Application Note

Application Note Number	A-NG-RQ-4A-4040-FB
Version	1.1
Function	Fan Trim Balance
Airframe	RQ-4A
Engine	Allison AE3007H
Other Application Notes Required	None
ACES Systems Analyzer	Viper 4040
Firmware Version	1.04 or greater
Procedure Cards	N/A

Introduction

This Application Note is number 1 of 1 Application Notes required to perform a fan trim balance on a Northrup Grumman RQ-4A Global Hawk with a Allison AE3007H engines. This Application Note describes the steps necessary for set up and operation of the Viper 4040 analyzer and associated equipment.

Required Equipment: The following equipment is required to accomplish a single engine fan trim balance.

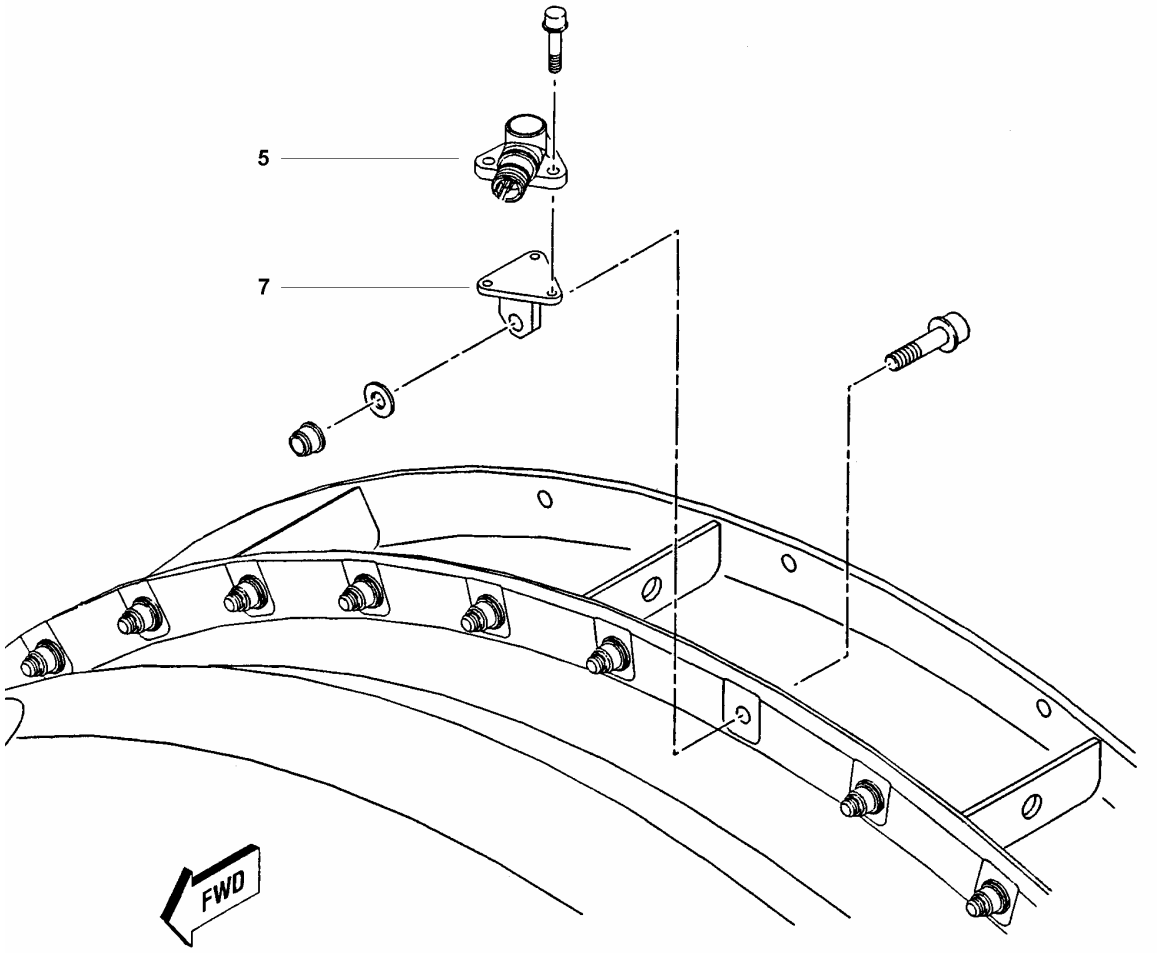
Item	Quantity	Description	Part Number
1.	1EA	Analyzer, Viper 4040	10-100-4040
2.	1EA	Cable, Vibe, Sensor, 991V	10-320-0158
3.	1EA	Tachometer, Lasetach II, 299 (Reflective tape included)	10-100-1300
4.	1EA	Mount, Lasetach Swivel	10-100-0369
5.	1EA	Sensor, Endevco 6222S-20 with 510 Chg Conv & Cable	Z10-100-1510
6.	1EA	Cable, Tachometer, Generic, 50 Ft.	10-320-0126
7.	1EA	Mount, Sensor, AE3007	22-430-0145
8.	As required	Balance weights (Rolls-Royce Part Numbers 23054038-X)	

