment is uncertain and requires flight-testing to determine need for further action. Because of the idiosyncrasies of the individual blades, it is occasionally necessary to attempt adjustment procedure not normally utilized, such as lateral procedures for a vertical, using roll when normally tab is used (and vice versa), or changing both tabs an equal amount.

Associated with the 1/rev vertical is the intermittent 1/rev vertical. Essentially, this is a vibration initiated by a gust effect causing a momentary increase of lift in one blade giving a 1/rev vibration. This momentary increase is normal but if picked up by the rotating collective controls and fed back to the rotor causing several cycles of 1/rev, it is undesirable. Sometimes during steep turns, one blade will 'pop' out of track and cause a hard 1/rev vertical. This condition is usually caused by too much differential tab in the blades and can be corrected by rolling one blade at the grip and removing some of the tab (as much as can be done without disruption to the ride in normal flight). Should a rotor or rotor component be out of balance, a 1/rev vibration called a lateral will be present. This vibration is usually felt as a vertical due to the rolling motion it imparts to the helicopter, causing the pilots seats to bounce up and down. It can be noted that the seats bounce up and down out of phase; that is, the pilot goes up while the copilot goes down. An unusually severe lateral can be felt as a definite sideward motion as well as a vertical motion. Laterals existing due to an imbalance in the rotor are of two types; spanwise and chordwise. Spanwise imbalance is caused simply by one blade and hub being heavier than the other (i.e., an imbalance along the rotor span). A chordwise imbalance means there is more weight toward the trailing edge of one blade than the other. Both types of imbalance can be caused by the hub as well as the blades. Another occasional source of a lateral is the stabilizer bar. Improper balancing of the bar prior to installation is the main reason for this problem. Lateral vibrations are usually felt in a hover and in descending moderate airspeed turns and tend to disappear in forward flight. An out-of-ground effect hover is usually the best place to feel a lateral and reducing the rpm to 97% will often make the lateral more prominent. The correction of 1/rev lateral vibration begins by determining if one blade is heavier than the other. This is done by wrapping one or two turns of 2.0 inches (50.8mm) masking tape (or equivalent weight of another type) around one blade, a few inches in from the tip. The helicopter is then hovered, either in or out of ground effect, wherever the lateral was most evident, and the effect of the tape noted. A worsening of the vibration means the tape was placed on the wrong blade. Once the correct blade is determined, further tape is added in amounts depending on the severity of the vibration until a final best balance using 1/2 wraps of tape is obtained. Should the lateral still be excessive or the tape not help on either blade, a chordwise unbalance condition exists and it will be necessary to sweep a blade. One blade is arbitrarily picked and swept aft by shortening the drag link. One flat of turn (1/6 of full turn) is used to start with. The helicopter is then hovered and the effect determined. Once it is ascertained that the correct blade is being swept, continued sweep adjustments in amounts based on the severity of the vibration is used until the lateral is eliminated or further sweep fails to help. If still not satisfactory, it will be necessary to return to taping and adjust tape and sweep until the optimum combination is obtained. If it is still not possible to eliminate the lateral, a small amount of grip rolling should be attempted as in the 1/rev vertical procedure, being careful not to adversely affect forward flight. Should the lateral still be present, a small about of tab may be tried. If still not corrected, the hub and blades should be checked for grip spacing and if no problem found, then removed from the helicopter and the alignment checked and the stabilizer bar balanced.

Two per rev (2/rev) vibrations are inherent with two bladed rotor systems and a low level of vibration is always present. A marked increase over the normal 2/rev level can be caused by two basic factors; a loss of designed dampening or absorption capability or an actual increase in the 2/rev vibration level of the rotor itself. The loss of dampening can be caused by such factors as deteriorated transmission mounts or lift link bushing, or an airframe component loosening up and vibrating in sympathy with the inherent 2/rev. An increase in the 2/rev level of the rotor itself can be caused by worn or loose parts in the rotor hub or looseness in the rotating controls. The correction of excessive 2/rev vibrations is primarily dependent upon the mechanic. The pilot generally cannot determine the exact cause and hence cannot prescribe specific corrective procedures. Occasionally tab settings and sweep will affect the overall 2/rev level. If no mechanical cause of excessive 2/rev can be found, an attempt to decrease the level by rotor adjustments may be made. It has been found that both blades may be swept in the same direction in small amounts and sometimes decrease 2/rev.

18-6. Medium frequency.

Medium frequency vibrations at frequencies of 4/rev and 6/rev are another inherent vibration associated with most rotors. An increase in the level of these vibrations is caused by a change in the capability of the fuselage to absorb vibration, or a loose airframe component, such as the skids, vibrating at that frequency. Changes in the fuselage vibration absorption can be caused by such things as fuel level, external stores, structural damage, structural repairs, internal loading, or gross weight. Abnormal vibration levels of this range are nearly always caused by something loose; either a regular part of the helicopter or part of the cargo or external stores. The vibration is felt as a rattling in the fuselage. The most common cause is loose skids caused by worn, loose, or improper skid retaining straps. Loose skids can be discovered by shaking the helicopter with cyclic and feeling if they vibrate or looking out the door at the skids while shaking the helicopter (excessive or severe shaking is undesirable and will make even tight skids vibrate). Many times skids will cause considerable vibration during turns and maneuvers if they are extremely loose. Loose skids are not a serious condition but can cause annoyance to flight crews and passengers. Other sources of medium frequency vibrations are the elevator access doors, cargo hook, electronic gear, safety belt out the door, and engine/transmission cowling. Sometimes air loads will cause the small fire extinguisher doors and the step doors to vibrate. Occasionally, portions of the cabinet roof, side panels, or doors, will "oil" can rapidly in flight, giving the same sensation as a medium frequency vibration.

18-7. High frequency.

High frequency vibrations can be caused by anything in the helicopter that rotates or vibrates at a speed equal to or greater than that of the tail rotor. This includes many unusual situations such as hydraulic line buzzing, or starter relay buzzing, to the most common and obvious causes; loose elevator linkage at swashplate horn, loose elevator, or tail rotor balance and track. Pilot experience can help greatly in troubleshooting the cause of a high frequency vibration, as a pilot who has experienced a vibration can often recognize the cause the next time the same vibration is felt. Generally, determining the cause of a high frequency should begin with investigating tail rotor track (ground track using a rubber tipped stick with grease, lipstick, or some marking substance on the tip to mark the blades and determine if one is out of track). Should the rotor be properly in track, balance should be checked by removing the tail rotor and hub assembly and checking on a balance stand. Should tail rotor balance check out also, an inspection of the complete driveshaft should be made. Physical damage like loss of balance tabs would be evident. Observing the shaft with cover removed while rotor is turning, may show up a bent shaft, faulty bearing, or some other obvious malfunction. Attempting to locate the source of the vibration by feeling the fuselage in various places while ground running can sometimes be successful in localizing the cause and at least eliminating some possible causes. It should be recognized that vibrations which are specifically being watched for, always appear more severe than when no particular attention is being directed to them. Many points on the airframe, such as the engine mounts, have a surprisingly high level of high frequency vibration and it is easy to decide that the level is higher than normal when actually it is not. A comparison between the feel of a helicopter without excessive vibration and the helicopter with the vibration is helpful in precluding erroneous conclusions.

18-8. TAIL ROTOR.

Vibrations from the tail rotor can occur at the 1, 2, and 4/rev levels. In general, only the 1/rev vibration can be corrected or reduced by tracking and balancing the tail rotor.

18-9. OTHER VIBRATIONS.

A high frequency vibration and pulsation noise in cabin can be caused by the engine-to-transmission driveshaft. This vibration can be eliminated by proper balancing of the engine-to-transmission driveshaft (paragraph 18-38).

18-10. TROUBLESHOOTING.

Refer to Chapter 62 for potential troubles, with the probable causes indicated and corrective action recommended which may occur in the main rotor assembly.

ROTOR TRACKING AND BALANCING.

18-11. MAIN ROTOR TRACKING.

1. Coat tracking tips of each blade with grease pencil, using a different color on each tip.

2. Take a low-speed blade track (90% rpm) by following the steps in the tracking chart (figure 18-1).

3. Correct a low speed out-of-track condition by rolling down high blade as follows:

a. Loosen jamnuts on pitch change link of the high blade.

b. Turn pitch link barrel one flat at a time to lengthen pitch link.

NOTE

One flat rotation of barrel will result in approximately 3/8 inch (9.525 mm) in blade track for all rpm.

c. Tighten jamnuts and lockwire barrel to nuts.

d. Recheck track with flag. Continue adjustments and checks until blades are in track.

4. Take a high-speed track (100% rpm).

5. If blades are out of track at high speed, make no adjustments but record which blade is low (paragraph 18-12).

18-12. MAIN ROTOR BLADE VIBRATION CHECK AND ADJUSTMENT.

Refer to BHT- ALL- SPM for specification and source.

MATERIALS REQUIRED

Refer to BHT- ALL- SPM for specification and source.

NUMBER	NOMENCLATURE
C-405	Lockwire

SPECIAL TOOLS REQUIRED

NUMBER	NOMENCLATURE
T101597	Bender
T101598	Gage

NOTE

When troubleshooting for 1/rev vibrations, ensure helicopter does not have a lateral 1/rev vibration before troubleshooting for a vertical 1/rev vibration.

1. Fly helicopter through full airspeed range and check for lateral vibration (lateral vibrations are usually more pronounced in hover). Verify adjustments have not changed autorotation rpm.

2. If lateral vibration is felt, follow procedures charted in figure 18-2 (refer to paragraph 18-13 for main rotor blade sweeping procedure).

NOTE

When lateral vibrations have been corrected by taping blades with 2.0 inches masking tape on blade tips, tape is then removed and required weight added to blade bolt.

3. Remove tape from blade, counting number of wraps.

4. Remove cap from retaining bolt of taped blade.

5. Add weight (lead wool or shot) in blade bolt to compensate for weight of tape removed from blade tip, calculated as follows:

NOTE

One full wrap of masking tape on blade tip equals approximately 3 ounces (0.227 kg) weight in blade bolt.

6. Install cap and secure with lockwire (C-405).

7. Test fly helicopter. If no vibrations are felt, no further adjustment will be required.

8. If vertical vibrations are felt, designate high blade A and low blade B. Install a tab bender (T101597) and gauge (T101598) on blade and begin making blade adjustments according to Figure 18-3. Use blade designations A and B to keep a running account of adjustments. See Figure 18-4 for tool application.

CAUTION

TABS MAY BE BENT TO MAXIMUM ANGLE OF 8° UP OR DOWN. MAXIMUM TAB ANGLE DIFFERENCE BETWEEN BLADES IS 16°.

9. Test fly helicopter after each adjustment. Continue adjustments until vibration is worked out. Keep accurate record of all adjustments.

NOTE

When bending tabs, experiment to see which tab has best effect with least amount of bending. For example 2° down tab on one blade might, in some instances, have same effect as 6° up tab on opposite blade.

18-13. BLADE SWEEPING

1. Loosen jam nuts on drag brace enough to turn barrel one flat AFT as shown by direction of arrows.

2. After adjustment, tighten jam nuts. Record adjustment.

3. Make additional adjustments, as required, but do not exceed two full turns of barrel.

NOTE

If maximum adjustments fail to correct vibrations, rotor shall be removed from helicopter, placed on stand, and aligned using a scope.

4. Torque jam nuts 275 to 325 foot-pounds (373 to 441 Nm).

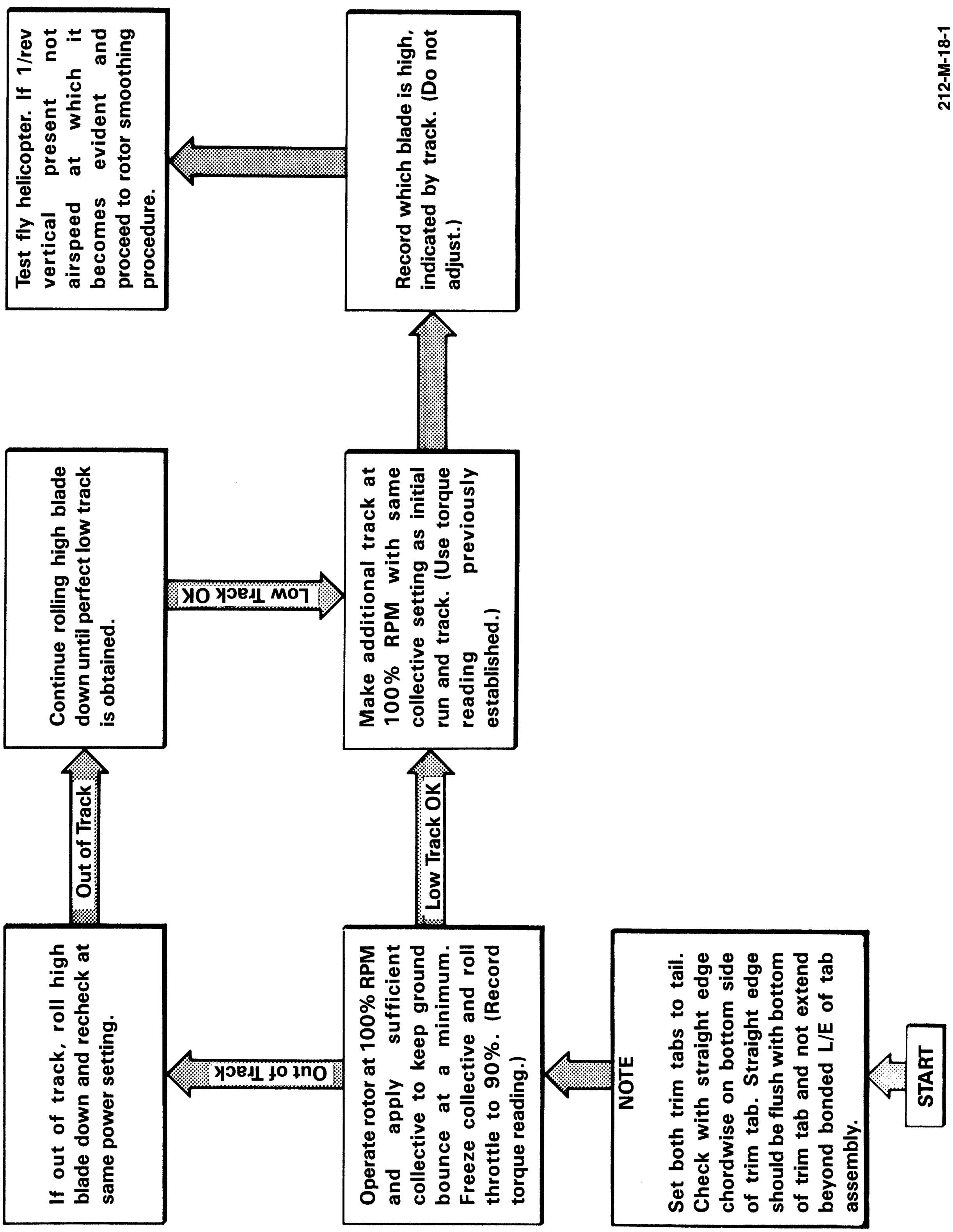


Figure 18-1. Main rotor tracking

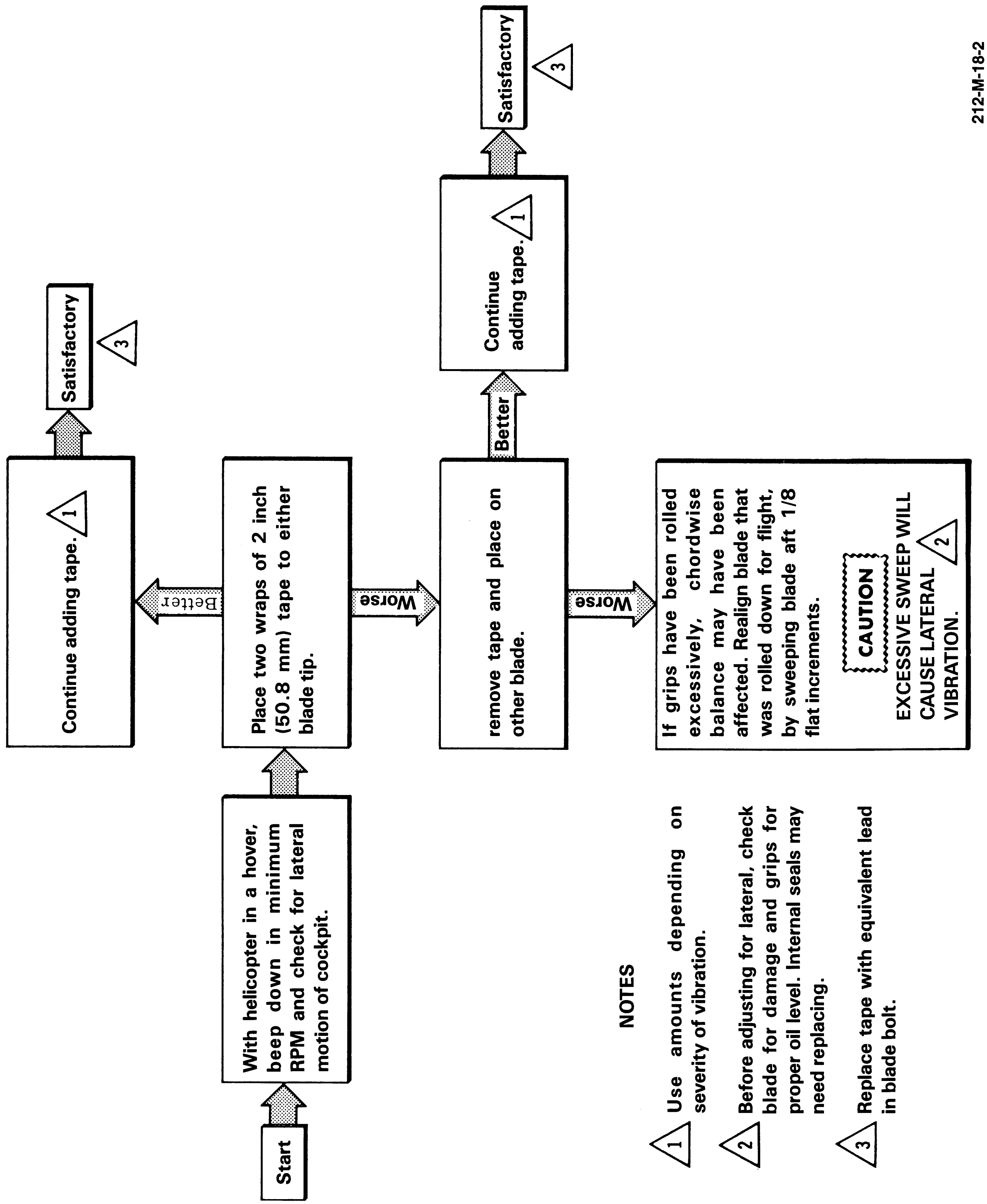
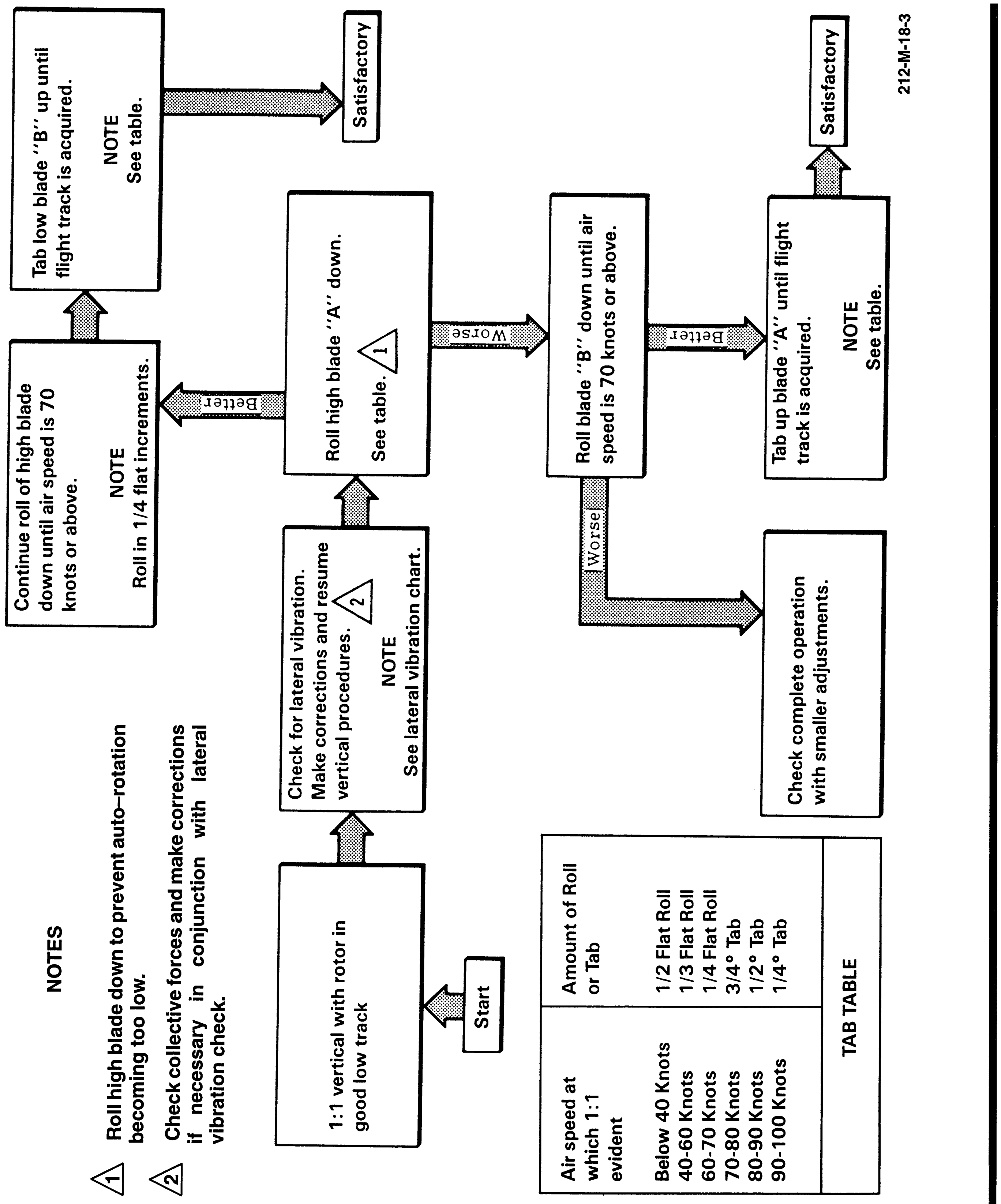


Figure 18-2. Lateral vibration troubleshooting



TAB TABLE

Air speed at which 1:1 evident	Amount of Roll or Tab
Below 40 Knots	1/2 Flat Roll
40-60 Knots	1/3 Flat Roll
60-70 Knots	1/4 Flat Roll
70-80 Knots	3/4° Tab
80-90 Knots	1/2° Tab
90-100 Knots	1/4° Tab

Figure 18-3. Rotor smoothing

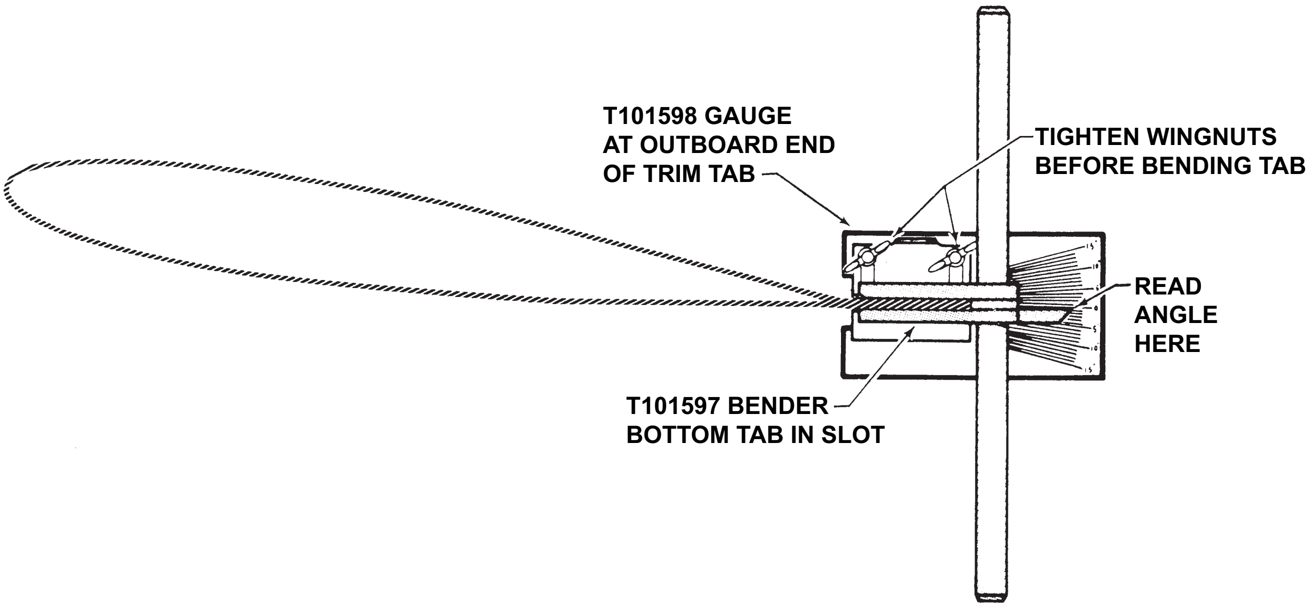


Figure 18-4. Trim Tab Bender and Gauge

18-14. Main Rotor Autorotation RPM — Adjustment

Autorotation RPM should be adjusted with consideration given to seasonal OAT and altitudes in the operating environment. Low gross weight, low temperature/low density altitude result in lower autorotation RPM when compared to high gross weight, high temperature/high density altitude.

This procedure uses a seasonally adjusted density altitude ($H_D$min), as a baseline to optimize autorotation RPM throughout the gross weight range. It is recommended that a check/adjustment of autorotation RPM be carried out, at a minimum, when seasonal changes result in a change in average minimum OAT or when the helicopter geographical location changes. An autorotation RPM adjustment log (Table 18-1) is provided to assist in completing the procedure.

Density altitude is the result of pressure altitude corrected for temperature. To define $H_D$min, the following two factors must be considered:

- Determine the lowest pressure altitude ($H_P$min) over which operations are likely to be carried out. The lowest geographic altitude may be used for the purpose of these calculations.
- Determine the seasonal average minimum temperature (OATmin) in the operating region. (Use average temperature anticipated until next autorotation check/adjustment is anticipated.)

Initiate calculations to determine the correct main rotor autorotation RPM as follows:

NOTE

Record information in the Autorotation RPM Adjustment Log (Table 18-1).

1. Using $H_P$min and OATmin, calculate $H_D$min using the density altitude conversion chart (Figure 18-4A). The value ($H_D$min) is the minimum density altitude over which operations are likely to be carried out.

The following provides two examples of determining $H_D$min.

Table 18-1. Autorotation RPM — Adjustment Log

	AUTOROTATION RPM ADJUSTMENT LOG **Date:** ____________________ **Helicopter S/N:** _______________________ **Total Flight Time:** ___________________
1.	Determine $H_D$min (minimum density altitude): $H_P$min (use lowest operational geographic altitude) ____________ OATmin (use average seasonal minimum temperature) ____________ $H_D$min (calculate from Figure 18-4A) ____________
2.	Conduct autorotation RPM check (collective full down, both throttles at idle, stabilize at 70 KTS): $H_P$check (set 29.92 (1013 mb) on altimeter) ____________ OATcheck ____________ Main Rotor RPM ____________ Fuel Quantity ____________
3.	Calculate $H_D$check: Apply $H_P$check __________ and OATcheck ___________ against Figure 18-4A to obtain $H_D$check ____________
4.	Calculate delta density altitude (ΔH_D): $H_D$check __________ – $H_D$min ___________ = ΔH_D ____________
5.	Compute Delta Gross Weight: Test Gross Weight (at time of RPM check) ____________ GWmin (Empty weight plus pilot) ____________ Delta Gross Weight ____________
6.	Apply ΔH_D and helicopter test gross weight to Autorotational Adjustment RPM Chart (Figure 18-4B): ΔH_D ____________ Delta Gross Weight ____________ Target Main Rotor RPM ____________
7.	Adjust main rotor RPM if not within ±2% of target. Refer to paragraph 18-14A.
8.	Final adjusted main rotor autorotational RPM _______________

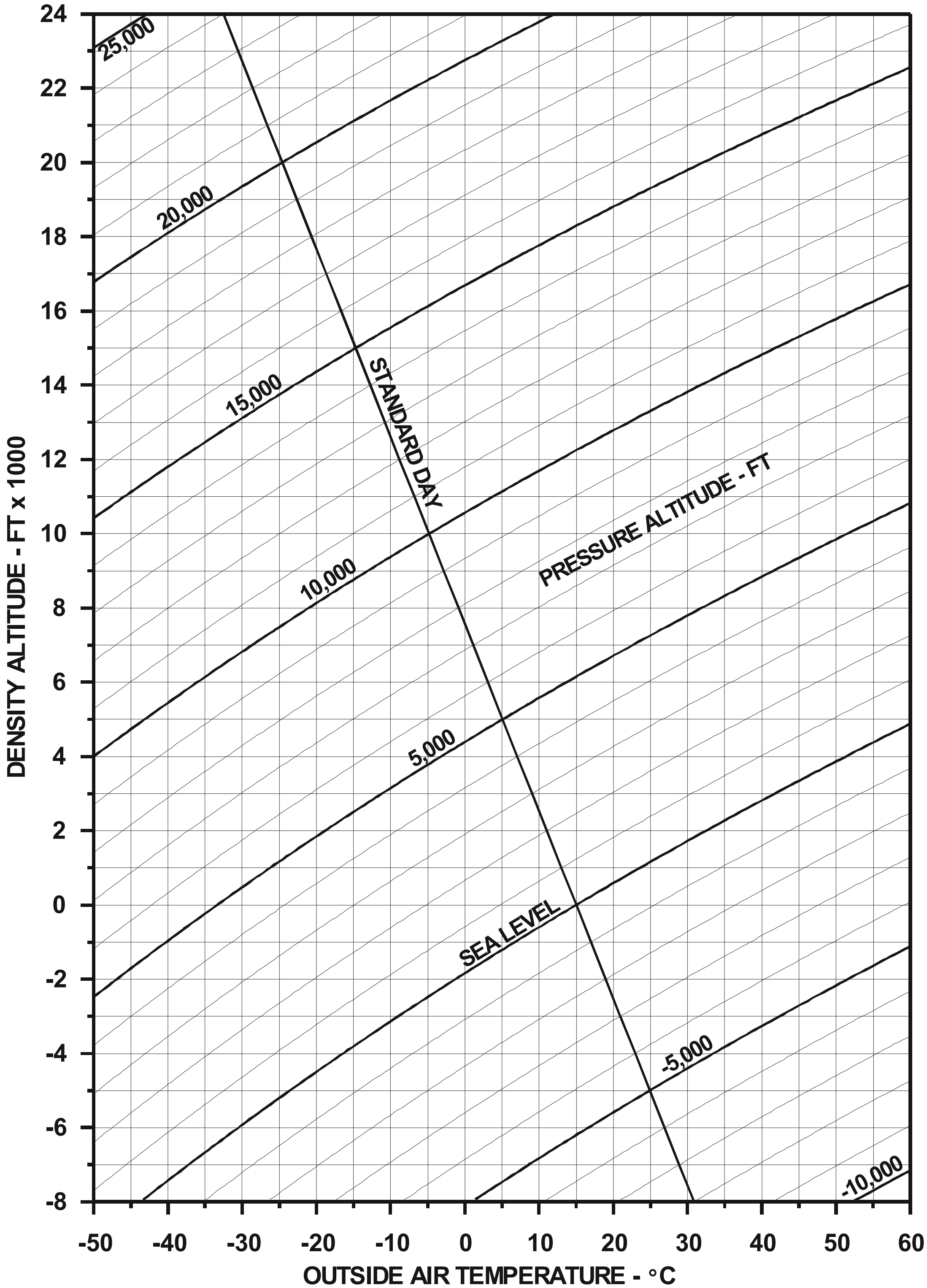


Figure 18-4A. Density Altitude ($H_D$min) Chart

NOTE

Refer to Figure 18-4C, Sheet 1 of 2 for the first example.

- The helicopter is based at 2000 feet (609.6 m) and the minimum average seasonal temperature (OATmin) is 62.6°F (17°C). The helicopter is normally operated at or above these conditions, so $H_D$min will be the resultant density altitude at 2000 feet (609.6 m) ($H_P$min) and 62.6°F (17°C) (OATmin), or 2700 feet (822.9 m) ($H_D$min). This becomes the baseline for the autorotation adjustment chart.

NOTE

Refer to Figure 18-4C, Sheet 2 of 2 for the second example.

- The helicopter is based at an airport at 700 feet (213.4 m) ASL, but is frequently operated offshore (sea level). The average seasonal minimum temperature is 17.5°F (-8°C). Therefore, the seasonal minimum density altitude over which operations are likely to be carried out is sea level ($H_P$min) at 17.5°F (-8°C) (OATmin), or -2900 feet (-883.9 m) ($H_D$min).

CAUTION

A QUALIFIED PERSON MUST BE AT THE HELICOPTER CONTROLS DURING THE FOLLOWING PROCEDURE.

2. Start and operate helicopter (BHT-212-FM-1 or BHT-212-FM-2, Section 2).

CAUTION

BE PREPARED TO APPLY THROTTLE IF N_R DROPS BELOW 91%. BE PREPARED TO APPLY COLLECTIVE TO PREVENT N_R OVERSPEED ABOVE 104.5%.

3. Fly the helicopter and establish the existing autorotation RPM (N_R) by initiating an autorotative descent (collective full down, both throttles at IDLE position) at 70 KIAS. Once stabilized, record pressure altitude ($H_P$check), outside air temperature (OATcheck), main rotor RPM, and fuel quantity on the autorotation RPM Adjustment Log (Table 18-1).

4. Using $H_P$check and OATcheck, establish the density altitude ($H_D$check) at which the autorotative RPM check was conducted from the density altitude chart (Figure 18-4A).

5. Compute the delta density altitude (ΔH_D) between $H_D$min and $H_D$check. This is done by subtracting $H_D$min from $H_D$check:

$$H_D\text{check} - H_D\text{min} = \Delta H_D$$

NOTE

Subtracting a minus (negative) value from another value results in the two values being added.

For example:

$$+2000 - (-1000) = +3000$$

6. Determine the test gross weight of the helicopter using the recorded fuel quantity and loading configuration at the time of the RPM check. Compute the Delta Gross Weight using Test Gross Weight and GWmin as follows:

NOTE

GWmin corresponds to the helicopter's empty weight plus the weight of one pilot.

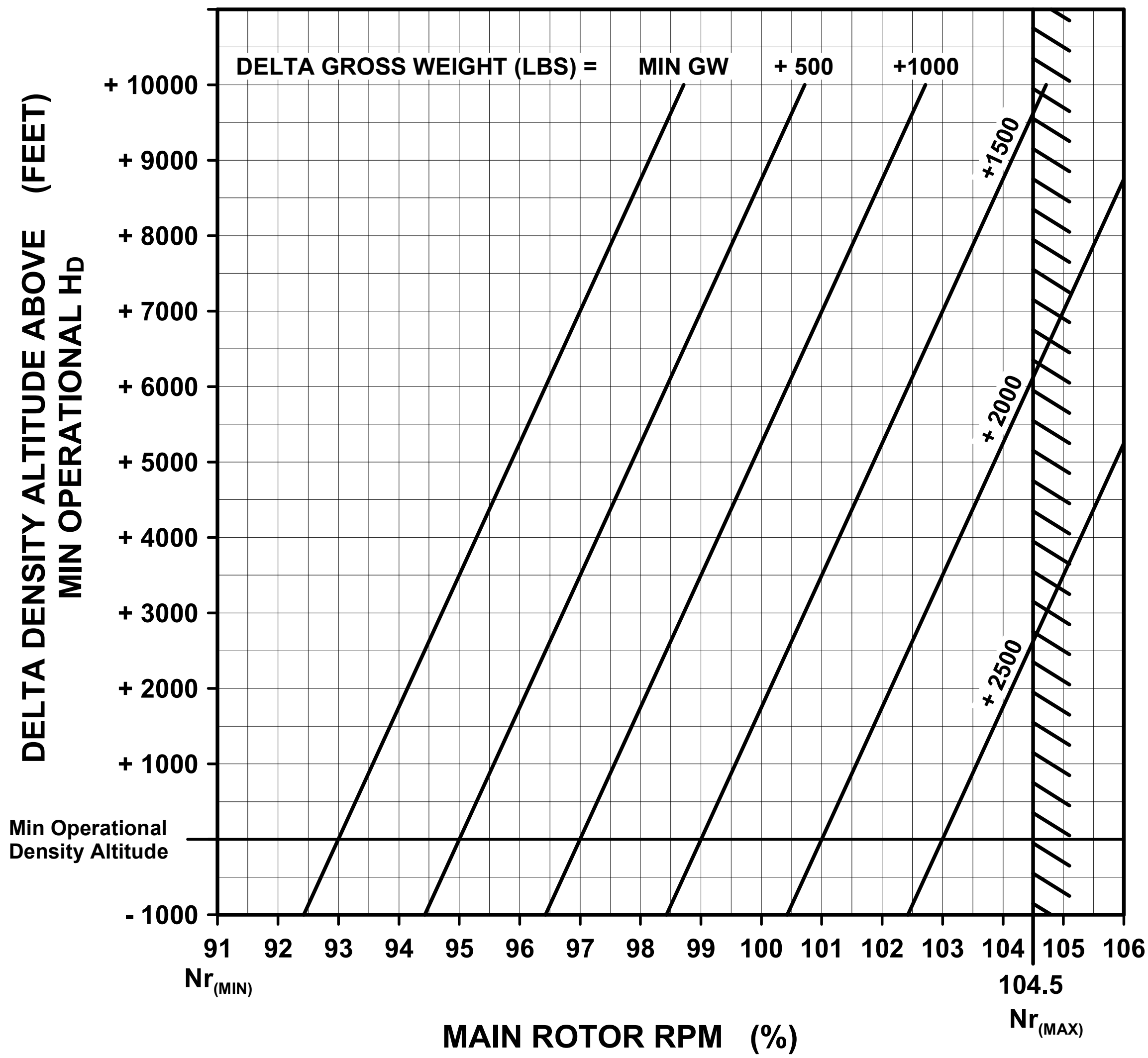
Test GW - GWmin = Delta GW

7. Using the autorotation RPM adjustment chart (Figure 18-4B), plot the ΔH_D value computed in step 5. Move over to the appropriate Delta gross weight line and down to the target main rotor RPM (N_R).

NOTE

If the chart target N_R value is above 104.5%, adjust gross weight or modify check altitude as necessary to achieve a target N_R value within chart limits.

212 AUTOROTATION Nr



NOTES:
1. "Min Operational Density Altitude" refers to the absolute minimum density altitude at which operations are to be carried out.
2. MIN GW is aircraft empty weight plus weight of one pilot (no fuel).

Figure 18-4B. Autorotation RPM Adjustment Chart

Determining $H_D$min:

$H_P$min =	2000 feet
OATmin =	17°C
$H_D$min =	**2700 feet** (Calculated from Density Altitude chart, Figure 18-4A)

Auto N_R check:

$H_P$check =	3000 feet
OATcheck =	24°C
$H_D$check =	4700 feet (Calculated from Density Altitude chart, Figure 18-4A)
ΔH_D = ($H_D$check - $H_D$min) =	4700 - 2700 **= 2000 feet ΔH_D**
Test Gross weight =	7224 pounds
GW min =	6724 pounds
Delta Gross Weight =	**+500 pounds**

Target N_R = **96.2%**

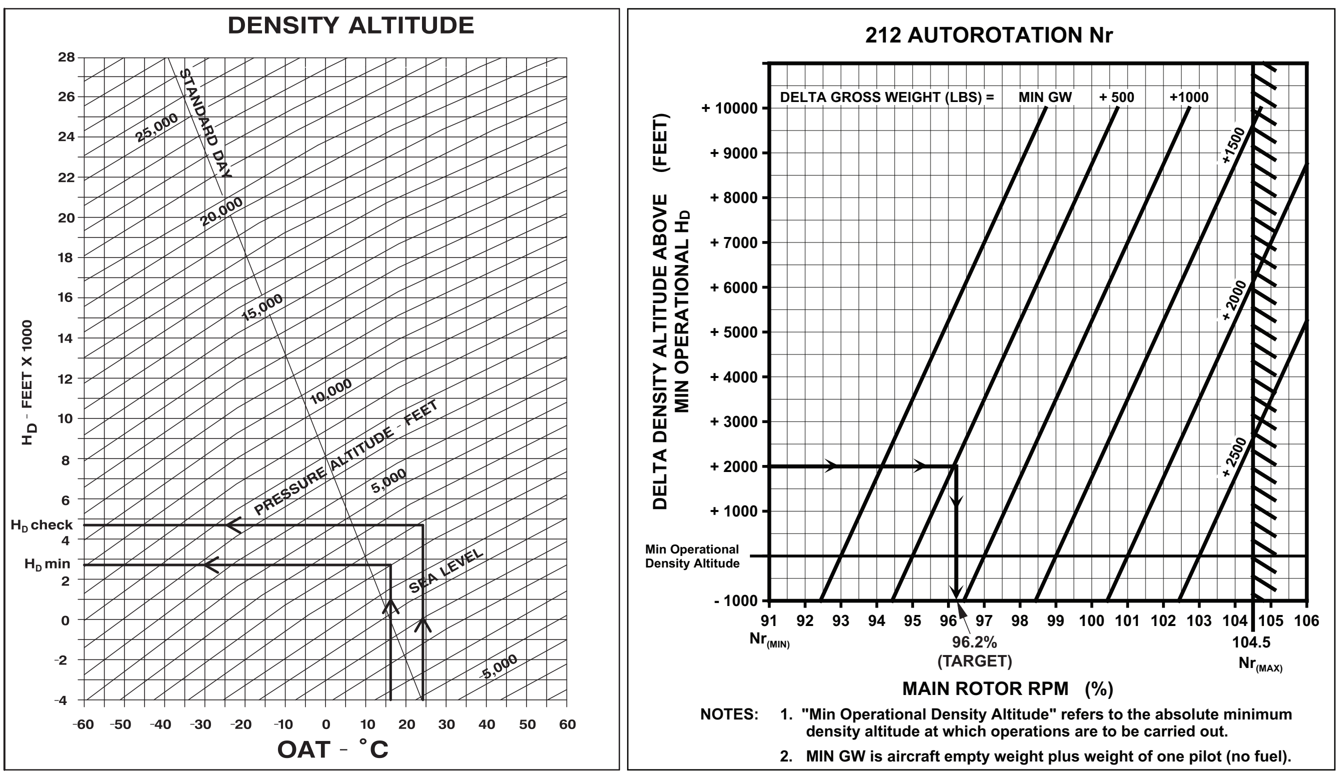


Figure 18-4C. Autorotation RPM Adjustment — Example (Sheet 1 of 2)

Determining $H_D$min:

$H_P$min =	Sea level
OATmin =	-8°C
$H_D$min =	**-2900 feet** (Calculated from Density Altitude chart, Figure 18-4A)

Auto N_R check:

$H_P$check =	2000 feet
OATcheck =	0°C
$H_D$check =	650 feet (Calculated from Density Altitude chart, Figure 18-4A)
ΔH_D = ($H_D$check - **H_D**min) =	650 minus -2900 **= 3550 feet ΔH_D**
Test Gross weight =	7724 pounds
GW min =	6724 pounds
Delta Gross Weight =	**+1000 pounds**
Target N_R =	**99%**

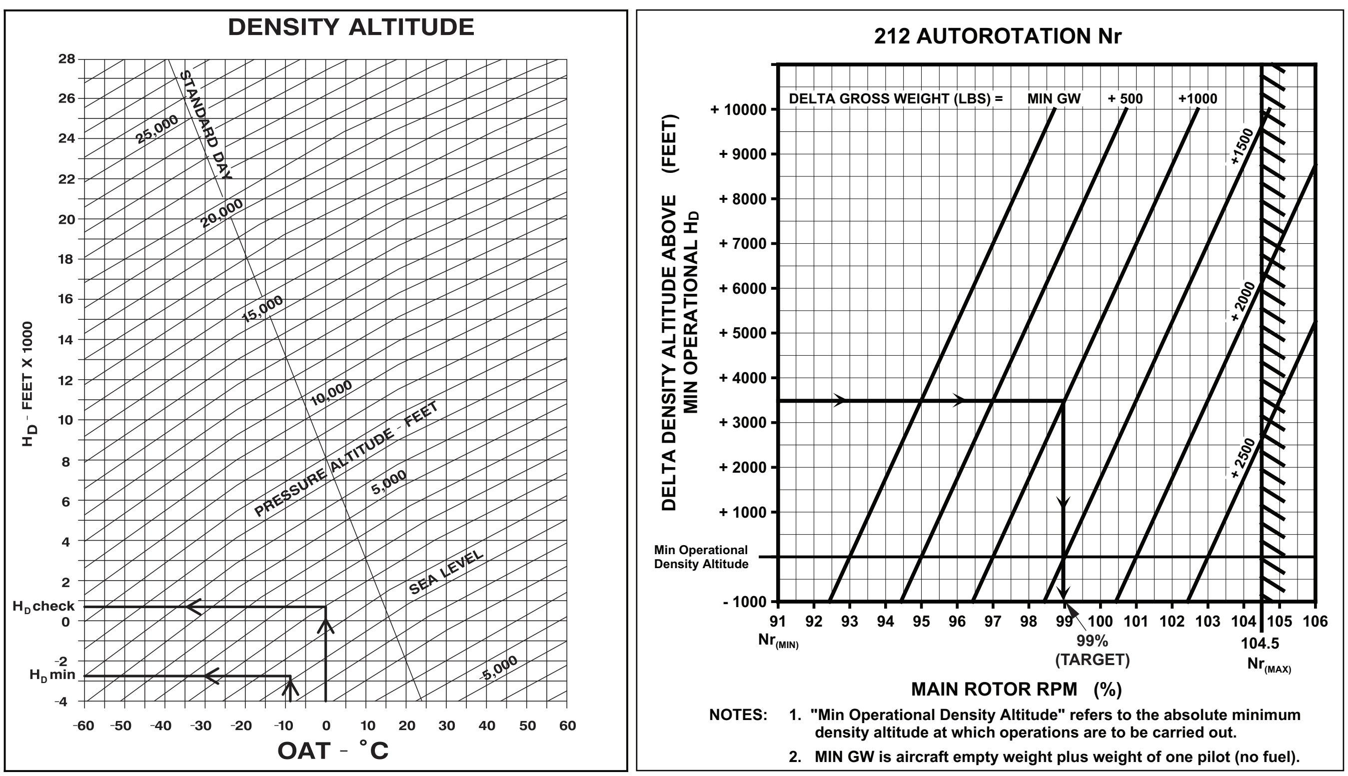


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Figure 18-4C. Autorotation RPM Adjustment — Example (Sheet 2 of 2)

8. Adjust the main rotor pitch links (paragraph 18-14A) if the autorotation RPM is not within ±2% of the required RPM.

9. If necessary, repeat step 1 through step 8 and adjust the main rotor pitch links until the correct autorotation RPM has been established.