Optional Equipment: You may extend the distance to the analyzer in 50 increments with an additional item 6 and a generic vibration cable, PN 10-320-0127.

TEC Part Number 11-200-0160

A. Equipment Set Up

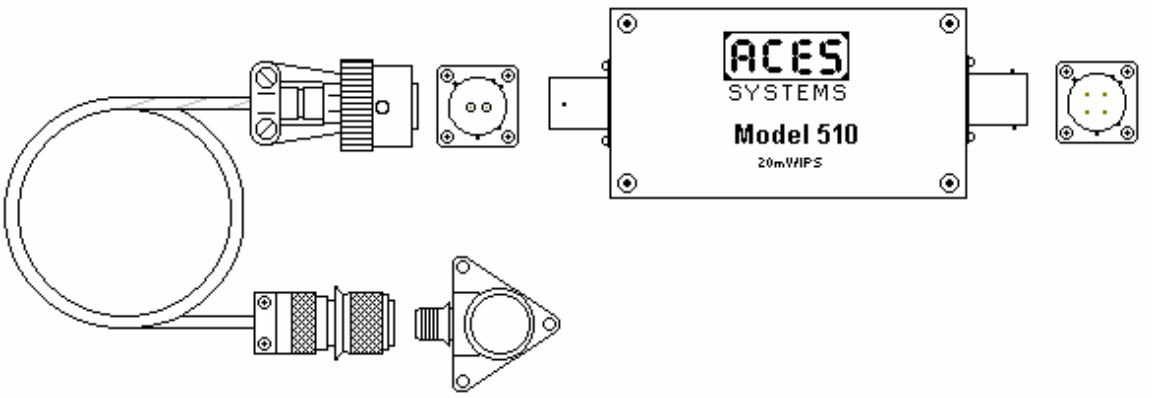
1. Open the engine cowling to gain access to the outer-bypass duct rear support. Remove the bolt, washer, and the nut from the 12:00 position that attaches the outer bypass duct to the outer bypass duct rear support. Attache the vibration sensor mount, item 7, to the rear support using the nut, washer and bolt removed from the outer bypass duct as shown in the drawing below. Torque the nut to 74 – 89 inch pounds.



Vibration Sensors – Installation

2. Install the 6222S-20 sensor, itme 5, to the installed sensor mount using the three socket head screws supplied with the sensor. Torque the socket head screws to 37 – 42 inch pounds.