10. Some examples of autorotation RPM calculations are provided in Figure 18-4C.

18-14A. Main Rotor Autorotation RPM — Pitch Link Adjustment

1. If rotor RPM is high, shorten both pitch change links equally. One turn of pitch link barrel changes rotor RPM approximately 2.5%.

2. If rotor RPM is low, lengthen both pitch change links equally.

3. Tighten locknuts. Secure bottom locknut to barrel and top locknut to barrel and clevis with lockwire (C-405).

NOTE

After final pitch link adjustment, exposed thread length of upper and lower fittings shall be equal within 2 1/2 threads for pitch links without thread engagement inspection holes. For pitch links with thread engagement inspection holes, exposed thread lengths shall be equal within 5 threads, provided adequate thread engagement is indicated at inspection hole.

4. Recheck RPM in flight and repeat adjustment as necessary.

ROTOR TRACKING AND BALANCING
SCIENTIFIC ATLANTA ROTOR ANALYSIS AND DIAGNOSTIC SYSTEM, MODEL AT (RADS AT).

18-15. MAIN ROTOR TRACKING AND BALANCING.

The following paragraphs provides the necessary information to track and balance the main rotor. The primary instrumentation for measuring rotor vibration is the Scientific Atlanta Rotor Analysis and Diagnostic System, Model AT (RADS AT). The RADS AT automates the acquisitions of blade track and vibration data as well as corrective actions required to accomplish tracking and balancing. Also, the RADS AT automatically obtains blade sweep (lead-lag) information which helps to locate problem components in the hub and rotating control system.

18-16. ROTOR VIBRATION MEASUREMENT INSTRUMENTATION.

SPECIAL TOOLS REQUIRED

NUMBER	NOMENCLATURE
P/N29333300 or 29313100 Scientific Atlanta San Diego, CA 92123	Basic RADS AT kit with basic software 212 Version 4.20.
P/N 29203300D Scientific Atlanta	212/412 Optical tracker bracket
P/N 29338500A Scientific Atlanta	212/412 Optical tail rotor adapter
P/N 29105600 or 29105605 Scientific Atlanta	Accelerometer cable (additional)
P/N 991D Wilcox	Accelerometer (2 total)
P/N 29329700 Scientific Atlanta	Accelerometer brackets

Refer to BHT-ALL-SPM for specification and source.

MATERIALS REQUIRED

Refer to BHT-ALL-SPM for specification and source.

NUMBER	NOMENCLATURE
C-405	Lockwire
C-482	Duct tape
C-483	Reflective tape

18-17. Installation - RADS AT

1. Position and install 29328200 DAU in cabin aft of crew seats with connectors up.

2. Using a 29329700 accelerometer bracket install one 991D accelerometer on front face of transmission island near the top with cable connector to left (view A, figure 18-5). Connect end of 29105600 or 29105605 accelerometer cable to accelerometer. Route cable to DAU so it does not foul controls. Connect to ACC CH1 port (figure 18-6).

3. Using a 29329700 accelerometer bracket, install one 991D accelerometer on the copilot side of the instrument panel face adjacent to the pedestal with the cable connector down (View B, figure 18-5). Connect end of 29105600 or 29105605 accelerometer cable to vertical accelerometer. Route cable to DAU so it does not foul controls. Connect to ACC CH2 port (figure 18-6).

4. Remove nuts and washers from top two bolts on left swashplate horn/boost cylinder attachment (figure 18-7). Install 29312600 magnetic sensor bracket to this location with the hole for the sensor toward the mast. Install new AN960JD416L washer and MS21042L4 nut on top two bolts and torque to 75 to 95 inch- lbs. (8.475 to 10.735 Nm).

5. Remove top jamnut from magnetic rpm sensor (27288400) and insert into magnetic sensor support bracket. Reinstall outer jam nut and loosely tighten so only one thread is showing beyond jam nut. Rotate rotor so magnetic interrupter is next to sensor. Adjust both jam nuts until gap between sensor and interrupter is 0.060 inch ±0.010 (1.524 ±0.254 mm). Tighten jam nuts while maintaining this spacing and secure with lockwire (C-405). Connect helicopter magnetic sensor cable to sensor and tighten to secure.

6. Move cyclic stick to the right rear position to fully extend left front control rod. Tie-wrap magnetic RPM sensor cable to left control rod just below the rivets in the swaged end of tube with one inch of slack. Secure cable to airframe leaving a minimum 6 inches (152.4 mm) of slack between airframe and control tube to allow for movement of controls and pylon in flight. Route cable under cowling and into cabin through left cargo door and secure cable. Connect opposite end of cable to port TACHO #1 on DAU.

7. Connect 28 VDC power cable (29104700) to 28 VDC port on copilot side of pedestal. Connect opposite end of cable to 28 VDC connector on the DAU.

8. Install day-night optical tracker (4, Figure 18-8) as follows:

a. Remove screws (1) left side of upper nose panel.

b. Position tracker bracket (8) on left nose panel and secure using bolts (7).

c. Torque bolts (7) 15 to 20 inch-pounds (1.69 to 2.69 Nm).

d. Install the day-night optical tracker (4) on bracket (8) using bolts (9), washers (3), and nut (5). Tighten upper bolt enough to allow tracker to be moved by hand.

NOTE

Use an inclinometer to verify the angle of tracker when first installed on a new mount. Scribe mark angle on mount so subsequent installations will not require an inclinometer for alignment. Set angle of tracker (4) to 45° as shown in Figure 18-9. Tighten bolts to secure tracker in position.

CAUTION

DO NOT BLOCK STATIC PORTS ON SIDE OF NOSE WHEN ROUTING CABLE.

9. Connect tracker cable (6) to tracker (4) and route through lower front edge of copilot door. Secure cable to nose using tape (C-482). Route cable in cabin to avoid flight controls and connect to Tracker #1 on DAU.

10. Connect CADU 29314101 to DAU using communications cable 29325601.

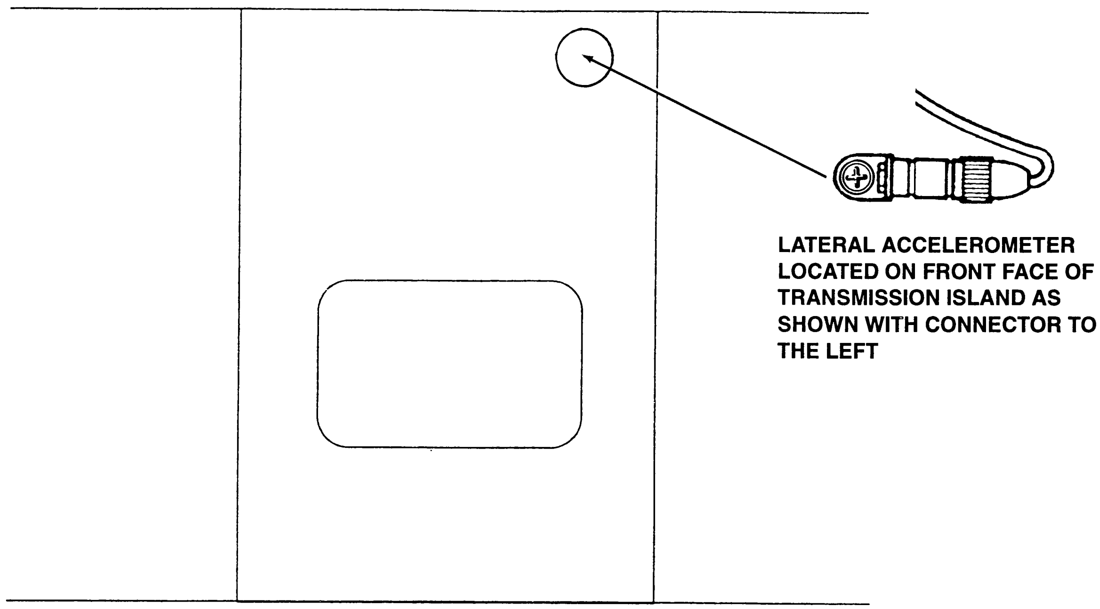
11. Install tape (C-483) on trailing edge of each blade for night tracking (Figure 18-10). Paint leading edge of each blade black for daylight tracking.

12. The RADS is now installed and ready to smooth the rotor system. When correctly installed, RADS should be configured as shown in Figure 18-6.

18-18. Flight Tests to Smooth Rotor

Table 18-1A shows test conditions used by various flight plans to smooth the rotor. It is recommended all flight tests be conducted at a light gross weight as this is the configuration for which RADS diagnostics have been optimized. The recommended configuration is two/three crew and 500 to 1500 pounds of fuel. Two flight plans are used to smooth the rotor system. These are:

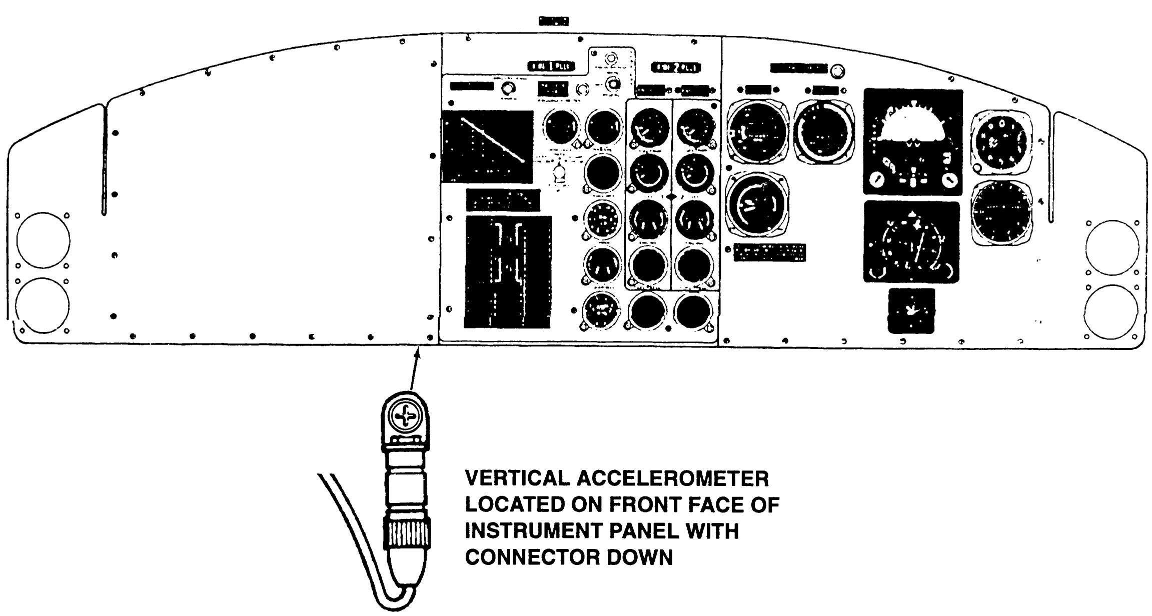
INITIAL: The purpose of this mode is to track rotor on ground and in hover and to balance rotor while on the ground. This mode is used to set up rotors with one or more major component changes prior to flight (i.e. blade, hub, pitch link, etc.). The purpose of this mode is to track rotor at both low (62%) and high (100%) rotor RPM to properly set up the pitch links and trim tabs for flight and to balance rotor in hover (or on the ground at 100% RPM if the hover



FRONT FACE OF TRANSMISSION ISLAND
(LOOKING AFT)

VIEW A.

LOCATION OF LATERAL ACCELEROMETER



VIEW B.