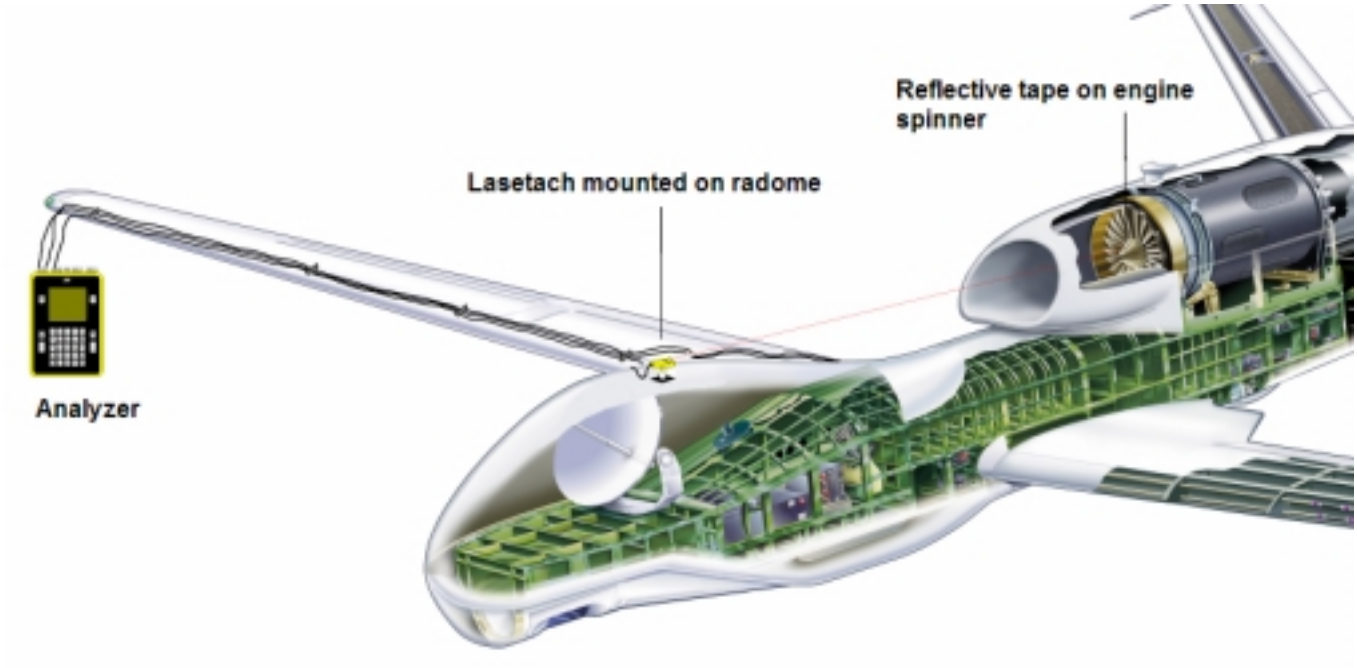
3. Attache the sensors white high temperature cable to the sensor and to the 2-pin connector of the 510 charge converter.



4. Route the four pin socket end of the 991V sensor vibe cables (item 2.) to the engine and though available access doors in the cowling to the sensor location. Attache the cable, itme 2, to the four pin end of the 510 charge converter. Secure the cables and charge converter with wire ties to prevent movement during the engine run. Close the cowling and route the cable along the fuselage and leading edge of the wing toward the location where the analyzer will be positioned for the balance job. Use additional Generic tach cables, item 6, and optional Generic vibration cable, PN 10-320-0127, as necessary to extend the distance between the aircraft and the analyzer operator in 50 ft increments. Secure the cable every 36 inches with duct tape or aluminum speed tape.

5. Assemble the ACES Model 299 Lasetach (item 3.) and swivel mount (item 4.). Position this assembly on top of the radome and in a direct line with the engine intake. Secure the swivel mount base (item 4.) to the radome with speed or duct tape.

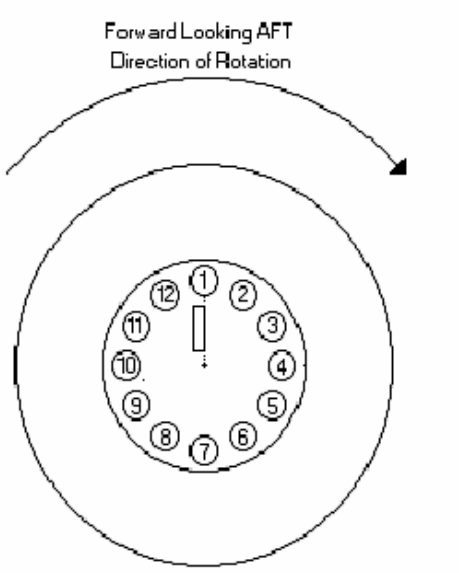
6. Attach socket end of the 50 Ft. TACH CABLE (item 6.) to the pin end of the Lasetach connector. Route the cable along the fuselage and leading edge of the wing toward the location where the analyzer will be positioned for the balance job. Use additional Generic tach cables, item 6, and optional Generic vibration cable, PN 10-320-0127, as necessary to extend the distance between the aircraft and the analyzer operator in 50 ft increments. Secure the cable every 36 inches with duct tape or aluminum speed tape.