LOCATION OF LATERAL ACCELEROMETER

212-M-18-5

Figure 18-5. Accelerometer locations

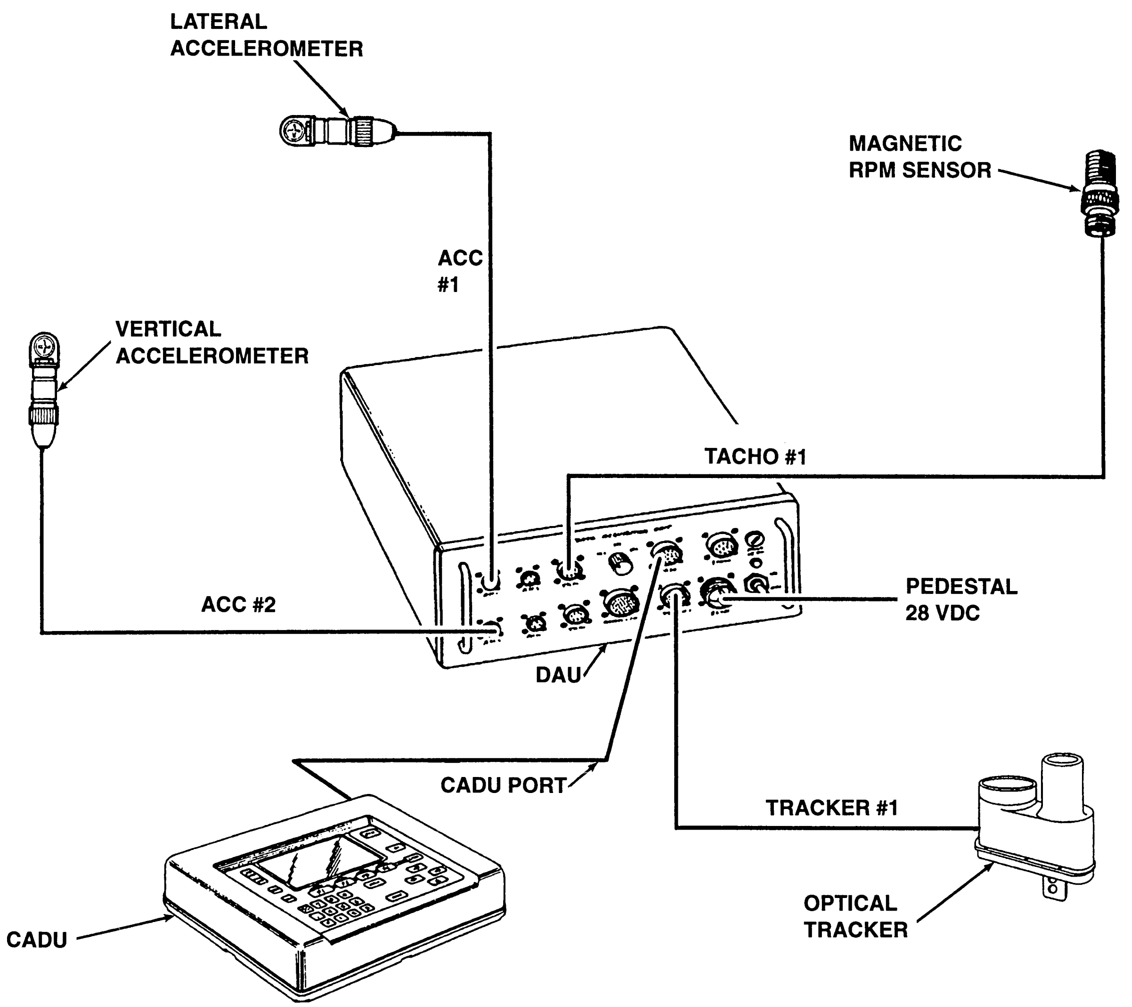


Figure 18-6. Main rotor — proper RADS AT installation

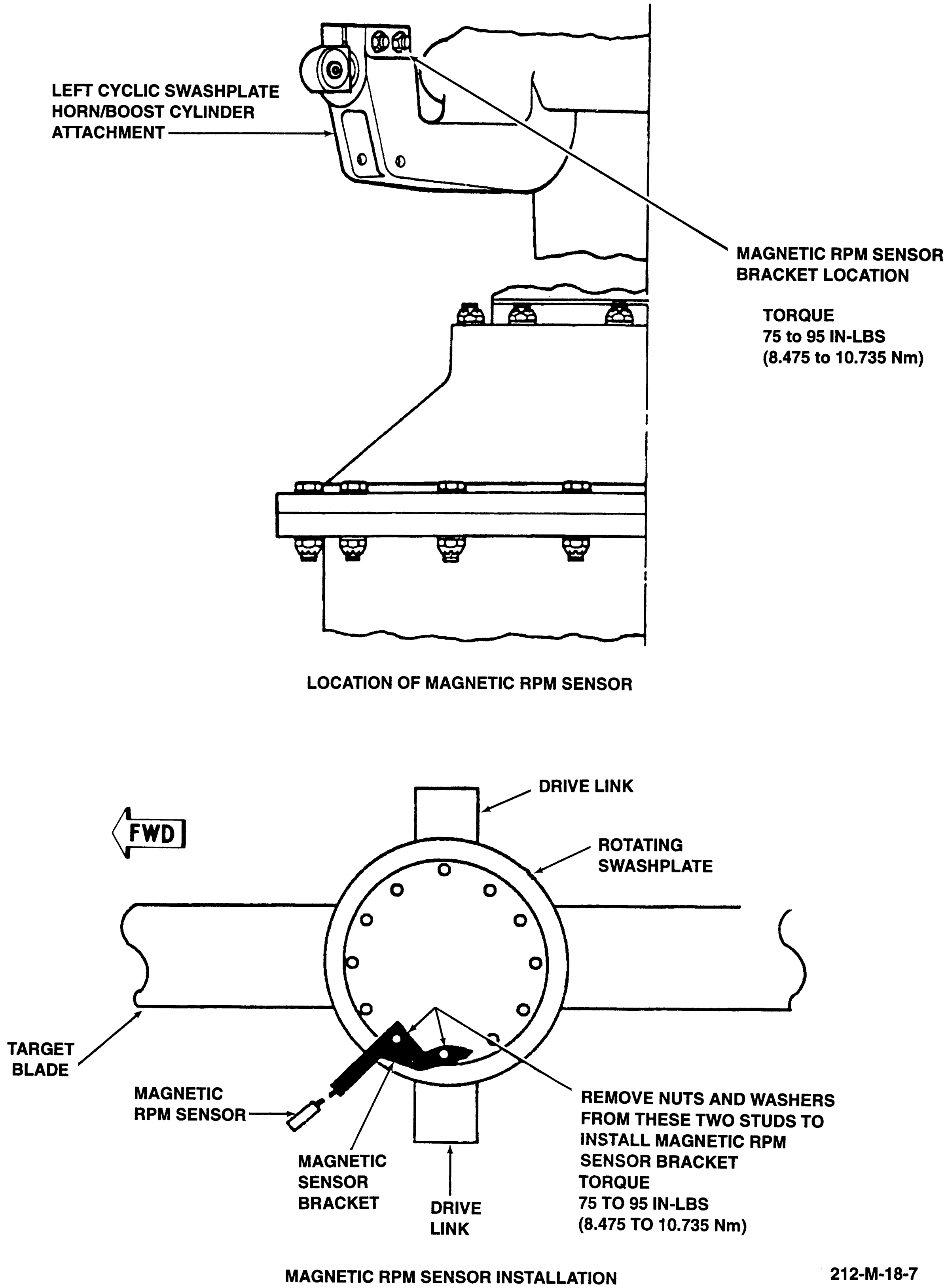


Figure 18-7. Magnetic pickup and interrupter

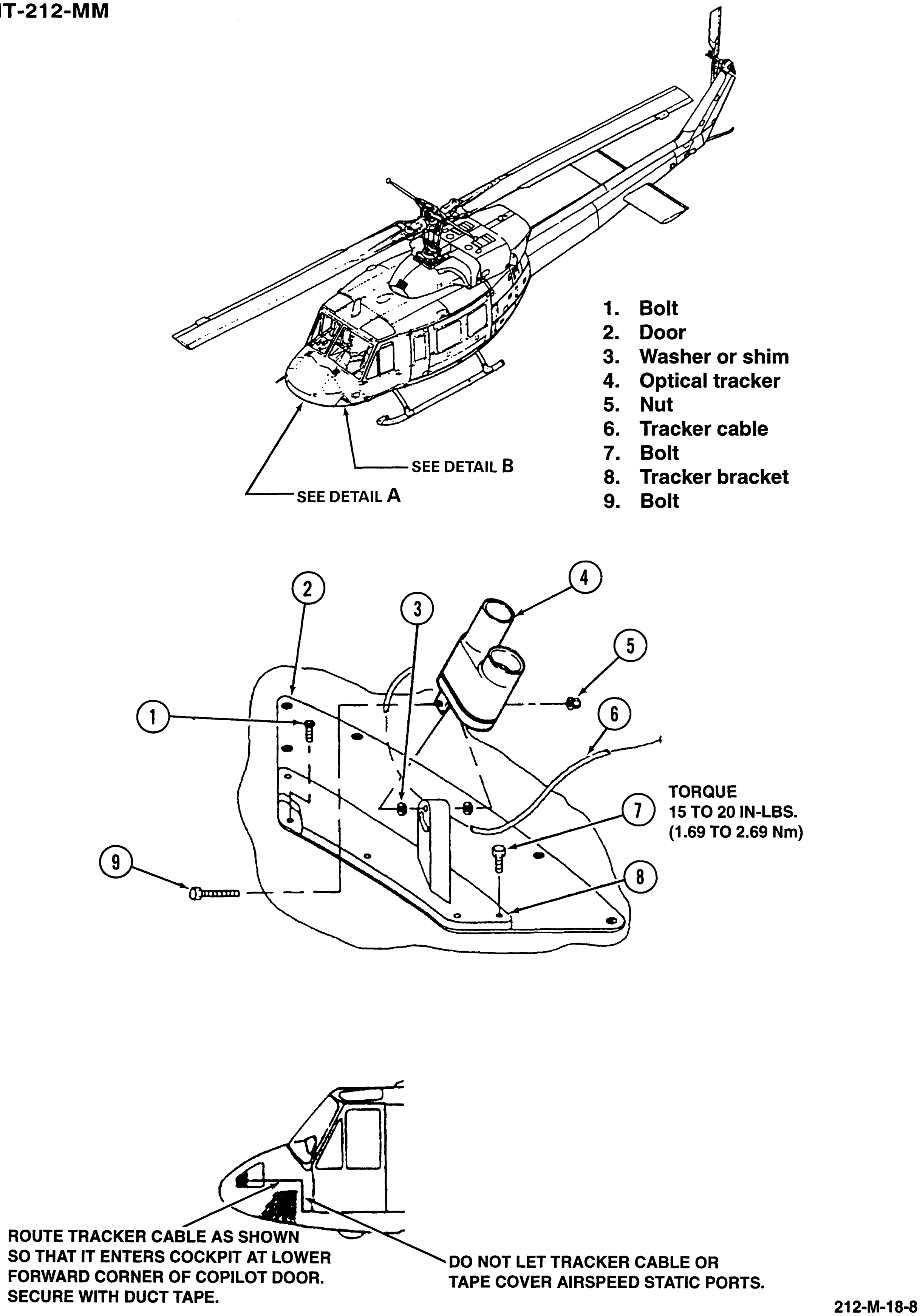


Figure 18-8. Passive optical tracker location and cable routing

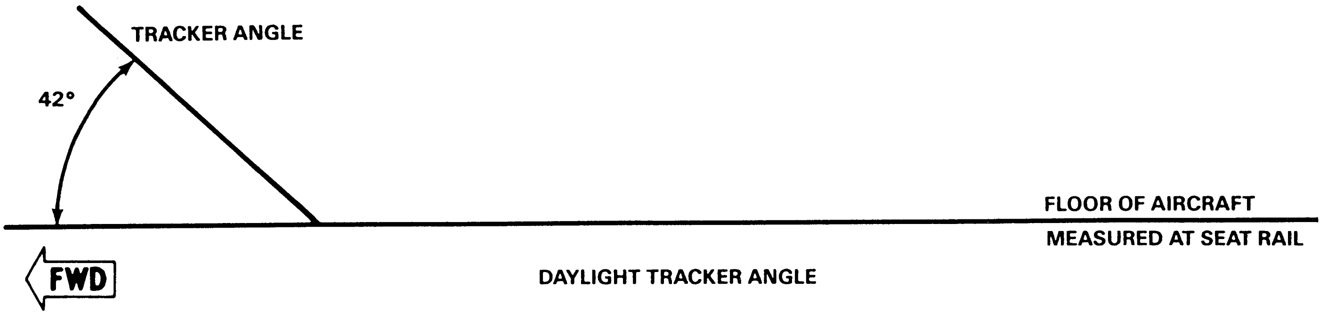


Figure 18-9. Optical tracker angle

information is missing). By using the initial mode, excessive 1/rev vibration in forward flight can be avoided during the first flight after maintenance. Once the helicopter has been flown, the initial test does not need to be conducted again until the next major rotor maintenance. For procedures to perform INITIAL mode test refer to step 1 .

FLIGHT: The purpose of this mode is for periodic/routine smoothing with respect to main rotor 1/rev. It is also used as a follow on to the INITIAL test when that test has been successfully accomplished after replacement of major main rotor components. For procedures to perform FLIGHT mode test refer to step 2 .

1. Smooth rotor with RADS AT (INITIAL mode) as follows:

a. Ensure system is installed properly (paragraph 18-17).

b. Turn on CADU to review main screen. Press QUIT until the main screen has been cleared of previous entries. Use arrow keys to select AIRCRAFT TYPE and press DO. Use arrow keys to highlight 212 and press DO.

c. With helicopter type select, press DO to selected or define TAIL NUMBER of helicopter (BHT prefers operator to use S/N and not registration number). When TAIL NUMBER has been highlighted or defined, press DO to select.

d. With helicopter type and tail number defined, select INITIAL as the FLIGHT PLAN and press DO.

e. Once the CADU is properly configured for the initial mode, the CADU screen should look similar to example in figure 18-11 . With CADU properly configured, press F1 to initiate MEASUREMENT mode of RADS.

f. Operate helicopter with one engine and stabilize main rotor rpm at approximately 62 percent NR. Center cyclic and ensure collective is all the way down.

g. On CADU highlight IDLE and press DO to select. If all internal checks are successful the test condition title will appear at the bottom of screen and the system will be armed to collect data. Press DO again to begin data collection. Once all data has been obtained, The CADU will indicate to proceed to next test condition.

NOTE

Upon completion of obtaining data do not push QUIT until the list of test conditions appears or an error message appears as all data from previous test condition will be erased. If any warnings appear, attempt to retake data at the test condition. If warning repeats, record error code and shut down helicopter. Perform corrective action. Refer to table 18-3 for corrective action.

h. Start second engine once data has been collected at IDLE. On CADU highlight FPG100 and HOVER and press DO to arm. Press DO again to begin data collection when helicopter has been stabilized at desired condition.

i. If helicopter is vibrating excessively on the ground it is acceptable to skip HOVER test condition and:

(1) Press QUIT to exit measurement mode.

(2) Using arrow keys select SAVE and exit and press DO to save all data obtained.

(3) Select DIAGNOSTICS from menu and press DO. If you have returned to main menu press F3 to enter DIAGNOSTICS menu.

(4) Proceed to step k.

j. Upon completion of collecting data at both test conditions land helicopter, but do not shutdown. Select DIAGNOSTICS from menu. If limits are exceeded these will be shown on screen. If no limits are exceeded then helicopter is ready to be smoothed in forward flight. Press QUIT to return to main menu and bypass the recommended rotor adjustments. If any limits are exceeded proceed to next step.

NOTE

If any limits are exceeded, rotor adjustments should be made and initial mode repeated.

k. With limits page displayed press DO to display recommended rotor adjustments.

l. Using arrow keys, scroll through recommended adjustments. Record adjustments on form shown in figure 18-12 .

m. Press DO to review predicted results and DO again to view DIAGNOSTICS menu. If all adjustments have been recorded then select MAIN MENU and press DO to return to main menu.

NOTE

To view predictions on 6.01 systems select VIEW PREDICTIONS from main menu.

When in EDIT ADJUSTABLES, one and only one each span balance and chord balance adjustments must be turned on at all times.

n. Make adjustments in accordance with paragraphs 18-23 through 18-26 .

NOTE

The word limit does not mean an actual limit for track or vibration that cannot be exceeded, but only refers to terminology used in RADS AT to guide tracking and balancing of components.

o. Repeat steps a. through n. until all initial limits have been met. Once all limits have been met, proceed to the FLIGHT test mode (step 2). No further initial runs are required until next major rotor system maintenance.

2. Smooth rotor with RADS AT (FLIGHT mode) as follows:

a. Ensure system is installed (paragraph 18- 17).

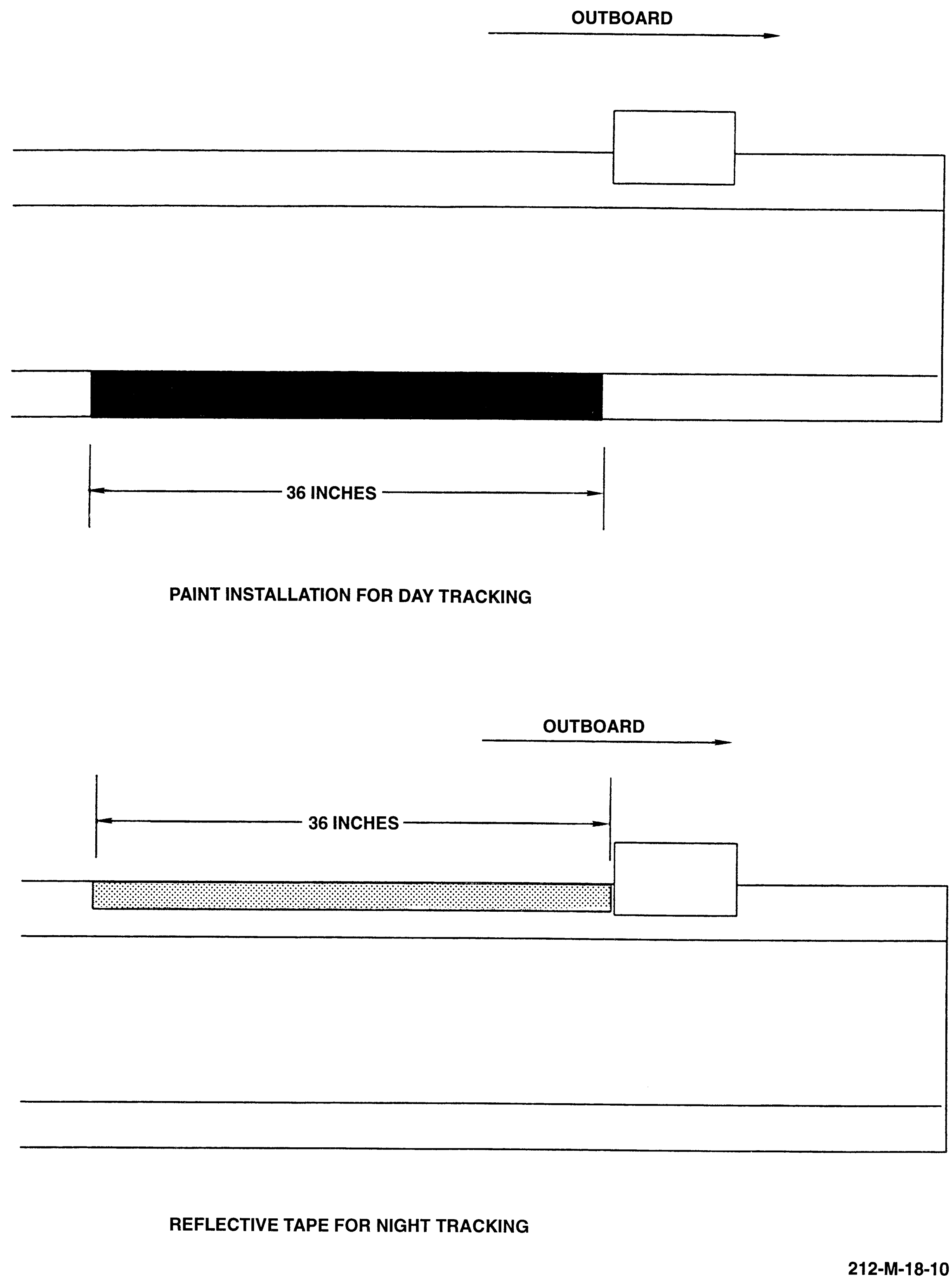


Figure 18-10. Location of paint and tape for tracking

SCIENTIFIC ATLANTA - STEWART HUGHES
RADS AT VERSION 3.10AP35D
18-APR-94 12:29:08

Aircraft Type	**212 4.1**
Tail Number	**35###**
Flight Plan	**INITIAL**
Flight I.D.	

[DO] = Select Highlighted Item
[QUIT] = Clear Highlighted Item

MEASURE DISPLAY DIAGS MANAGER

INITIAL MODE

SCIENTIFIC ATLANTA - STEWART HUGHES
RADS AT VERSION 3.10AP35D
18-APR-94 12:29:08

Aircraft Type	**212 4.1**
Tail Number	**35###**
Flight Plan	**FLIGHT**
Flight I.D.	

[DO] = Select Highlighted Item
[QUIT] = Clear Highlighted Item

MEASURE DISPLAY DIAGS MANAGER

FLIGHT MODE

212-M-18-11

Figure 18-11. Main rotor smoothing CADU screen

SHIP S/N = __________ TARGET = __________ BLANK = __________

RADS AT FLIGHT I.D.	BLADE I.D.	SPAN BALANCE	SWEEP	PITCH LINK	OUTBOARD TAB
DATE = ______	BLANK				
TIME = ______	TARGET				

NOTES ON PREVIOUS FLIGHT:

RADS AT FLIGHT I.D.	BLADE I.D.	SPAN BALANCE	SWEEP	PITCH LINK	OUTBOARD TAB
DATE = ______	BLANK				
TIME = ______	TARGET				

NOTES ON PREVIOUS FLIGHT:

RADS AT FLIGHT I.D.	BLADE I.D.	SPAN BALANCE	SWEEP	PITCH LINK	OUTBOARD TAB
DATE = ______	BLANK				
TIME = ______	TARGET				

NOTES ON PREVIOUS FLIGHT:

RADS AT FLIGHT I.D.	BLADE I.D.	SPAN BALANCE	SWEEP	PITCH LINK	OUTBOARD TAB
DATE = ______	BLANK				
TIME = ______	TARGET				

NOTES ON PREVIOUS FLIGHT:

FINAL SETTINGS

RADS AT FLIGHT I.D.	BLADE I.D.	SPAN BALANCE	SWEEP	PITCH LINK	OUTBOARD TAB
DATE = ______	BLANK				
TIME = ______	TARGET				

212-M-18-12

Figure 18-12. Model 212 main rotor adjustment log

b. Turn on CADU to view main screen. Press QUIT until the main screen has been cleared of previous entries. Use arrow keys to select AIRCRAFT TYPE and press DO. Use arrows to highlight 212 and press DO.

c. With helicopter type selected, press DO to select or define TAIL NUMBER of helicopter (BHT prefers operator to use S/N and not registration number). When TAIL NUMBER has been highlighted or defined, press DO to select.

d. With helicopter type and tail number defined, select INITIAL as the FLIGHT PLAN and press DO.

e. Once the CADU is properly configured for the initial mode, the CADU screen should look similar to example in Figure 18-11. With CADU properly configured, press F1 to initiate MEASUREMENT mode of RADS.

NOTE

When continuing from an INITIAL test you must repeat the IDLE, FPG100, and HOVER test.

Table 18-1A. Test Conditions — Main Rotor

INITIAL	FLIGHT/ 2/R-CHK	TEST DESCRIPTION	LATERAL LIMIT	VERTICAL LIMIT
IDLE	IDLE	Flat pitch at 62% Rotor RPM		
FPG100	FPG100	Flat pitch at 100% Rotor RPM	0.5 IPS	
HOVER	HOVER	Hover into Wind	0.1 IPS	
	60K	Level Flight at 60 Knots		0.20 IPS
	110K	Level Flight at 110 Knots		0.20 IPS
	L/DOWN	70 Knot Letdown at 1000 ft/min		0.20 IPS

NOTE:

The limits in the above table are not actual airframe or ride quantity limits, but are used to guide the RADS diagnostics program. Actual recommended vibration criteria can be found in Table 18-2.

Table 18-2. Vibration criteria — Main rotor

SOURCE	IDENTIFICATION	LEVEL — IPS	RECOMMENDED ACTION
MAIN ROTOR 1/REV	HOVER LATERAL	LEVEL — 0.2	No action recommended
		LEVEL — 0.2	Balance rotor when practical
	60 to 110 KNOT VERTICAL	LEVELS — 0.2	No action recommended
		0.2 — LEVELS 0.5	Reduce at customer option no action required
		0.5 — LEVELS 1.0	Reduce as soon as practical
		1.0 — LEVELS	Remove aircraft from service; reduce as soon as possible

f. Operate helicopter on both engines and obtain data at each test condition shown on screen using basic procedures of steps f. and g. of INITIAL mode testing. When obtaining data in flight it is not necessary to obtain data at high speed test conditions if the 1/rev becomes higher than is comfortable. When skipping test conditions or acquiring data out of sequence the arrow keys can be used to select the desired conditions.

NOTE

The RADS AT needs only the on forward flight condition to begin to analyze the adjustments required to smooth the rotor. It is important however, as 1/rev levels are reduced, to obtain data at all displayed test conditions to ensure that optimum rotor 1/rev levels are achieved throughout the flight envelope of helicopter.

Never store data from one test condition under another label or diagnosis will not function properly.

g. When data to be obtained have been collected, land and shutdown helicopter. If all data have been collected the program will automatically display menu options. If all test conditions have not been obtained, press QUIT to exit MEASUREMENT MODE. Use arrow keys to select SAVE and EXIT. Press DO to store all data.

h. Using arrow keys highlight DIAGNOSTICS and press DO to select. If you have returned to main menu, press F3 to enter DIAGNOSTICS MENU.

i. Compare data obtained to limits listed in table 18-3. If no limits are exceeded press QUIT to exit program.

NOTE

Using arrow keys scroll through recommended adjustments. Record adjustments on form shown in figure 18-12.

j. Press DO to review predicted results and DO again to view DIAGNOSTICS menu. If all adjustments have been recorded then select MAIN MENU and press DO to return to main menu.

NOTE

To view predictions on 6.01 systems select VIEW PREDICTIONS from main menu. If three or more adjustments are recommended or the recommended adjustments include bending outboard tab in direction opposite indicated pitch link adjustment, acceptable ride may be obtained with fewer adjustment.

k. Using arrow keys select EDIT DEFAULTS and press DO.

l. To calculate best adjustments, type number one (1) and press DO. Note adjustments and view predicted results. If predicted results are satisfactory record adjustments on figure 18-12.

m. Make adjustments in accordance with paragraphs 18-23 through 18-26 and proceed to step n.

n. If predicted results are not acceptable repeat EDIT DEFAULTS and select 2, 3, and then 4, if necessary, until predicted results are acceptable. Record adjustments on form shown on figure 18-12. Make adjustments in accordance with paragraphs 18-23 through 18- 26.

NOTE

For diagnostics to work properly the HOVER and at least one forward speed must be obtained. If a limited number of tests points has been obtained, adjustments must be edited using EDIT ADJUSTABLES option of DIAGNOSTICS menu. The following edit is required:

No forward airspeed: Turn off (use F1 to select N) both pitch links and trim tab. If this is not done these adjustments will be used to track the rotor on the ground.

NOTE

When in EDIT ADJUSTABLES, one and only one each span balance and chord balance adjustments must be turned on at all times.

If any 1/rev levels are above limits it is up to operator to determine if levels require further improvement.

o. With limits page displayed press DO to display recommended rotor adjustments.

p. Make adjustments in accordance with paragraphs 18-23 through 18-26. Repeat steps e. through n. until acceptable ride is obtained.

q. Remove RADS AT in accordance with paragraph 18-22.

18-19. MAIN ROTOR 2/REV CHECK (OPTIONAL).

18-20. Installation for 2/rev check RADS AT.

1. Install and secure 29328200 DAU in cabin aft of crew seats with connectors up.

2. Using a 29329700 accelerometer bracket install one 991D accelerometer on the pilots outboard seat rail, using forward stop bolt to secure, with cable connector up. Connect end of 29105600 or 29105605 accelerometer cable to accelerometer. Route cable to DAU so it does not foul controls. Connect to ACC CH3 port (figure 18-13).

3. Using a 29329700 accelerometer bracket, install one 991D accelerometer on the copilot outboard seat rail, using forward stop bolt to secure, with the cable connector up. Connect end of 29105600 or 29105605 accelerometer cable to vertical accelerometer. Route cable to DAU so it does not foul controls. Connect to ACC CH4 port (figure 18-13).

4. Remove nuts and washers from top two bolts on left swashplate horn/boost cylinder attachment (figure 18-7). Install 29312600 magnetic sensor bracket to this location with the hole for the sensor toward the mast. Install new AN960JD416L washer and MS21042L4 nut on top two bolts and torque to 75 to 95 inch-lbs. (8.475 to 10.735 Nm).

5. Remove top jamnut from 27288400 magnetic rpm sensor and insert into magnetic sensor support bracket. Reinstall outer jamnut and loosely tighten so only one thread is showing beyond jamnut. Rotate rotor so magnetic interrupter is next to sensor. Adjust both jamnuts until gap between sensor and interrupter is 0.060 inch ± 0.010 (1.524 ± 0.254 mm). Tighten jamnuts while maintaining this spacing and secure with lockwire (C-405). Connect helicopter magnetic sensor cable to sensor and tighten to secure.

6. Move cyclic stick to the right rear position to fully extend left front control rod. Tiewrap magnetic rpm sensor cable to left hand control rod just below the rivets in the swaged end of tube with one inch of slack. Secure cable to airframe leaving a minimum six inches of slack between airframe and control tube to allow for movement of controls and pylon in flight. Route cable under cowling and into cabin through left cargo door and secure cable. Connect opposite end of cable to port TACHO #1 on DAU.

7. Connect 29104700 28 VDC power cable to 28 VDC port on copilots side of pedestal. Connect opposite end of cable to 28 VDC connector on the DAU.