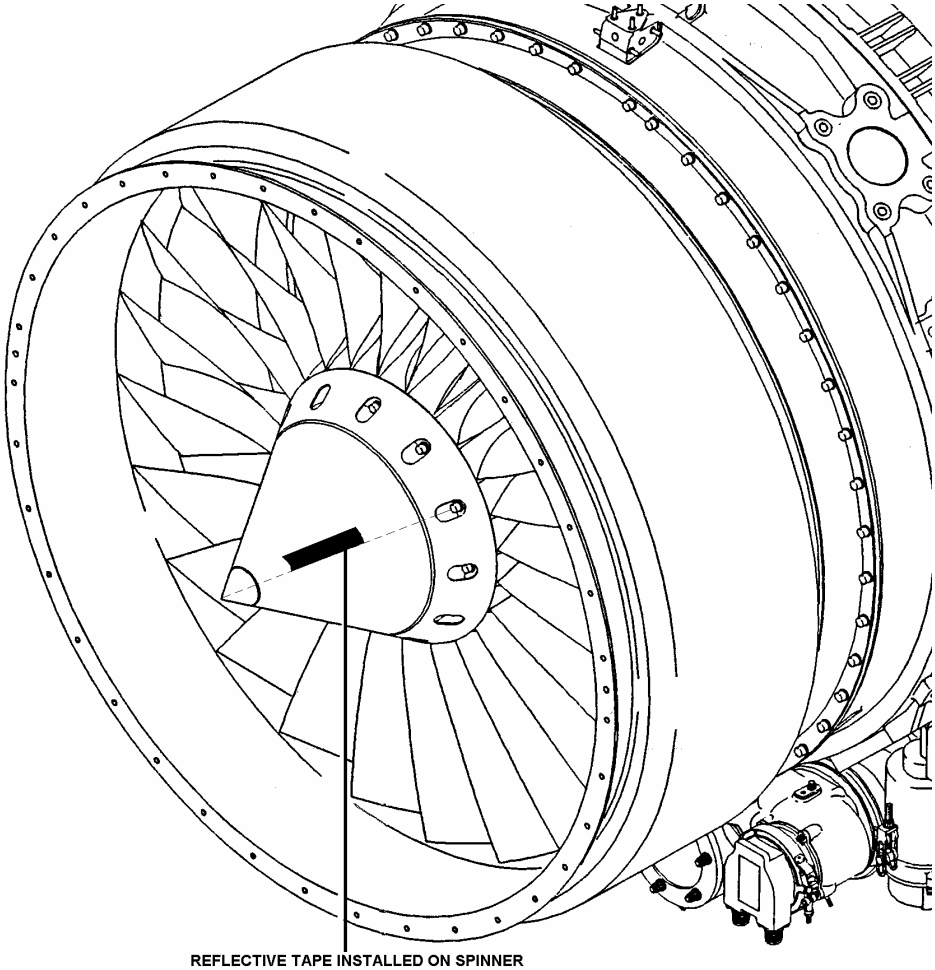


NOTE
Reflective quality is not the same for all reflective tape. Use only 3M brand, #7610 for best results with the Lasetach.

7. On the engine spinner, draw an imaginary line from the center of the spinner tip to the center of any one of the twelve weight attachment boltholes. Clean the surface along the trailing edge of this line with a degreaser such as MEK and dry thoroughly. Visually align the leading edge of a two-inch length of reflective tape with the imaginary line. Remove the protective backing from the tape and apply at this location. (See Figure below.) Make sure all edges are smooth and flat and that no bubbles are under the tape. The bolt aligned with the tape is now designated #1. The remaining numbers, 2 through 12, are in a clockwise accending order, from forward looking aft, as shown in the drawing below. Alignment of the laser will be accomplished later in this procedure.