Table 18-3. Troubleshooting

INDICATION OF TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Adjustments do not reduce 1/rev	Improper accelerometer installation.	Refer to appropriate section in this manual for proper installation.
Data is not stored when flight condition is completed	Operator pressing ‘QUIT‘ before data is stored.	Do not press ‘QUIT‘ unless it is to clear a warning or leave the list of test conditions.
Accelerometer saturation	Soft accelerometer bracket.	Install thicker bracket.
	Damaged accelerometer cable.	Replace cable.
	Failed accelerometer.	Replace accelerometer.
Tacho failure	Magnetic sensor gap too wide.	Adjust gap minimum 0.025 inch (0.635 mm), maximum 0.07 inch (1.79 mm).
	Damaged magnetic sensor cable.	Replace cable.
Track failures or obviously bad track data	Wrong tracker angle.	Set tracker to 45 degrees.
	Bright blade leading edge.	Paint leading edge blade color.
	Corruption by sun.	Install sunshield.
Tacho out-of-bounds when checking tail rotor or driveshaft	Photocell tape not in correct position.	Lengthen tape, make sure red light is on the photocell when rotor is flapped or

Table 18-3. Troubleshooting (Cont)

INDICATION OF TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
		reflector is under photocell on the driveshaft.
	Corruption by sun.	Orient helicopter so photocell is pointing at the sun for the tail rotor or so driveshaft is in shadow.
CADU will not communicate with DAU	Shorted tracker cable.	Remove tracker cable. If problem is solved, replace or repair tracker cable.

18-21. 2/Rev Check — RADS AT

1. Smooth rotor with RADS as follows:

a. Ensure system is installed properly (paragraph 18-17).

b. Turn on CADU to view main screen. Press QUIT until the main screen has been cleared of previous entries. Use arrow keys to select HELICOPTER TYPE and press DO. Use arrow keys to highlight 212 and press DO.

c. With helicopter type selected, press DO to selected or define TAIL NUMBER of helicopter (BHT prefers operator to use S/N and not registration number). When TAIL NUMBER has been highlighted or defined, press DO to select.

d. With helicopter type and tail number defined, select 2/R-CHK as the FLIGHT PLAN and press DO.

e. Once the CADU is properly configured for the initial mode, the CADU screen should look similar to example in Figure 18-14. With CADU properly configured, press F1 to initiate MEASUREMENT mode of RADS.

f. Fly helicopter and obtain data in the 2/R-CHK mode. Refer to Table 18-1A for test conditions.

g. When all data has been obtained, land helicopter. Select MAIN MENU and press F2 to display. Select SINGLE FLIGHT and record data, time, and date on form shown in Figure 18-15.

h. If levels are found to be higher than normal, refer to Table 18-3 for corrective action.

i. Make adjustment in accordance with Table 18-3 until acceptable ride is obtained.

j. Remove RADS AT in accordance with paragraph 18-22.

18-22. Removal — RADS AT

1. Disconnect 28 VDC power cord from 28 VDC port on copilot side of pedestal and DAU.

2. Disconnect communications cable 29325601 from CDAU and DAU.

3. Disconnect tracker cable from tracker and remove cable.

4. Remove day/night optical tracker and bracket.

5. Remove magnetic sensor and bracket from left side of swashplate horn/boost cylinder. Install nuts and washer removed and

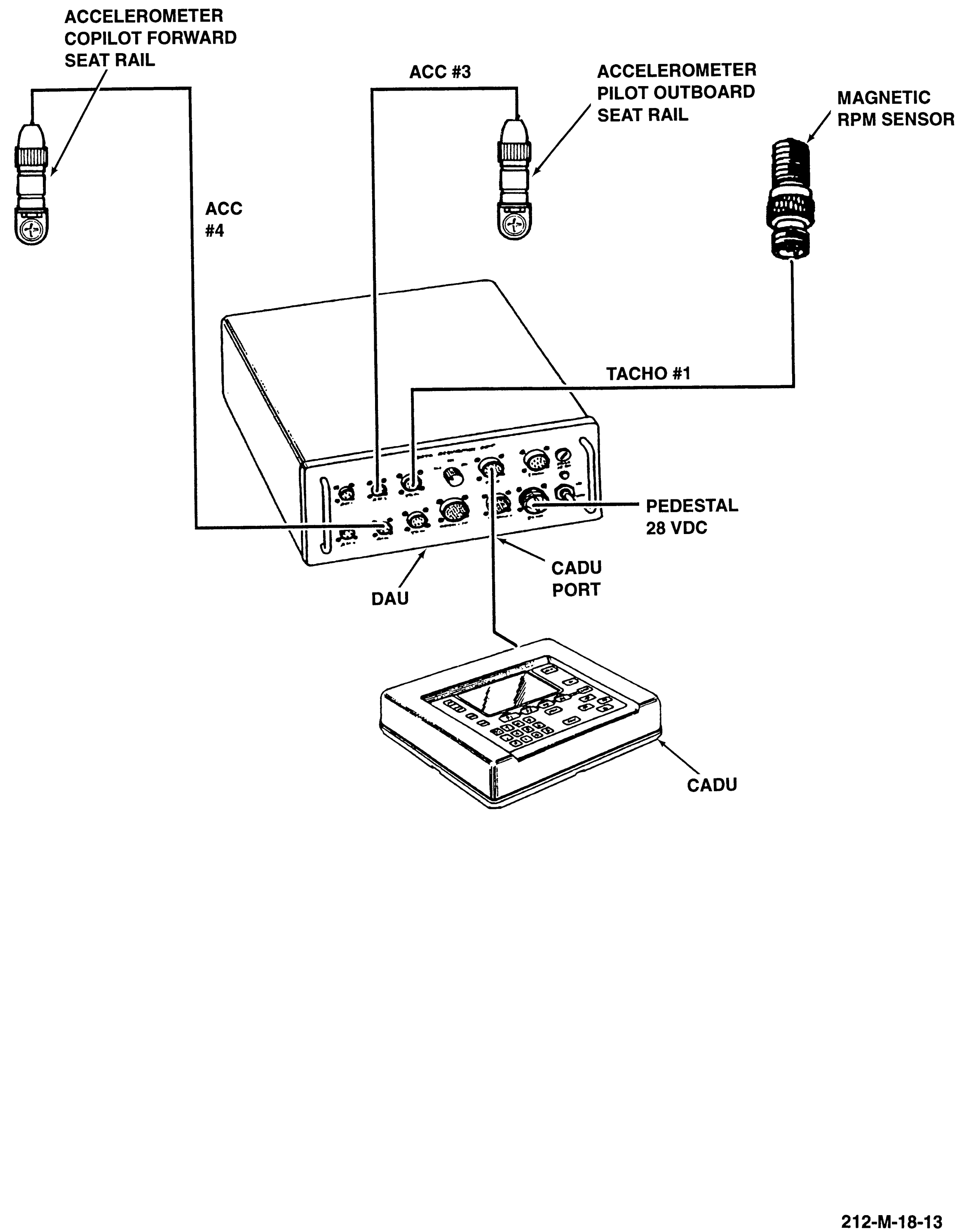
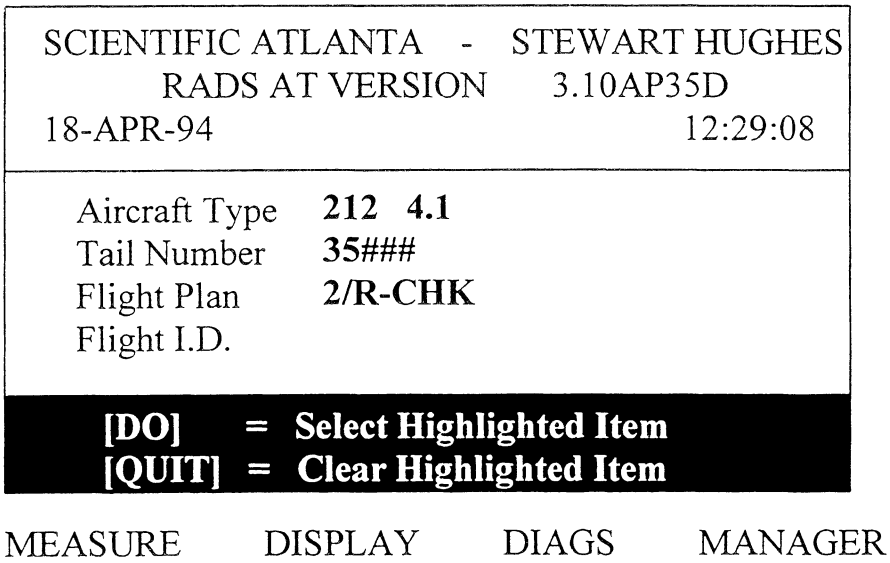


Figure 18-13. RADS AT proper configuration (2/R-CHK)



212-M-18-14

Figure 18-14. Main rotor smoothing CADU screen (2/R-CHK)

torque to 75 to 95 inch-lbs. (8.475 to 10.735 Nm).

6. Remove 991D accelerometer and 29329700 bracket from copilot side of instrument panel face adjacent to pedestal. Install new nut and washer and torque 50 to 70 inch-lbs. (5.65 to 7.91 Nm).

7. Remove 991D accelerometer and 29329700 accelerometer bracket from front face of transmission island.

8. Remove 29105600 or 29105605 accelerometer cables.

9. Remove 29328200 DAU from cabin aft of crew seats.

10. Store the final flight in the CADU or on a computer for future reference.

18-23. SPAN BALANCE ADJUSTMENT - RADS AT.

The RADS AT specifies the amount of span balance adjustment to be made in grams with a positive (+) adjustment meaning to add weight to the designated blade and a negative (-) adjustment meaning to remove weight from the designated blade. If the RADS AT specifies to remove weight from the blank blade and that blade does not have weight, then add the weight to the target blade. The effect will be identical.

1. Review span balance adjustment recorded on the adjustment log to determine the adjustment to be made. Refer to rotor adjustment log to verify blade identification to ensure correct blade is adjusted. The span balance location is inside blade bolts figure 18- 16).

NOTE

Lead shot (0.44 caliber) weighs nine grams per ball. If none is available use electronic scale to determine

SHIP S/N = ____________ TARGET = ____________ BLANK = ____________

RADS AT FLIGHT I.D.	LOCATION	HOVER 2/REV	60K 2/REV	110K 2/REV
DATE = _______	PILOT			
TIME = ________	COPILOT			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	LOCATION	HOVER 2/REV	60K 2/REV	110K 2/REV
DATE = _______	PILOT			
TIME = ________	COPILOT			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	LOCATION	HOVER 2/REV	60K 2/REV	110K 2/REV
DATE = _______	PILOT			
TIME = ________	COPILOT			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	LOCATION	HOVER 2/REV	60K 2/REV	110K 2/REV
DATE = _______	PILOT			
TIME = ________	COPILOT			

NOTES ON PREVIOUS RUN:

212-M-18-15

Figure 18-15. Model 212 main rotor adjustment log (2/R-CHK)

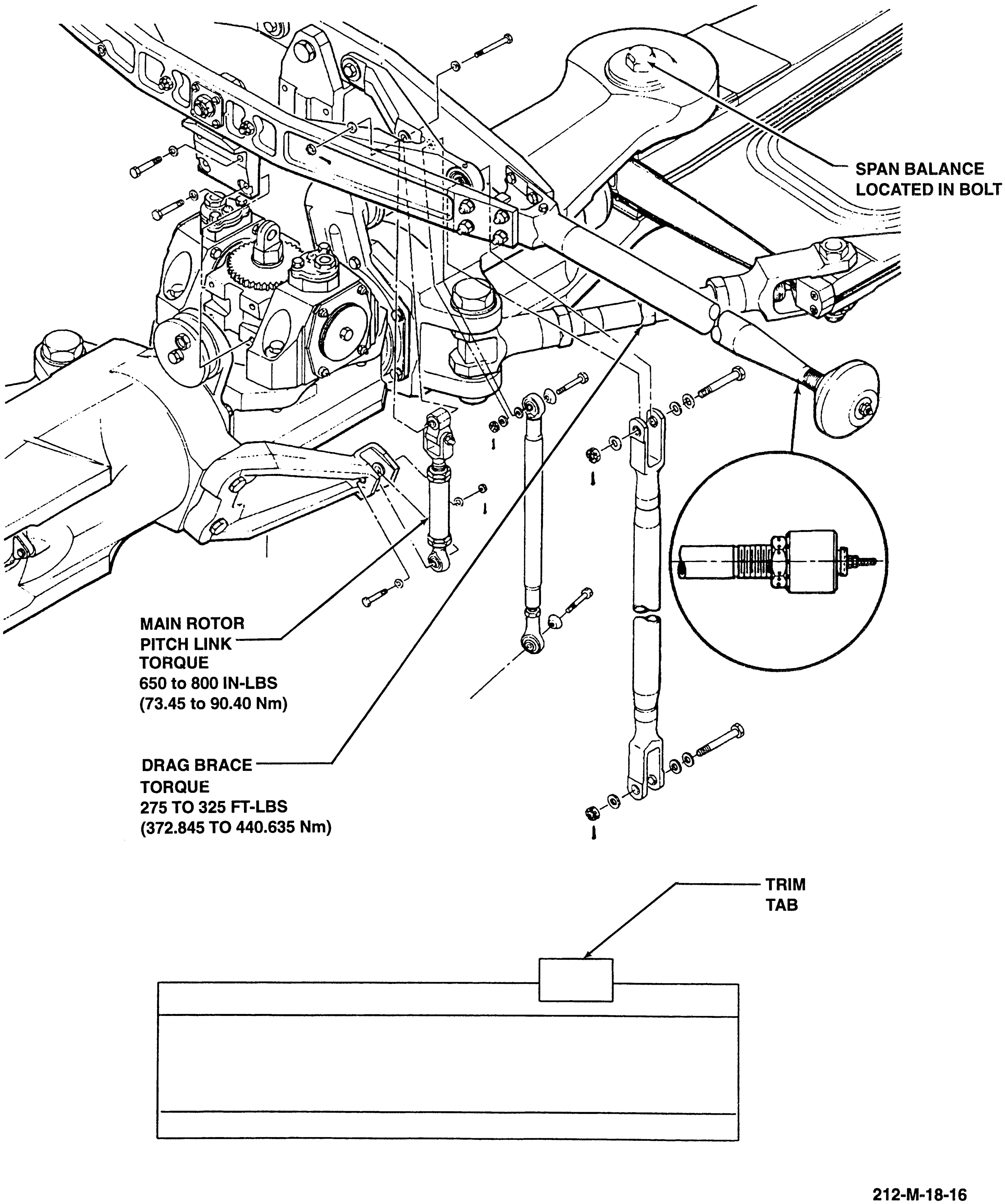


Figure 18-16. Main rotor adjustments

amount of alternate weight to be used.

2. Once blade to be adjusted has been identified remove safety wire from plug of selected blade bolt and remove plug.

3. Add weight to blade bolt (0.44 caliber lead shot recommended). If weight is already present in the opposite blade bolts then remove weight from that blade prior to adding to original blade.

4. Install all plugs removed and safety with lockwire.

Table 18-4. Accelerometer location, channel and installations

CHANNEL I.D.	LOCATION	ORIENTATION	INSTALLATION
1	Aft cabin bulkhead	Lateral, connector right	Section 3.3 (b)
2	Pilot seat rail	Vertical, connector up	Section 5.2 (b)
3	Combining gearbox lateral	Lateral connector to right	Section 6.2 (c)
4	90 degree gearbox	Vertical with connector up	Section 4.3.1(d)

Table 18-5. Test conditions (VIBCHK) — Main rotor

TEST I.D.	CHANNEL I.D.	FREQUENCY RANGE	TEST DESCRIPTION
GR-CH1	ACC #1	250 HZ	Ground run at 100% rpm with data from aft cabin bulkhead lateral
GR-CH2	ACC #2	250 HZ	Ground run at 100% rpm with data from pilot seat vertical
GR-CH3	ACC #3	250HZ	Ground run at 100% rpm with data from engine combining gearbox lateral
GR-CH4	ACC #4	250 HZ	Ground run at 100% rpm with data from tail rotor gearbox vertical
FL-CH1	ACC #1	250 HZ	Level flight at 110 knots with data from aft cabin bulkhead lateral
FL-CH2	ACC #2	250 HZ	Level flight at 110 knots with data from pilot seat vertical

Table 18-5. Test conditions (VIBCHK) — Main rotor (Cont)

TEST I.D.	CHANNEL I.D.	FREQUENCY RANGE	TEST DESCRIPTION
FL-CH3	ACC #3	250 HZ	Level flight at 110 knots with data from engine combining gearbox lateral
FL-CH4	ACC #4	250 HZ	Level flight at 110 knots with data from tail rotor gearbox vertical
1KHZ-3	ACC #3	1000 HZ	Level flight at 110 knots with data from engine combining gearbox lateral
1KHZ-4	ACC #4	1000 HZ	Level flight at 110 knots with data from tail rotor gearbox vertical

18-24. SWEEP ADJUSTMENT - RADS AT.

CAUTION

AT NO TIME SHOULD THE BLADE BE SWEPT FORWARD OF THE ALIGNED POSITION. IT IS ACCEPTABLE TO REMOVE AFT SWEEP BY SWEEPING FORWARD.

The RADS AT uses sweep as the primary adjustment for chordwise balance. The RADS AT specifies sweep in number of flats of adjustment of the outboard drag brace nut. A positive (+) adjustment means to sweep the blade aft and a negative (-) adjustment means to sweep blade forward. Once rotor has been aligned prior to installation, a grease pencil mark should be made on each outboard drag brace nut and clevis to indicate the aligned position.

1. Review sweep adjustment recorded on the adjustment log to determine the magnitude and direction of the adjustment to be made. Refer to rotor adjustment log verify blade identification to ensure correct blade is adjusted.

2. Once blade to be adjusted has been identified remove lockwire from the two drag brace jamnuts.

3. Loosen inboard and outboard drag brace jamnuts.

4. Rotate drag brace barrel the number of flats required for adjustment (down sweeps blade aft and up sweeps blade forward.

5. Holding drag brace barrel torque inboard and outboard jamnuts 275 to 325 Ft. lbs. (372.845 to 440.635 Nm) and safety with lockwire.

18-25. PITCH LINK ADJUSTMENT - RADS AT.

The RADS AT specifies the amount of pitch link adjustment to be made in the number of flats of the pitch link barrel with a positive (+) meaning increase pitch and negative (-) meaning decrease pitch.

1. Review sweep adjustment recorded on the adjustment log to determine the magnitude and direction of the adjustment to be made. Refer to rotor adjustment log verify blade identification to ensure correct blade is adjusted.

2. Once blade to be adjusted has been identified remove lockwire and loosen upper and lower jamnuts of pitch link while holding barrel with a wrench.

3. Mark pitch link barrel and lower clevis with grease pencil to show original alignment.

4. Using wrench, turn barrel required number of flats for adjustment.

NOTE

Using a piece of lockwire verify adequate thread engagement. If threads are not felt with lockwire, rig pitch links prior to further helicopter operation.

5. Equalize clearance on the inside of lower pitch link clevis. Holding barrel torque 650 to 800 inch-lbs (73.45 to 90.40 Nm) and safety with lockwire.

18-26. OUTBOARD TRIM TABS ADJUSTMENT - RADS AT.

SPECIAL TOOLS REQUIRED

NUMBER	NOMENCLATURE
T101654-101	Trim tab bender
T101656-145	Trim tab gage

The RADS AT specifies the amount of outboard trim tab adjustment to be made in number of degrees with positive (+) adjustment meaning bend tab up and negative (-) meaning bend tab down. Adjustment of 0.25 degrees is provided to allow the biasing of 0.50 degree moves to the light (undershoot) or heavy (overshoot) side.

NOTE

It is good practice to have the total amount of bend in each of the blade tabs equal.

1. Review outboard tab adjustment recorded on the adjustment log to determine the magnitude and direction of the adjustment to be made. Refer to rotor adjustment log verify blade identification to ensure correct blade is adjusted.

2. Loosen wing nuts and install trim tab bender T101597 on trim tab to be adjusted. Position bender so that there is approximately 1/8-inch gap between bender and trailing edge of blade. Tighten wing nuts to secure bender to blade.

3. Install T101598 tab gauge to blades with correct scale adjacent to trim tab. Square gauge to chord line of blade with scale touching angle indicator on bender.

4. Bend tab in required direction until tab is at rest (no load on bender) approximately two degrees beyond desired final tab angle. Bend tab back until desired angle is reached. This overbending will minimize any tendency of the tab to creep over time.

5. Remove tab gauge and tab bender from blade.

18-27. GENERAL VIBRATION CHECK (OPTIONAL) - RADS AT.

The following paragraphs contain procedures to provide the operator the ability to monitor the general vibration levels of the helicopter over time. This is accomplished by using the general spectrum analysis capability of the RADS AT. The 212 software contains a flight plan VIBCHK with 250 Hz spectrums for use with four accelerometers and 100 Hz spectrums for use with two accelerometers.

18-28. Installation (VIBCHK) - RADS AT.

1. Install and secure 29328200 DAU in cabin aft of crew with connectors up.

2. Install four accelerometers. Refer to table 18- 4 for location and installation of accelerometers.

3. Secure tail rotor cable down fin and under tailboom so it cannot foul elevator or rotating components. Ensure cables are clear of engine exhaust.

4. Connect accelerometers to DAU channels (table 18-4) using 29105600 or 29105605 accelerometer cable.

5. Connect 29325601 communication cable to CADU port on DAU and opposite end to the CADU.

6. Connect 29104700 28 VDC power cable to 28 VDC port on copilot side of pedestal. Connect opposite end of cable to 28 VDC connect on DAU.