[redacted]


Forward Looking AFT
Direction of Rotation
12
1
2
3
4
5
6
7
8
9
10
11


REFLECTIVE TAPE INSTALLED ON SPINNER

7. Place the analyzer, item 1, in the location it where the operator will use it. Connect the various cables as follows:

7.1 991V Vibe Sensor Cable, item 2, (or Generic vibration cable if being used as an extension) to the six pin connector marked "**CHANNEL A**"

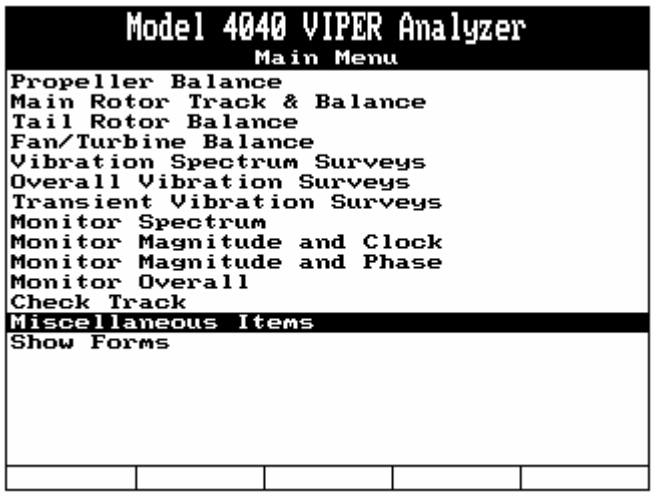
7.2 Tach Cable, item 3, to the three pin connector marked "**TACH 1**"

8. **Fan Balance Setup.**

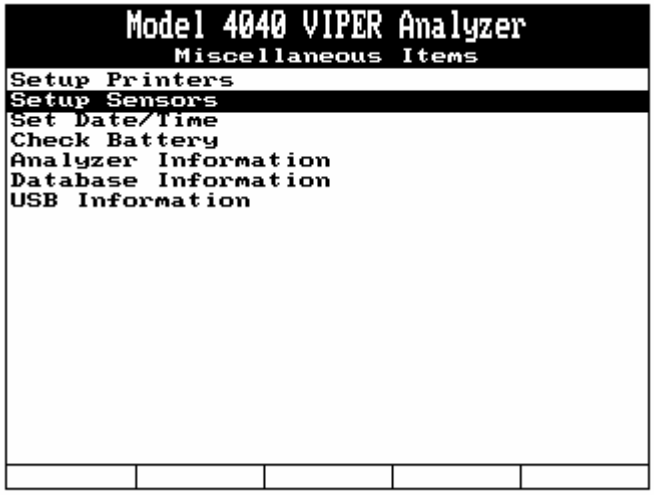
8.1 This section will give you the steps to enter the AE3007H Setup into the Viper Analyzer. If the setup has been previously entered, you need not repeat this step. If the setup is available, go to section B. Data Acquisition. Otherwise proceed to 8.2 below.

8.2 Turn the analyzer on by pressing the ON/OFF key.

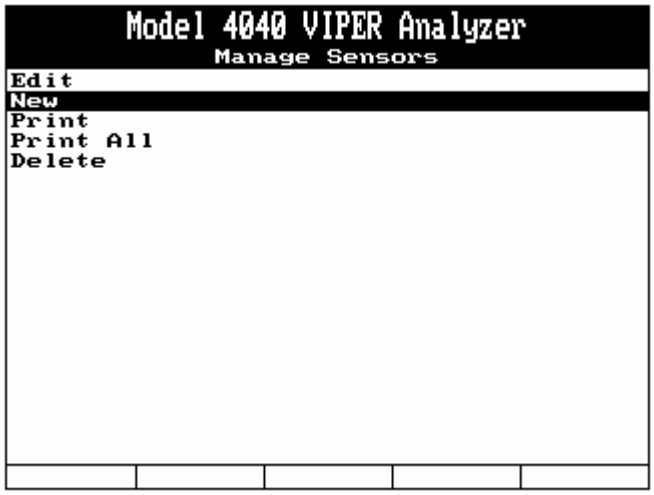
8.3 From the Main Menu, select Miscellaneous Items.