7. The RADS AT should now be installed as shown in figure 18-17 .

Table 18-6. Vibration source — Main rotor

PROBLEM	FREQ (HZ)	PROBABLE CAUSE	CORRECTIVE ACTION
Low Frequency Oscillation	5.4	Worn pylon dampers	Replace worn dampers
Main Rotor Lateral in Flight	5.4	Main rotor out-of-balance	Balance main rotor
Main Rotor Vertical in Flight	5.4	Main rotor out-of-track	Track main rotor
Instrument Panel Vibration	10.8	Instrument panel support failure	Inspect instrument panel supports; replace or repair as necessary
Increased Cabin Vibration	10.8	Degraded skid gear supports	Inspect skid gear supports; replace degraded assemblies
	10.8	Loose battery	Inspect battery and battery deck, tighten and repair as necessary
	10.8	Degraded pylon mounts	Inspect pylon corner and fifth mount, replace degraded components
	10.8	Swashplate freeplay	Inspect swashplate; replace worn bearings
Medium Frequency Vibration in Flight	27.7	Tail rotor out-of-track and balance	Track and balance tail rotor
Tail Rotor Balance Erratic	27.7	Loose tail rotor trunnion	Inspect and recenter tail rotor trunnion
Vibration in Pedals	70-80	Chattering tail rotor boost	Replace tail rotor boost trunnion
Pulsating Noise in Cabin	110	Out-of balance main driveshaft	Balance driveshaft
High Frequency Vibration in Cabin or on Drivetrain	139	Rotor brake out-of-balance or support bearings worn	Inspect disk and bearings for damage or wear; replace damaged components
	144	Oil cooler fan blades damaged	Inspect oil cooler fans; replace any damaged components

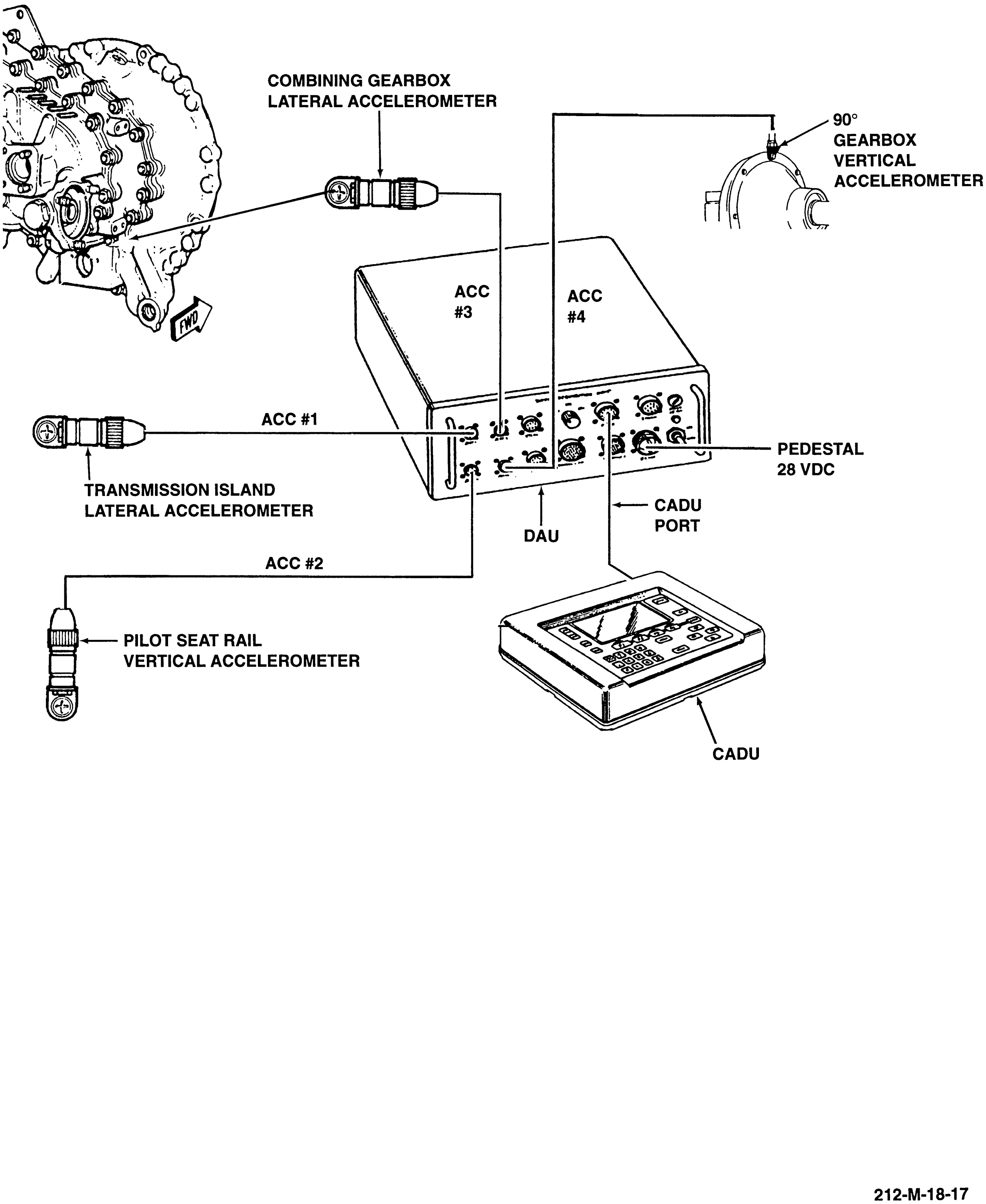


Figure 18-17. RADS AT proper configuration (VIBCHK)

18-29. VIBCHK - RADS AT.

1. Ensure system is installed properly (paragraph 18-28).

2. Turn on CADU to view main screen. Press QUIT until the main screen has been cleared of previous entries. Use arrow keys to select HELICOPTER TYPE and press DO. Use arrow keys to highlight 212 and press DO.

3. With helicopter type selected, press DO to selected or define TAIL NUMBER of helicopter (BHT prefers operator to use S/N and not registration number). When TAIL NUMBER has been highlighted or defined, press DO to select.

4. With helicopter type and tail number defined, select VIBCHK as the FLIGHT PLAN and press DO.

5. Once the CADU is properly configured for the VIBCHK, the CADU screen should look similar to example in figure 18-18 . With CADU properly configured, press F1 to initiate MEASUREMENT mode of RADS.

6. Operate helicopter on both engines at 100 percent rpm and flat pitch. Obtain data at the four ground run conditions (GR). Once this data has been obtained conduct a flight and obtain data in level flight at 110 knots using the flight acquisitions (FL) and the two 1000 HZ acquisitions (1KHz).

7. When all data has been collected, land and shut down helicopter. If limits are exceeded refer to table 18-6 for probable cause of vibration and corrective action.

8. When all data has been obtained and all corrective action completed remove all RADS AT hardware in accordance with paragraph 18- 22 .

18-30. VIBRATION TROUBLESHOOTING (OPTIONAL) - RADS AT.

The following paragraphs provide information to help the operator isolate an unknown vibration and locate the source. Provided within the 212 software is a flight plan (SPECTRUM) with a 250 Hz spectrum and a 1000 Hz spectrum for channels one through four accelerometers installed at locations where suspected vibrations are felt.

18-31. Installation (SPECTRUM) - RADS AT.

1. Install and secure 29328200 DAU in cabin aft of crew with connectors up.

2. Identify locations where abnormal vibrations are felt and install (or hold by hand if possible) accelerometers.

3. Connect end of 29105600 or 29105605 accelerometer cable to accelerometers. Route cable to DAU so it does not foul controls and is clear of engine exhaust. Connect opposite end of cable to DAU port.

4. Connect 29104101 CADU to DAU using 29325601 communication cable.

5. Connect 29104700 28 VDC power cable to 28 VDC port on copilot side of pedestal. Connect opposite end of cable to 28 VDC connect on DAU.

6. The RADS AT should now be installed and ready to perform SPECTRUM test.

18-32. Vibration troubleshooting (SPECTRUM) - RADS AT.

1. Ensure system is installed properly (paragraph 18-31).

2. Turn on CADU to view main screen. Press QUIT until the main screen has been cleared of previous entries. Use arrow keys to select HELICOPTER TYPE and press DO. Use arrow keys to highlight 212 and press DO.

3. With helicopter type selected, press DO to select TAIL NUMBER. When TAIL NUMBER has been highlighted, press DO to select.

4. With helicopter type and tail number selected, select SPECTRUM as the FLIGHT PLAN and press DO.

5. Once the CADU is properly configured, the CADU screen should look similar to example in figure 18-19 . With CADU properly configured, press F1 to initiate MEASUREMENT mode of RADS.

6. Operate helicopter at test condition at which problem is suspected and obtain on appropriate channels. Once this data has been obtained, identify a test condition where the vibration is not as pronounced. Using a new flight I.D., obtain data at this condition.

7. When all data has been collected, land and shut down helicopter and review data and isolate the problem as follows:

a. Look for the highest peaks and compare to and previous data to determine if they have changed.

b. Compare the problem data to determine which peaks have been reduced or which ones have disappeared. These are the peaks causing problems.

c. Compare suspected peaks to those shown in figure 18-20 to identify the source.

d. Inspect, service, and/or replace assembly causing the problem.

8. Upon completion of test remove all RADS AT hardware in accordance with paragraph 18-22 .

18-33. TAIL ROTOR - TRACKING AND BALANCING.

The following paragraphs provide the necessary information to track and balance the tail rotor using the Scientific Atlanta Rotor Analysis and Diagnostic System, Model AT (RADS AT). The RADS AT automates the acquisition of blade track and vibration data as well as corrective actions required to accomplish tracking and balancing.

18-34. TAIL ROTOR VIBRATION MEASUREMENT INSTRUMENTATION.

SPECIAL TOOLS REQUIRED

NUMBER	NOMENCLATURE
29333300 or 29133100 Scientific Atlanta San Diego, CA 92123	Basic RADS AT kit with basic software 212 Version 4.20
29338500A or 29338501 Scientific Atlanta	Optical rpm sensor bracket
2920330D or later Scientific Atlanta	Model 212/412 optical tracker bracket
29329700 Scientific Atlanta	Accelerometer bracket
29328200 Scientific Atlanta	Data Acquisition Unit (DAU) (included in basic RADS AT kit)
29314101 Scientific Atlanta	Control and Data Unit (CADU)
991D Wilcox	Accelerometer (3 total)
29105600 Scientific Atlanta	Accelerometer cable 50 foot (additional)
29105605 Scientific Atlanta	Accelerometer cable 25 foot (additional)

18-35. Installation - RADS AT.

Refer to BHT- ALL- SPM for specification and source.

MATERIALS REQUIRED

Refer to BHT- ALL- SPM for specification and source.

NUMBER	NOMENCLATURE
C-483	Reflective tape

1. Position and install 29328200 DAU in cabin aft of crew seats with connectors up.

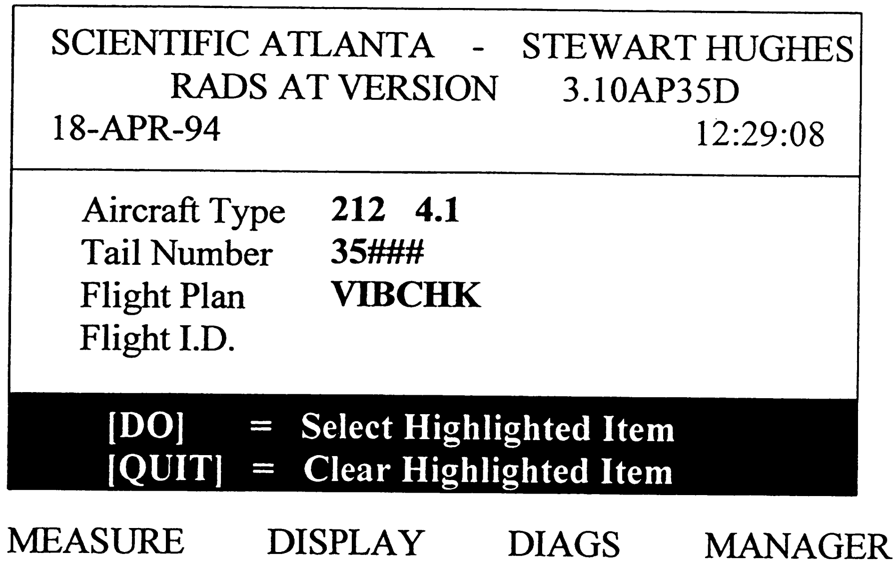


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Figure 18-18. Main rotor smoothing CADU screen (VIBCHK)

2. Remove nut from top stud (12:00 o'clock position) on 90 degree gearbox (figure 18-21); install one 991D accelerometer on stud with connector up and secure with nut. Connect accelerometer end of 29105600 accelerometer cable to vertical accelerometer. Route to DAU down left side of fin and tailboom. Secure cable so it cannot foul tail rotor or controls. Connect cable to port ACC #4 on DAU (figure 18-22).

3. Attach 29314700 optical rpm sensor to 29337400A tail rotor optical sensor bracket so wire is on flange edge of bracket. Secure sensor to bracket with MS21040-04 (#440) self-locking nuts. Remove nut from aft stud on 90-degree gearbox and install sensor/bracket. Secure with gearbox nut so it is level to horizon and pointed directly aft (figure 18-21). Route optical sensor cable to DAU down left side of fin and tailboom. Secure cable so it cannot foul tail rotor or controls. Connect cable to port TACHO #2 on DAU (figure 18-22).

4. Install a full width piece of tape (C-483) between two blade bolts on gearbox side of blade (figure 18-21). This will be target blade.

5. Connect 29104700 28 VDC power cable to 28 VDC port on copilot side of pedestal (figure 18-22). Connect other end of cable to 28 VDC connector on DAU.

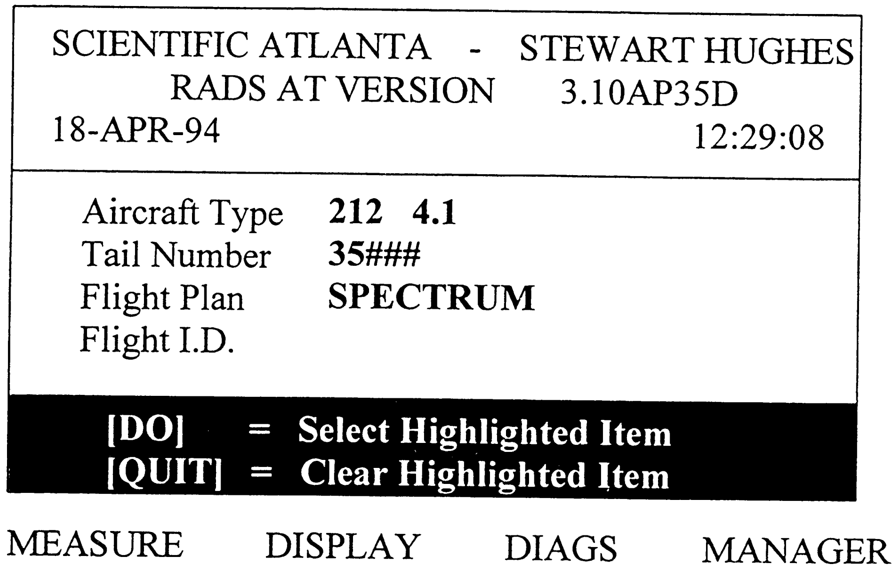
6. Connect 29104700 28 VDC power cable to DAU using 29325601 communications cable.

7. When correctly installed, RADS AT should be configured as shown in figures 18-21 and 18-22.

18-36. TEST TO BALANCE TAIL ROTOR.

1. Turn on CADU to view main screen. Press QUIT until the main screen has cleared of previous entries. Use arrows to select AIRCRAFT TYPE, TAIL NUMBER, select TAIL as the flight plan and press DO. The CADU screen display will be as shown in figure 18-23 .

2. Press F1 to initiate MEASUREMENT mode.



212-M-18-19

Figure 18-19. Main rotor smoothing CADU screen (SPECTRUM)

3. Operate helicopter with one engine and stabilize rotor rpm as close to 100 percent as possible. Center cyclic, ensure collective is all the way down and the directional pedals are centered. With T/R highlighted press DO on CADU to arm. If all internal checks are successful then the test condition title will appear at the bottom of screen. Press DO to view data. Press DO again to obtain data. When data is obtained RADS AT will indicate test has been completed.

4. Select FINISH then DIAGNOSTICS to review tail rotor 1/rev levels and determine if any adjustments are required. If TACH error occurs while obtaining data, repeat test at least two times.

5. If failure occurs, shut down helicopter. Inspect reflective tape. Replace if necessary. With power to DAU verify red light on back of optical rpm sensor illuminates when reflector is in front of optical sensor. Verify that the optical rpm sensor is hooked to port TACHO #2.

NOTE

If all the above test conditions are OK and red light still does not illuminate, remove clear cover from optical rpm sensor. Gently turn brass screw clockwise to increase gain until a slight click is felt. With optical rpm sensor pointing at reflector tape red light should illuminate. Reinstall clear plastic cover.

6. If tail rotor balance is not acceptable record predicted adjustments on form similar to one shown in figure 18-24 . Perform corrective action. Refer to table 18-7 for corrective action.

7. Repeat steps 1. through 5. until tail rotor is balanced.

NOTE

The RADS AT is operating on preset limits of 0.20 IPS for tail rotor balance. If the operator desires to

SOURCE	SOURCE I.D.*	HARMONIC	FREQ. (HZ)	FREQ. (CPM)
MAIN ROTOR	1	1/REV	5.4	324
MAIN ROTOR	1	2/REV	10.8	648
MRGB UPPER SUN GEAR	2		16.7	1000
MAIN ROTOR	1	4/REV	21.6	1296
TAIL ROTOR	18	1/REV	27.7	1662
MRGB UPPER PLANETARY DEFECT	3		41.5	2488
MRGB UPPER RING GEAR DEFECT	4		43.2	2592
LOWER SUN GEAR/BEVEL GEAR (MRGB)	5		51.5	3087
TAIL ROTOR	18	2/REV	55.3	3324
DEFECT ON LOWER RING GEAR	7		66.7	4000
HYDRAULIC PUMP	12	1/REV	71.7	4302
TACH GENERATOR	13	1/REV	71.7	4302
TAIL ROTOR DRIVESHAFT	15	1/REV	71.7	4302
TAIL TAKEOFF QUILL	11	1/REV	75	4498
OIL PUMP (MRGB)	14	1/REV	75	4498
DEFECT ON UPPER SUN GEAR	2		90.2	5411.4
MAIN DRIVESHAFT	8	1/REV	110	6600
NO. 2 HYDRAULIC PUMP	9	1/REV	110	6600
TAIL ROTOR	21	4/REV	110.6	6640
DEFECT ON LOWER PLANETARY GEAR	6		128	7677
ROTOR BRAKE DISK	10	1/REV	138.7	8322
DEFECT ON LOWER SUN GEAR	5		139.2	8351
TAIL ROTOR DRIVESHAFT	18	2/REV	143.4	8604
OIL COOLER FAN		1/REV	143.8	8630
POWER TURBINE/CBOX INPUT		1/REV	550	33000
GAS GENERATOR-LOW		1/REV	508	30480
GAS GENERATOR-HIGH		1/REV	635	38100
UPPER PLANETARY	2,3,4	GEARMESH	642	38543
90 DEGREE GEARBOX	17	GEARMESH	1578	94660
TAIL TAKEOFF	11,15	GEARMESH	1649	98964
HYD. DRIVE QUILL	12	GEARMESH	1864	111852
LOWER PLANETARY	5,6,7	GEARMESH	1983	119000
TAIL TAKEOFF QUILL	11	GEARMESH	2624	157442
42 DEGREE GEARBOX	16	GEARMESH	2725	163505
INPUT BEVEL GEAR	5,8	GEARMESH	3190	191400

*SEE SHEET 2

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Figure 18-20. Excitation frequencies (Sheet 1 of 2)

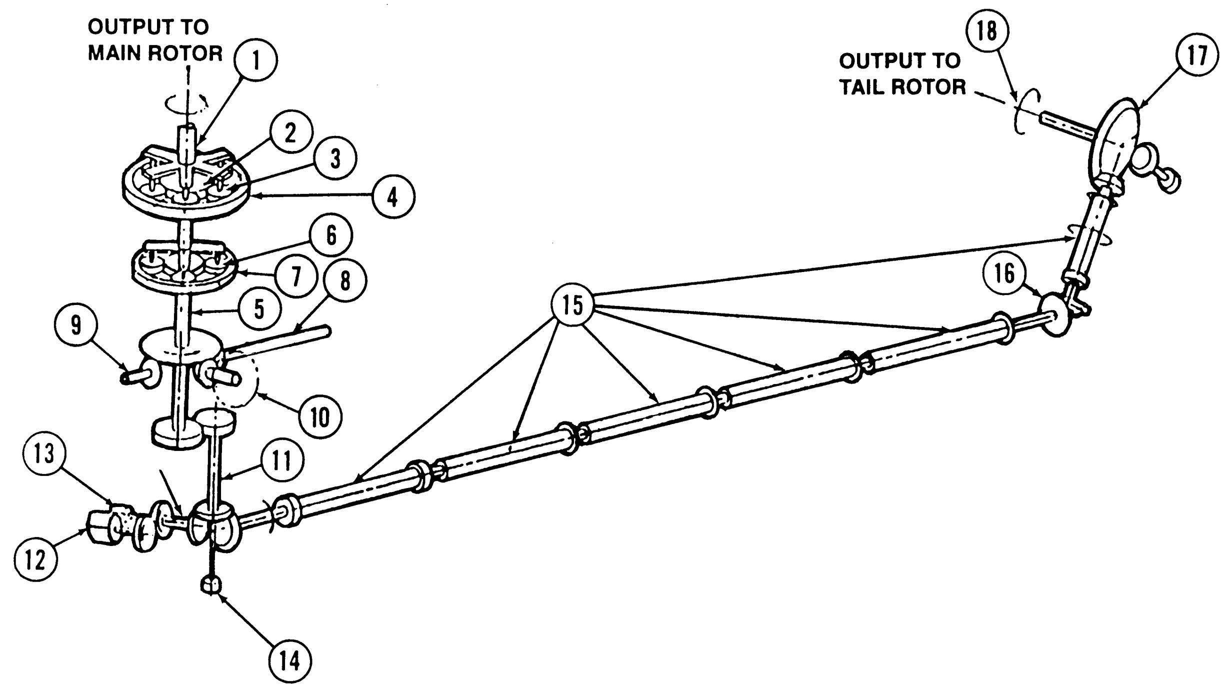

Figure 18-20. Excitation frequencies (Sheet 2)