"Setup Sensors".

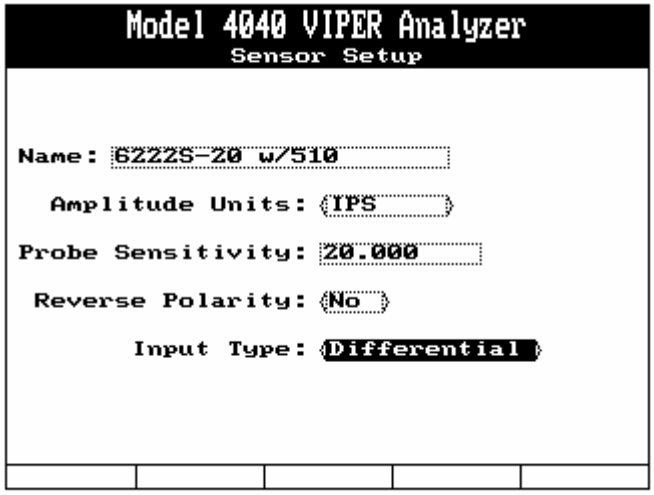


8.5 From the Manage Sensors menu, select “New”.



8.6 Complete the Sensor Setup screen, shown below, as follows:

n the **Name:** field, enter “6222S-20 w/510”. . Press the ⇩ key to move to the next field.



8.6.2 In the **Amplitude Units:** field, use the ⇨ key to select "IPS". This is the engineering unit of output for the charge converter. Press the ⇩ key to move to the next field.

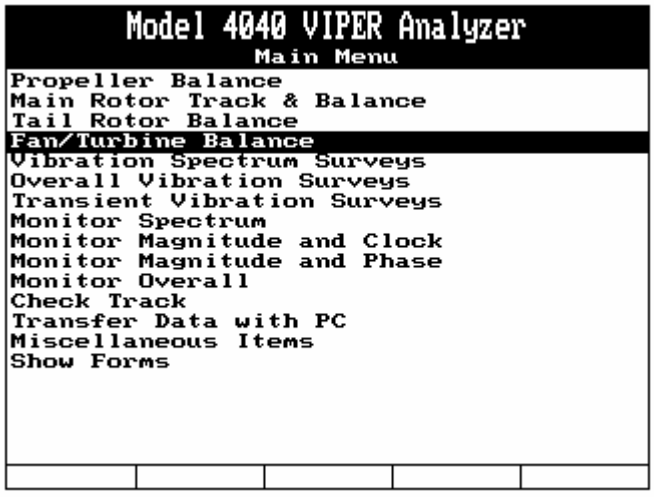
8.6.3 In the **Probe Sensitivity:** field, enter "20". This indicates the output of the sensor (20 pC/g) after it passes through the processing by charge converter which outputs 20 mV/IPS. Press the ⇩ key to move to the next field.

8.6.4 In the **Reverse Polarity:** field, use the ⇨ key, if necessary, to select "No" indicating the sensor polarity is not reversed. Press the ⇩ key to move to the next field.

8.6.5 In the **Input Type:** field, use the ⇨ key, if necessary, to select "Differential" indicating the type input to the sensor.

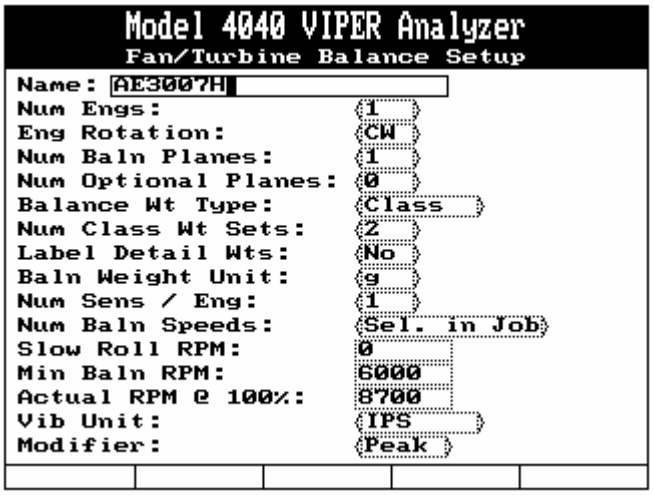
8.6.6 When all fields are complete, press ENTER to accept and save. The screen will return to the "Manage Sensors" screen. From that screen, press [BACKUP] repeatedly until the Main Menu is again displayed.