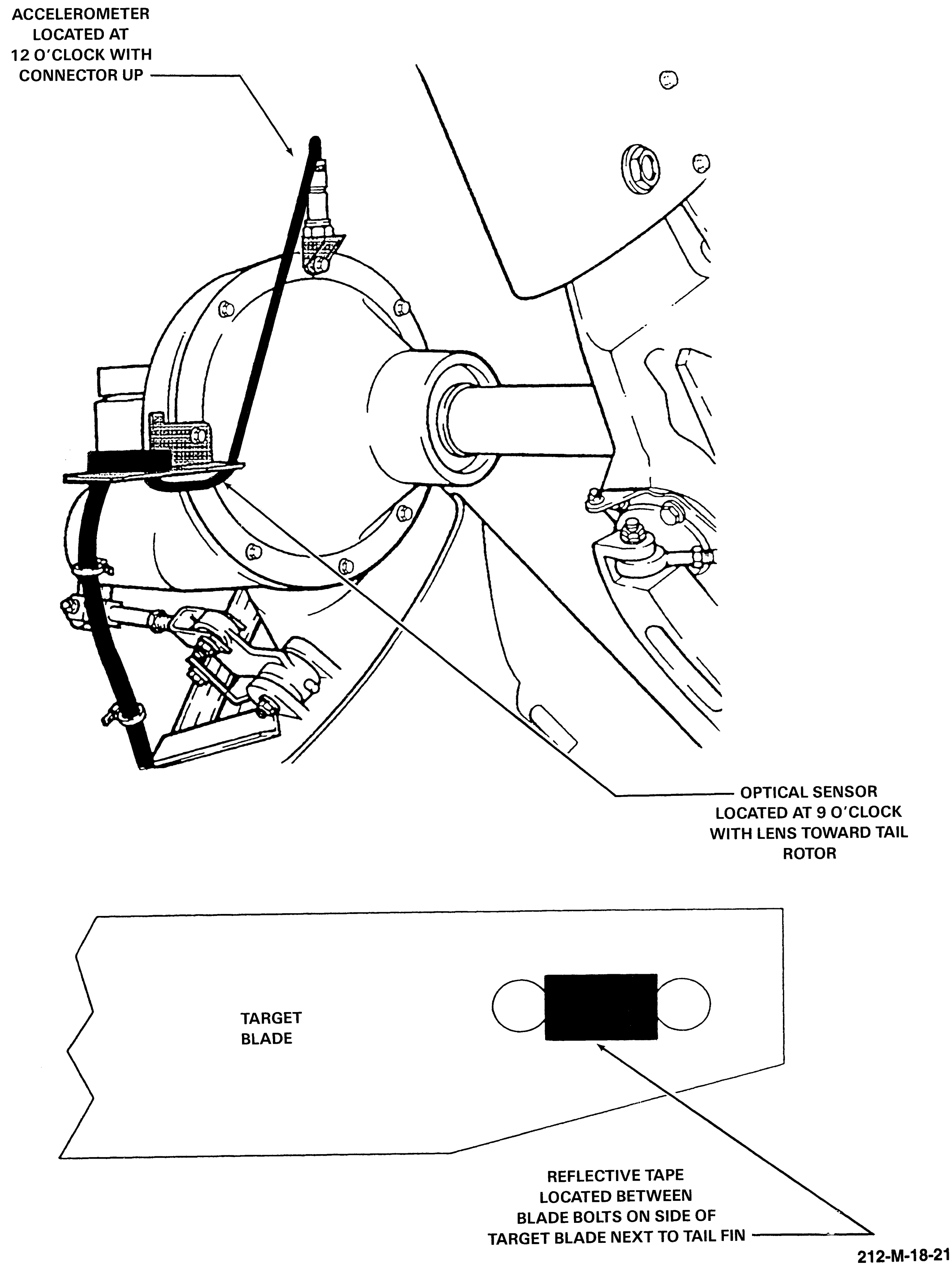

Figure 18-21. Accelerometer and optical sensor installation - Tail rotor

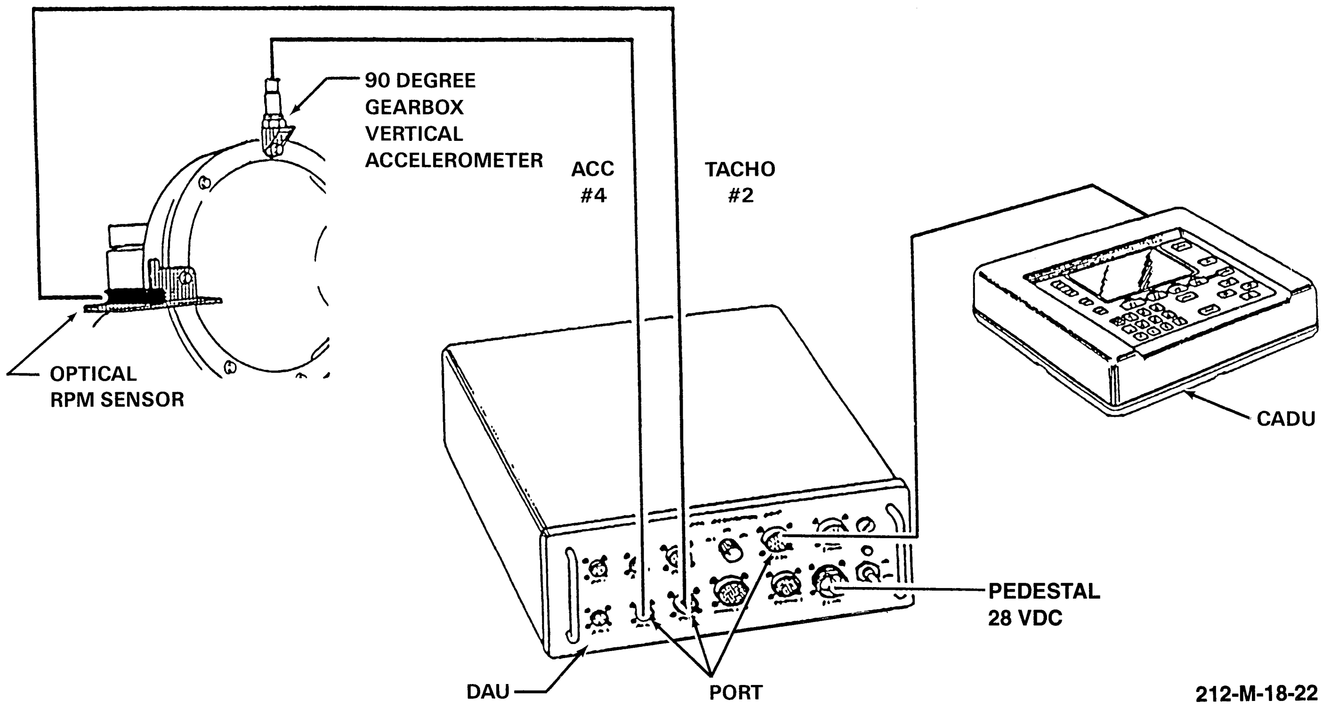

Figure 18-22. Tail rotor - proper RADS AT installation

reduce the level to below 0.20 IPS then this can be done by pressing DO from limits screen. The RADS AT will specify adjustments required to achieve a 0 IPS balance.

8. If tail rotor balance is acceptable remove RADS AT from helicopter (paragraph 18-38).

18-37. Tail rotor balance adjustments.

RADS AT specifies balance adjustments required to balance tail rotor as adjustments made only to target blade. There are three adjustments available; outboard blade bolt, inboard blade bolt, and chordwise balance. The default in the RADS AT software is to use only chord and outboard bolt. Should the operator need to use the inboard bolt for balance, then from within DIAGNOSTICS, select EDIT ADJUSTABLES from menu. Use F1 to turn off outboard blade bolt (by changing Y to N) and then use F1 to turn on inboard blade bolt on target blade only (N to Y). Pressing DO will automatically recalculate corrections using inboard blade bolt. Never have both blade bolts on at the same time and never edit the blank adjustments.

Once adjustments to target blade have been defined, determine what moves can be made. If RADS AT specifies to add weight to a location where weight is on opposite blade, the proper course is to remove required amount from opposite location. If RADS AT specifies to remove weight from location that does not have weight, add weight to opposite side.

1. Review the location and size of currently installed weights. It is best to remove weight when possible. It is acceptable to install weights on both sides to make small adjustments.

2. Remove any weight package already installed to which adjustments are to be made. Using hardware listed in table 18-2 create or adjust the weight package to achieve the desired amount of balance change. The gram scale supplied with the RADS AT can be used to obtain the desired adjustment. Install balance weights and torque in accordance with Chapter 64 .

18-38. Removal - RADS AT.

1. Disconnect 29104700 28 VDC power cable from 28 VDC port on copilot side of pedestal and from DAU.

2. Disconnect 29325601 communication cable from DAU and 29104700 power cable.

3. Remove optical rpm sensor and bracket from tail rotor gearbox. Install new nuts and washers (thick aluminum washer next to gearbox) and torque 50 to 70 inch-lbs. (5.65 to 7.91 Nm).

4. Remove 991D accelerometer and bracket from gearbox. Install new nut and washer and torque 50 to 70 inch-lbs. (5.65 to 7.91 Nm).

5. Remove DAU from cabin aft of crew seats.

Table 18-7. Vibration source — Tail rotor

PROBLEM	FREQ (HZ)	PROBABLE CAUSE	CORRECTIVE ACTION
	10.8	Degraded pylon mounts	Inspect pylon corner and fifth mount, replace degraded components
	10.8	Swashplate freeplay	Inspect swashplate, replace worn bearings
Medium Frequency Vibration in Cabin	27.7	Tail rotor out-of-track and balance	Track and balance tail rotor paragraph 18-32
Tail Rotor Balance Erratic	27.7	Loose tail rotor trunnion	Inspect and recenter tail rotor trunnion
Vibration in Pedals	70-80	Chattering tail rotor boost cylinder	Replace tail rotor boost cylinder
Pulsating Noise in Cabin	110	Out-of-balance main driveshaft	Balance driveshaft
High Frequency Vibration in Cabin or on Drivetrain	139	Rotor brake out-of-balance or support bearings worn	Inspect disc and bearings for damage or wear, replace damaged components
	144	Oil cooler fan blades damaged	Inspect oil cooler fans, replace any damaged components found

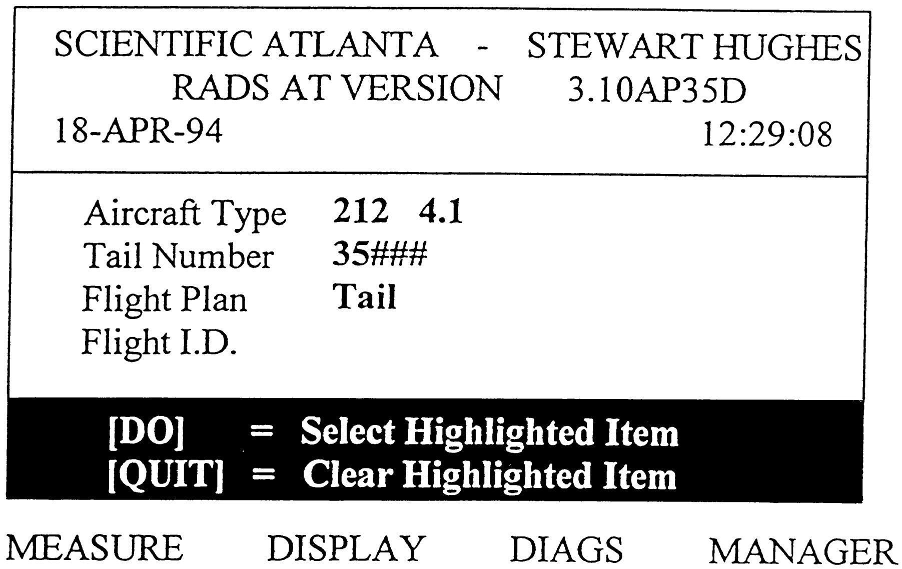

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Figure 18-23. Tail rotor smoothing CADU screen

SHIP S/N = __________ TARGET = __________ BLANK = __________

RADS AT FLIGHT I.D.	BLADE I.D.	BLADE BOLT	CHORD BALANCE	1/REV READING
DATE = _______	TARGET			
TIME = ________	BLANK			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	BLADE I.D.	BLADE BOLT	CHORD BALANCE	1/REV READING
DATE = _______	TARGET			
TIME = ________	BLANK			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	BLADE I.D.	BLADE BOLT	CHORD BALANCE	1/REV READING
DATE = _______	TARGET			
TIME = ________	BLANK			

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	BLADE I.D.	BLADE BOLT	CHORD BALANCE	1/REV READING
DATE = _______	TARGET			
TIME = ________	BLANK			

NOTES ON PREVIOUS RUN:

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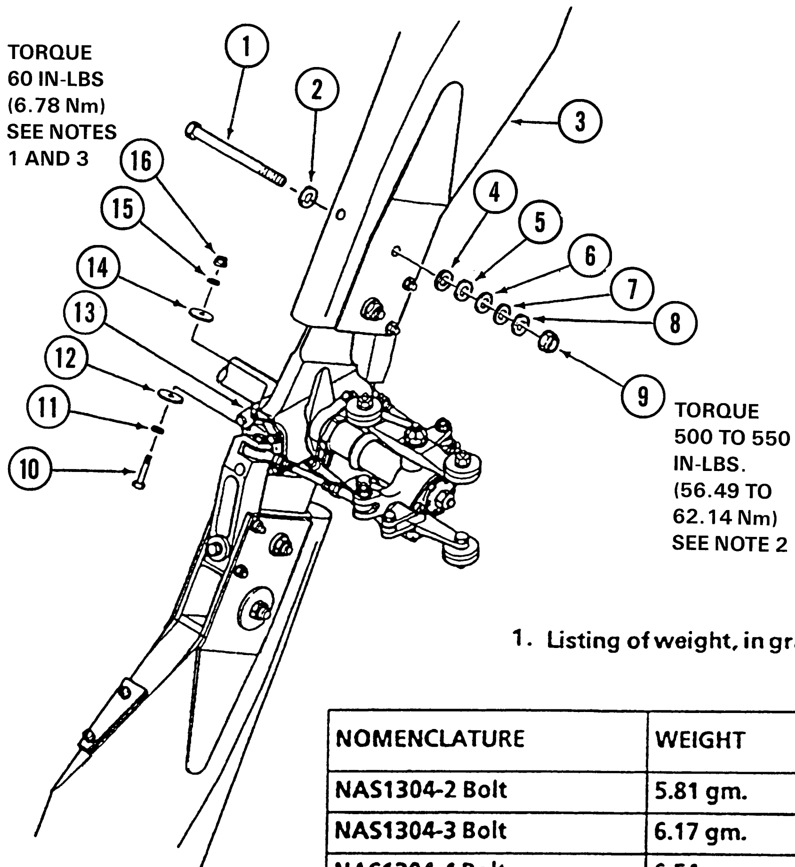
Figure 18-24. Tail rotor adjustment log



1. Blade bolt (outboard)
2. Washer (140-007-33-32C4)
3. Tail rotor blade
4. Washer (140)007-33-32C4)
5. Washer (212-010-764-1)
6. Washer (AN970-8)
7. Washer (AN960-816)
8. Washer (AN960-816L)
9. Nut
10. Bolt
11. Washer (AN960-416)
12. Washer (AN970-4)
13. Dynamic balance bracket
14. Washer (AN970-4)
15. Washer (AN960-416)
16. Nut

NOTES

1. Listing of weight, in grams, of individual components used for balance.

NOMENCLATURE	WEIGHT
NAS1304-2 Bolt	5.81 gm.
NAS1304-3 Bolt	6.17 gm.
NAS1304-4 Bolt	6.54 gm.
NAS1304-5 Bolt	6.90 gm.
NAS1308-34 Bolt	87.60 gm.
NAS1308-36 Bolt	90.80 gm.

NOMENCLATURE	WEIGHT
AN960-416 Washer	1.16 gm.
AN960-816 Washer	3.22 gm.
AN960-816L Washer	1.63 gm.
AN970-4 Washer	7.54gm.
AN970-8 Washer	37.80 gm.
MS21042L4-Nut	1.59 gm.

2. For spanwise dynamic balance, use NAS1308-34 through NAS1308-36 bolts (1) as required to accomodate balance washers. Bolts may be installed with head, inboard or outboard, but all four blade bolts must be installed the same. When change of balance washers and/or bolts is required, ensure that one washer (2) and one washer (4) are installed next to blade as illustrated. Then install heaviest balance washers next to washer (4). Install the above listed parts on blade (3) or on opposite blade as required to obtain balance.

3. For chordwise dynamic balance, use NAS1304-1, -2, -3, -4, -6, -8, -10, -12, or -14 bolts (10)as required to accomodate balance washers (11 ,12, 14, and 15). Use a maximum of two AN970-4 washers (12 and 14) and a maximum of ten AN960-416 washers (11 and 15) on one bracket. Install washers symmetrically. Install the above listed parts on bracket (13) or opposite bracket (not illustrated) as required to obtain balance.

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Figure 18-25. Tail rotor balance hardware

Table 18-8. Balancing hardware — Tail Rotor

ITEM	IDENTIFICATION	WEIGHT	NUMBERED REQUIRED
RADS AT Basic Kit	29333300 or later	N/A	One (1)
Optical RPM Sensor Bracket	29338500a or 29313100	N/A	One (1)
Stiff Accelerometer Brackets	29329700 or c-h #6752	N/A	Two (2)
Bolt for One Weight	AN5-12A	2 grams	As required
Bolt for Two Weights	AN5-13A	4 grams	As required
Balance Weight	100-106-1	14.18 grams	As required
Balance Weight	100-106-2	7.09 grams	As required
Balance Weight	100-106-3	2.84 grams	As required

18-39. MAIN DRIVESHAFT BALANCING.

The following paragraphs provide the necessary information to balance the driveshaft using the Scientific Atlanta Rotor Analysis And Diagnostic System, Model AT (RADS AT). This procedure may be accomplished while performing main rotor tracking and balancing (using two extra accelerometers and cables) or as a separate test.

18-40. DRIVESHAFT VIBRATION MEASUREMENT INSTRUMENTATION.

18-41. Installation of RADS.

SPECIAL TOOLS REQUIRED

NUMBER	NOMENCLATURE
29333300 or 29313100 Scientific Atlanta San Diego, CA 92123	Basic RADS AT kit with basic software 212 version 4.20
29328200 Scientific Atlanta	Data acquisition Unit (DAU) (included in basic kit)

SPECIAL TOOLS REQUIRED (CONT)

NUMBER	NOMENCLATURE
29314101 Scientific Atlanta	Control and Data Unit (CADU)
29338500A or 29338501 Scientific Atlanta	Optical RPM sensor bracket
29329700 Scientific Atlanta	Accelerometer bracket
991D Wilcox	Accelerometer (2 total)
29105600 Scientific Atlanta	Accelerometer cable (50 foot)
29105605 Scientific Atlanta	Accelerometer cable (25 foot)
29314101 Scientific Atlanta	Power cable (28 VDC)
29325601 Scientific Atlanta	Communication cable

Refer to BHT-ALL-SPM for specification and source.

MATERIALS REQUIRED

Refer to BHT-ALL-SPM for specification and source.

NUMBER	NOMENCLATURE
C-483	Reflective tape

1. Position and install 29328200 DAU in cabin aft of crewseats, with connectors up.

2. Install one 991D accelerometer using 29329700 bracket on right side of combining gearbox (figure 18-26). Connect accelerometer end of 29105600 accelerometer cable to combining gearbox accelerometer. Route and secure cable so cannot foul any rotating components, and connect opposite end to DAU port ACC #3.

3. Using a 29329700 accelerometer bracket, install one 991D accelerometer on stud at 1 o'clock position of transmission input quill by removing Allen head screw and using a 1/4 X 28 bolt to secure accelerometer laterally as shown in figure 18-26. Connect accelerometer end of 29105600 accelerometer cable to transmission input quill accelerometer, route and secure to DAU so it can not foul any rotating components and connect opposite end to DAU port ACC #4.

4. Using nut (4, figure 18-27), attach 29314700 optical rpm sensor (8) to 29338500A or 29338501 optical rpm sensor bracket (7) with clear lens adjacent to vertical attachment leg.

5. Using nut (2), washer (1) and washer (6), and bolt (5), attach 29314700 optical rpm sensor to tail rotor driveshaft 29337500A optical sensor bracket (7) to right hand inlet cowl alignment flange of transmission firewall (3). Align optical rpm sensor bracket in horizontal position directly over main driveshaft so that clear lens is level and pointed to the left. Tighten nut until bracket cannot move Tiewrap optical rpm sensor to a convenient point above to ensure bracket will not rotate and contact main driveshaft. Route and secure cable to DAU ensuring it can not foul any rotating components. Connect cable to DAU port TACHO #2.

6. With optical sensor installed, turn driveshaft so one shaft-to-adapter bolt is directly on top. With driveshaft in this position, center and install a three inch piece of tape (C-483) on shaft with long axis of tape aligned with long axis of driveshaft and centered relative to shaft-adapter bolt and under optical sensor. The bolt aligned with reflector is bolt #1 (figure 18-28).

7. Connect 29314101 28 VDC power cable to 28 VDC port on copilot side of pedestal. Connect other end of cable to 28 VDC connector on DAU.

8. Connect CADU to DAU using 29325601 communications cable.

9. The RADS is now installed and ready to balance driveshaft. When correctly installed, RADS AT should be configured as shown in figure 18-29.

18-42. Balancing main driveshaft - RADS AT.

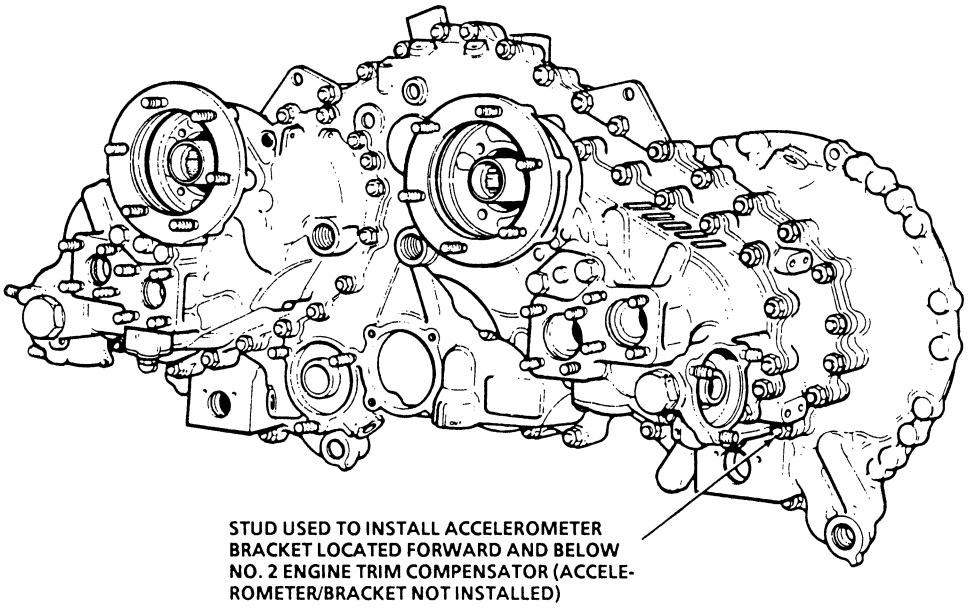
1. Ensure system is properly installed (figure 18-29).

2. Turn on CADU and, from the main screen, Press QUIT until main screen is cleared of previous entries. Use arrow keys to select AIRCRAFT TYPE and press DO. Use arrow keys to highlight 212 and press DO.

3. With helicopter type selected, press DO to select TAIL NUMBER. When TAIL NUMBER has been highlighted, press DO to select.

4. With helicopter type and tail number selected, select D/S as the FLIGHT PLAN and press DO.

5. Once the CADU is properly configured for the D/S mode, the screen should look similar to example in figure 18-30. With CADU properly configured, press F1 to initiate MEASUREMENT MODE OF rads at.



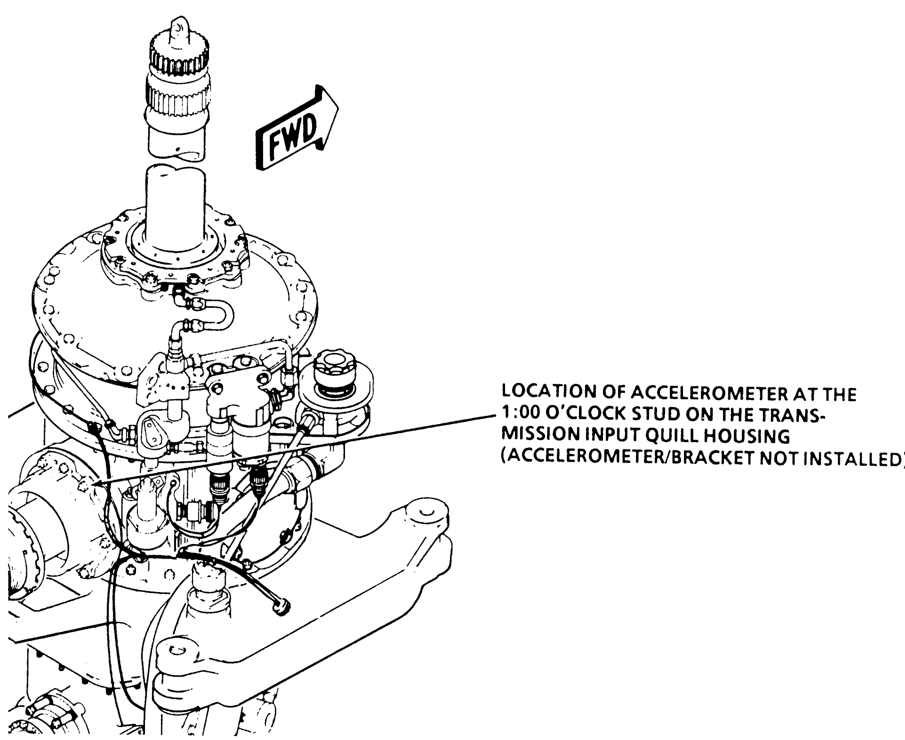


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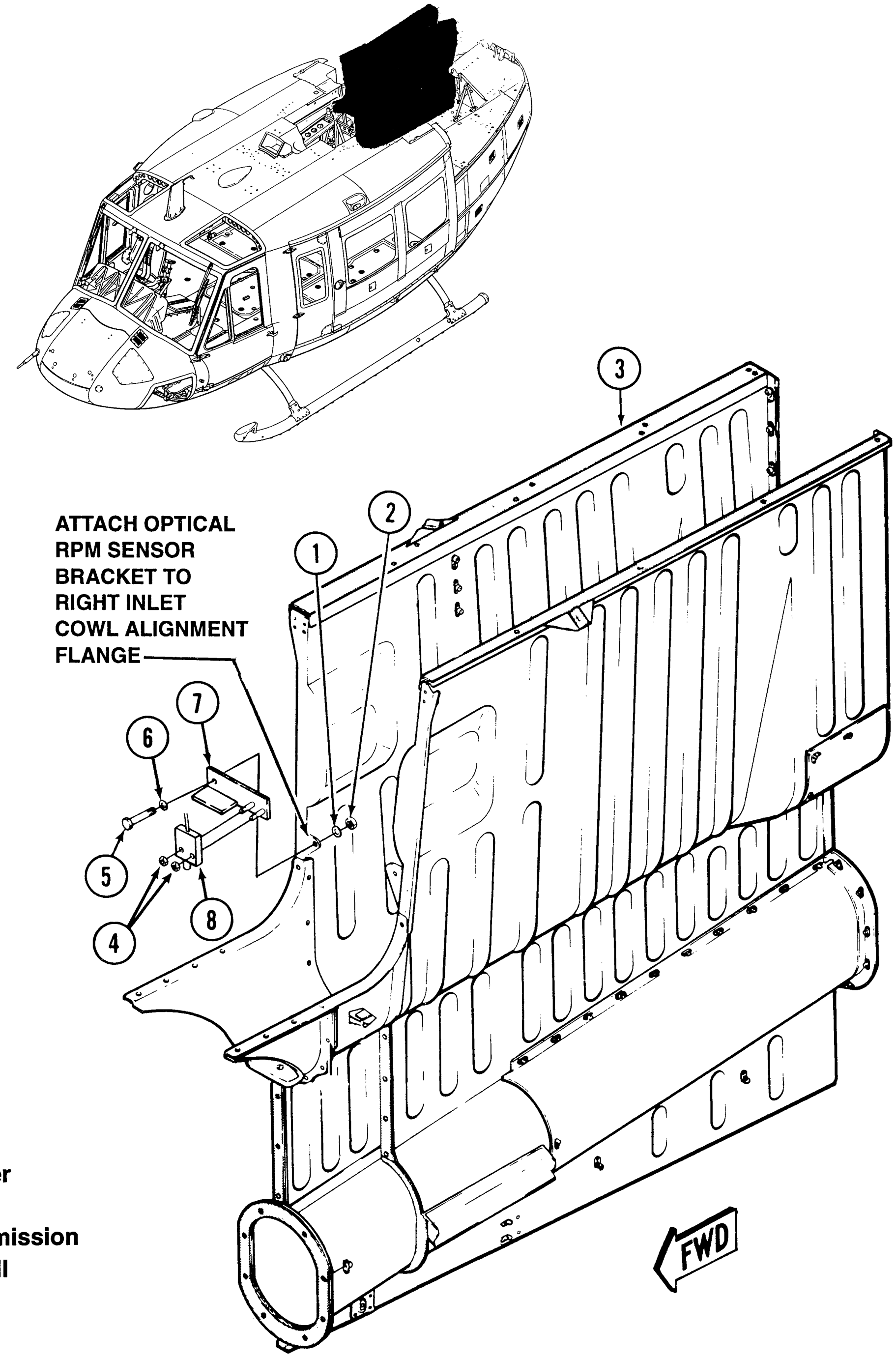
Figure 18-26. Combining gearbox and transmission input quill accelerometers



1. Washer
2. Nut
3. Transmission firewall
4. Nut
5. Bolt
6. Washer
7. Optical rpm sensor bracket
8. Optical rpm sensor

Figure 18-27. Optical rpm sensor and bracket

6. Operate helicopter with both engines and stabilize the main rotor at 100% percent rpm and increase torque to 30 percent. Center cyclic and directional pedals.

NOTE

On initial run, operate the helicopter for at least five minutes prior to taking tests.

7. With D/S highlighted, press DO to arm RADS AT. If all internal checks are successful the test condition title will appear at the bottom of the screen and system is armed to take data. Press DO to obtain data. If data has been successfully obtained, the RADS AT will indicate that the test is complete.

NOTE

If a TACH error occurs during testing, repeat test at least four times. If failure still occurs, proceed to next step.

8. If failure still occurs after repeating test four times:

a. Ensure reflective tape is in place and clean. Replace if necessary.

b. With power to DAU, verify that the red light on back of optical rpm sensor illuminates when the reflective tape is in front of optical rpm sensor.

c. Ensure that optical rpm sensor is connected to DAU port TACHO #2.

d. Orient helicopter so that sensor is in shadow (not in direct sunlight).

9. Select FINISH and then DIAGNOSTICS to review main driveshaft 1/rev levels and determine if any adjustments are required.

10. If main driveshaft balance is not acceptable, record predicted adjustments on form similar to one shown in figure 18-31 . Perform corrective action. Refer to table 18-9 for corrective action.

11. Repeat steps 1. through 9 . until main driveshaft is balanced.

NOTE

The RADS AT is operating on preset limits of 0.20 IPS for main driveshaft balance. If the operator desires to reduce the level to below 0.20 IPS then this can be done by pressing DO from limits screen. The RADS AT will specify adjustments required to achieve a 0 IPS balance.

12. If main driveshaft balance is acceptable, remove RADS AT from helicopter (paragraph 18- 43).

18-43. Main driveshaft balance adjustments.

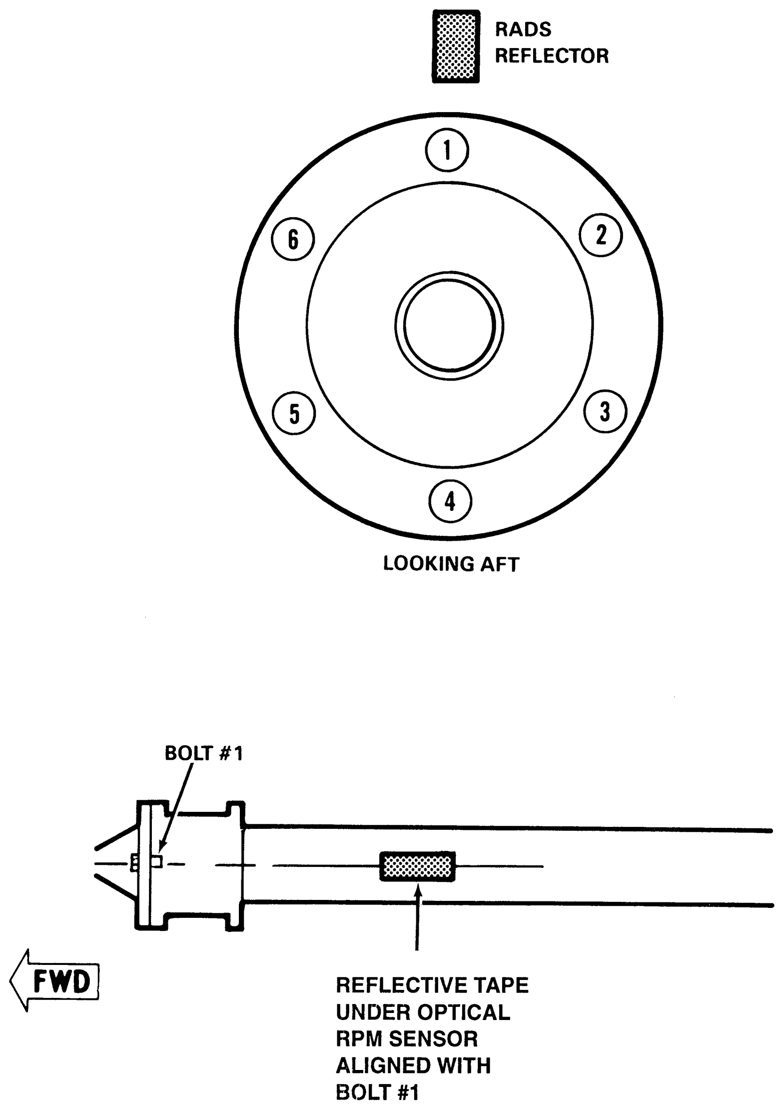
The RADS AT specifies corrections for main driveshaft balance as adjustments to balance weights on the aft and forward driveshaft shaft-to-adapter bolts as shown in figure 18-29 . As programmed, the RADS AT version 3.1 specifies adjustments only to #1 and #3 bolts. To specify adjustments for bolt #2, the EDIT ADJUSTABLES mode shall be used. The shaft is balanced by installing or removing balance weights from shaft-to-adapter bolts.

1. Once bolt to be adjusted has been determined, remove nut and bolt and using bolt/weight combination shown in table 18-10 , configure a weight package closest to weight specified by RADS AT.

NOTE

Bolt weights are referenced to minimum bolt size used. AN5-11A bolt shall be used when no weights are installed; AN5-12A bolt shall be used when one weight is installed, and the AN5-13A bolt shall be used when two weights are installed. Maximum stackup of weights is two per bolt.

2. Install bolt/weight package with weights under nut. Torque nuts 100 to 140 in lbs. (11.30 to 15.82 Nm).



NOTES

1. Bolt orientation shown is used to determine placement of balance weights from chart information.
2. Bolt #1 is bolt aligned with the reflective tape on the tube.
3. Bolt #1 and #3 are active in rads diagnostics.
4. Adding weight to bolt #1 is same as removing weight from bolt #4.
5. Adding weight to bolt #3 is same as removing weight from bolt #6.

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Figure 18-28. Reflective tape installation, main driveshaft

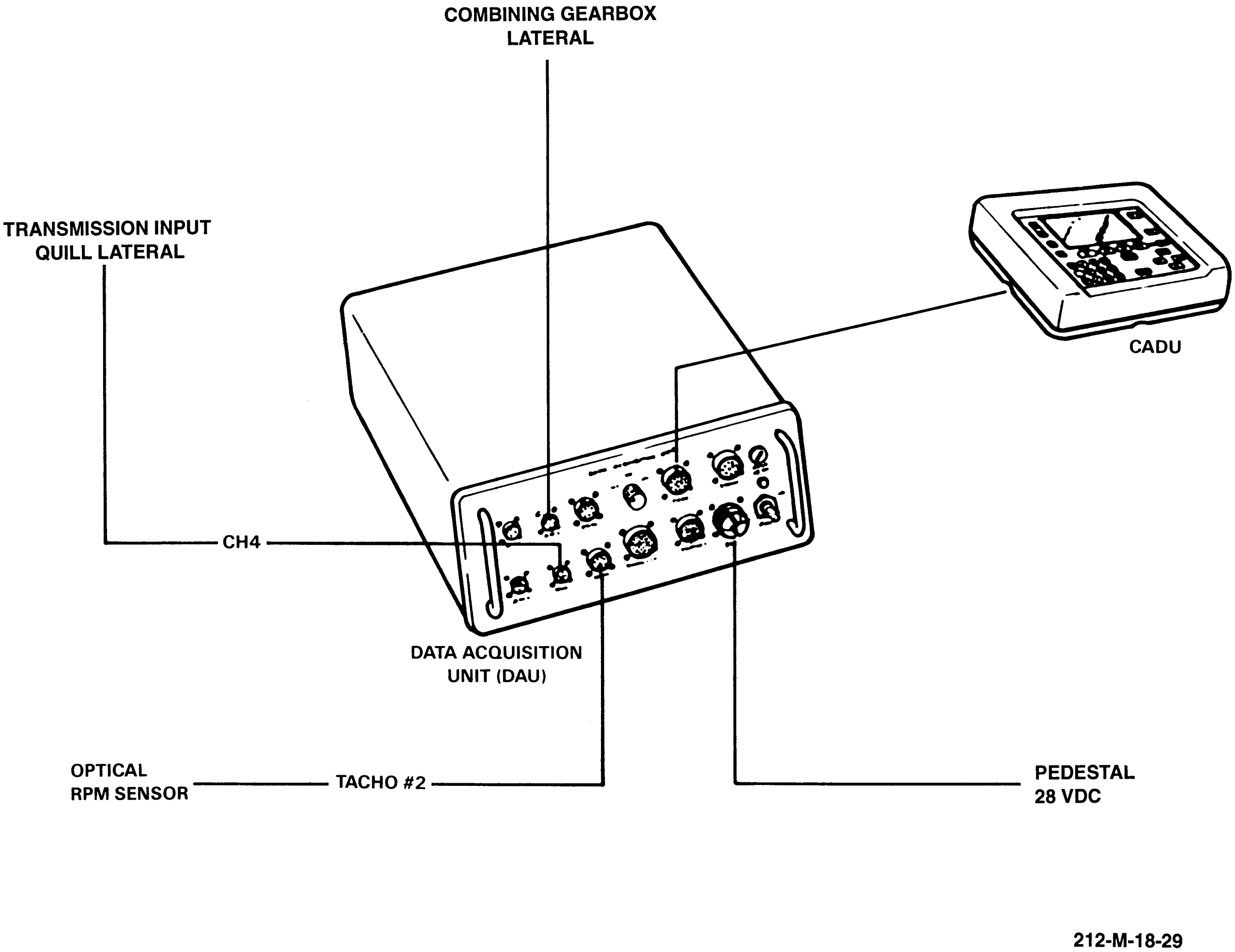

Figure 18-29. RADS AT configuration for balancing main driveshaft

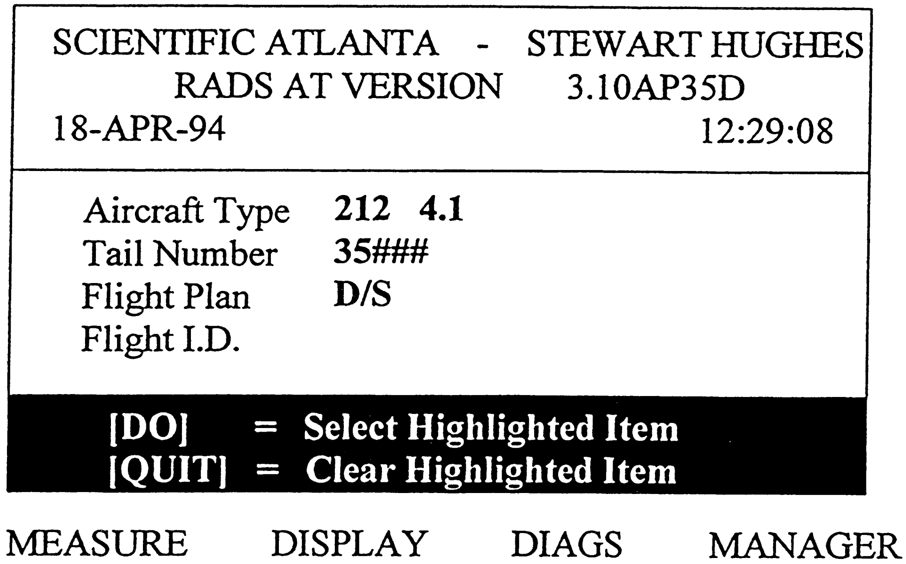

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Figure 18-30. Main driveshaft balancing CADU screen

3. Repeat procedures of paragraph 18-43 until main driveshaft is balanced.

18-44. Removal - RADS AT.

1. Disconnect 29314101 28 VDC power cable from 28 VDC port on copilot side of pedestal and from DAU.

2. Disconnect 29325601 communication cable from DAU and CADU.

3. Remove 29314700 optical rpm sensor and 29338500 or 29338501 optical rpm sensor bracket from right inlet cowl alignment flange of transmission firewall.

4. Remove 991D accelerometer and 29329700 accelerometer bracket from transmission input quill.

5. Remove 991D accelerometer and 29329700 accelerometer bracket from combining gearbox quill.

6. Remove DAU from cabin aft of crew seats.

18-45. GENERAL VIBRATION CHECK (OPTIONAL) - RADS AT.

For procedures to perform vibration check (VIBCHK), refer to paragraph 18-29.

18-46. VIBRATION TROUBLESHOOTING (OPTIONAL) - RADS AT.

For procedures to perform vibration troubleshooting (SPECTRUM), refer to paragraph 18-31.

RADS AT FLIGHT I.D.	SHAFT END	BOLT #1	BOLT #2	BOLT #3	BOLT #4	BOLT #5	BOLT #6	1/REV LEVEL
DATE = ______	AFT							
TIME = ______	FORWARD							

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	SHAFT END	BOLT #1	BOLT #2	BOLT #3	BOLT #4	BOLT #5	BOLT #6	1/REV LEVEL
DATE = ______	AFT							
TIME = ______	FORWARD							

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	SHAFT END	BOLT #1	BOLT #2	BOLT #3	BOLT #4	BOLT #5	BOLT #6	1/REV LEVEL
DATE = ______	AFT							
TIME = ______	FORWARD							

NOTES ON PREVIOUS RUN:

RADS AT FLIGHT I.D.	SHAFT END	BOLT #1	BOLT #2	BOLT #3	BOLT #4	BOLT #5	BOLT #6	1/REV LEVEL
DATE = ______	AFT							
TIME = ______	FORWARD							

NOTES ON PREVIOUS RUN:

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Figure 18-31. Main driveshaft adjustment log

Table 18-9. Vibration source — Driveshaft

PROBLEM	FREQ (HZ)	PROBABLE CAUSE	CORRECTIVE ACTION
Low Frequency Oscillation	5.4	Worn pylon dampers	Replace pylon dampers
Main Rotor Lateral in Flight	5.4	Main rotor out-of-balance	Balance main rotor
Main Rotor Vertical in Flight	5.4	Main rotor out-of-track	Track main rotor
Instrument Panel Vibration	10.8	Instrument panel support failure	Inspect instrument panel supports, replace or repair as necessary
Increased Cabin Vibration	10.8	Degraded skid gear supports	Inspect skid gear supports, replace degraded assemblies
	10.8	Loose battery	Inspect battery and battery deck, tighten and repair as necessary
	10.8	Degraded pylon mounts	Inspect pylon corner and fifth mount, replace degraded components
	10.8	Swashplate freeplay	Inspect swashplate, replace worn bearings
Medium Frequency Vibration in Cabin	27.7	Tail rotor out-of-track and balance	Track and balance tail rotor
Taill Rotor Balance Erratic	27.7	Loose tail rotor trunnion	Inspect and recenter tail rotor trunnion
Vibration in Pedals	70-80	Chattering tail rotor boost cylinder	Replace tail rotor boost cylinder
Pulsating Noise in Cabin	110	Out-of-balance main driveshaft	Balance driveshaft paragraph 18-41
High Frequency Vibration in Cabin or on Drivetrain	139	Rotor brake out-of-balance or support bearings worn	Inspect disc and bearings for damage or wear, replace damaged components
	144	Oil cooler fan blades damaged	Inspect oil cooler fans, replace any damaged components

Table 18-10. Hardware and Weight — Driveshaft

PART NO.	NAME	WEIGHT GRAMS	WEIGHT OUNCES
AN5-12A	Bolt	2.00	0.07
AN5-13A	Bolt	4.00	0.14
100-106-1	Plate, balance weight	14.18	0.50
100-106-2	Plate, balance weight	7.09	0.025
100-106-3	Plate, balance weight	2.84	0.10