8.7 From the Main Menu, select "Fan / Turbine Balance"



8.8 If there are other setups already in the analyzer, the Setup List banner screen will be displayed. From that screen, press the [F1] “New” key. If no setups are in the analyzer, the “Fan / Turbine Balance Setup” screen, shown below, will be displayed automatically. Complete the Balance Setup screen as follows:

8.8.1 Use the keypad to enter “AE3007H” in the **Name:** field. Press the ⇩ key to move to the next field.



8.8.2 In the **Num Engs:** (number of engines) field, use the use the ⇨ key to select “1”. Press the ⇩ key to move to the next field.

8.8.3 In the **Eng Rotation:** field, use the ⇨ key to select “CW” indicating the fan rotates clockwise as viewed from the front looking aft into the intake. Press the ⇩ key to move to the next field.

8.8.4 In the **Num Balan Planes:** (number of balance planes) field, use the ⇨ key to select “1”. Press the ⇩ key to move to the next field.

8.8.5 In the **Num Optional Planes:** (number of optional balance planes), use the ⇨ key to select “0”. Press the ⇩ key to move to the next field.

8.8.6 In the **Balance Wt Type:** field, use the ⇨ key to select “Class”. The class weights will be defined on another page. Press the ⇩ key to move to the next field.

8.8.7 In the **Num Class Wt Sets:** (number of class weight sets), use the ⇨ key to select “2”. The AE3007 has two class weight sets that may be used to trim balance the engine. Press the ⇩ key to move to the next field.

8.8.8 In the **Label Detail Wts:** field, use the ⇨ key to select “No”. Detail weights are those weights which cannot be removed but occupy holes normally used for adding trim balance weights. If the answer is yes in this field, the analyzer will optimize the balance solution on available holes only. The 3007 engine does not use detail weights in the trim balance weight locations so the answer for this field is “NO” Press the ⇩ key to move to the next field.

8.8.9 In the **Baln Weight Units:** field, use the ⇨ key to select "g' for grams. The class weights for the AE3007 are measured in grams. Press the ⇩ key to move to the next field.

8.8.10 In the **Num Sens / Eng:** field, use the ⇨ key to select 1. This is the number of speeds that will be used for the balance job. Press the ⇩ key to move to the next field.

8.8.11 In the **Num Baln Speeds:** field, use the ⇨ key to select the total number of speeds (up to 9) you will use for this setup. Optionally, you may choose "Select in Job" which will allow you to specify the number of balance speeds with each new job rather than defaulting to a number you select here in the setup. Three speeds are recommended for balancing if the throttle is routinely moved throughout a specific range. If typical operation is at a single speed, then the engine should be balanced at that speed and this field should read "1". Press the ⇩ key to move to the next field.

8.8.12 In the **Slow Roll RPM:** field, use the keypad to enter "0". Slow roll is a compensating RPM for use in engine applications where proximity probes are used and does not apply to this engine. Press the ⇩ key to move to the next field.

8.8.13 In the **Min Baln RPM:** field, use the keypad to enter the minimum speed at which this engine can be balanced. This speed will normally be a speed in the flight range. Press the ⇩ key to move to the next field.

8.8.14 In the **Actual RPM @ 100%:** field, use the keypad to enter the speed of the fan at 100% rpm. For the AE3007H, this is 8700. Press the ⇩ key to move to the next field.

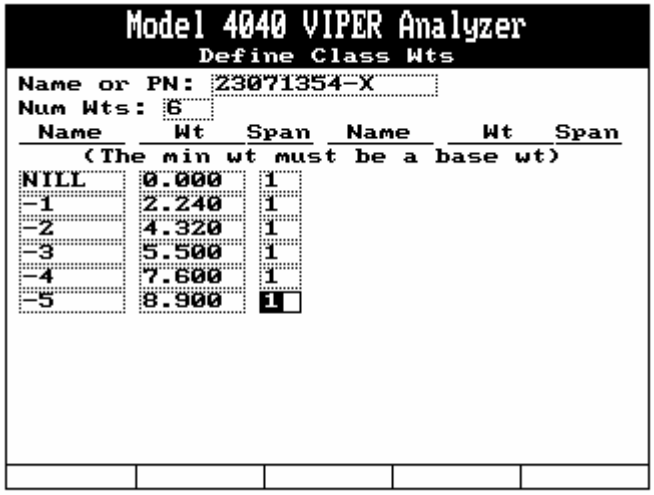
8.8.15 In the **Vib Unit:** field, use the ⇨ key to select "IPS". The AE3007H engine is balanced using velocity units of inches per second. Press the ⇩ key to move to the next field.

8.8.16 In the **Modifier:** field, use the ⇨ key to select "Peak". When all fields are complete, press [ENTER] to accept and continue.

8.7 The Define Class Weights banner screen will be displayed where each of the class weights used for the AE3007 fan trim balance will be added to the setup. Complete each field in the screen as follows:

8.7.1 In the **Name or PN:** field, use the keypad to enter "23071354-X". This is the part number, which identifies one of two class weight sets used for the AE3007E. The "-X" at the end of the number represents a digit (1 through 5) of the individual weights. Press the ⇩ key to move to the next field.

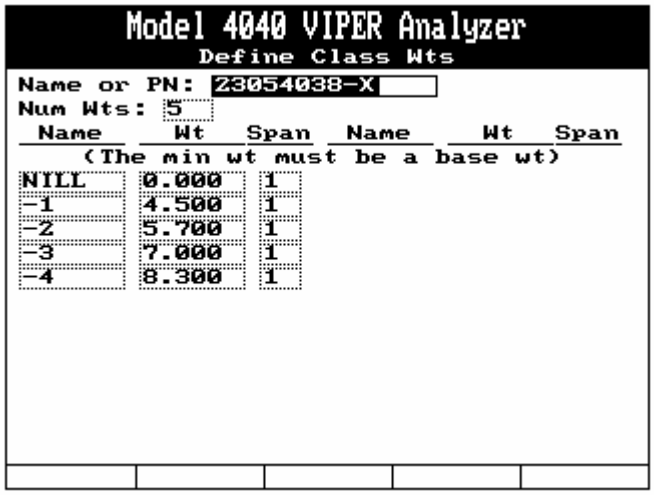
[redacted]



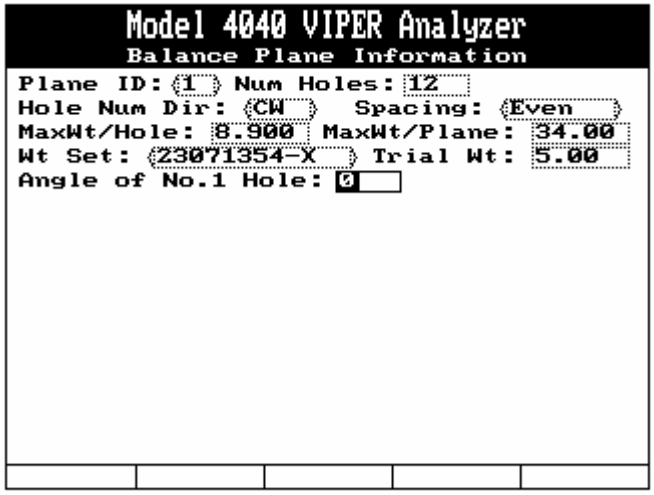
8.7.2 In the **Num Wts:** field, use the keypad to enter a total number of weights in this class weight set 5, plus 1 for a total of 6. The sixth weight will be the NILL weight which means a negative or null weight having no influence on the balance. Press the ⇩ key to move to the next field.

8.7.3 In the **Name, Wt,** and **Span** columns, enter the information as shown in the illustration above for the six class weights. The name will be the dash (-) number of the individual weights, the weight is measured in grams for each individual class weight and the span is the number of holes each individual weight covers when installed. When all information is entered as shown, press [ENTER] to accept and continue.

8.8 The Define Class Weights banner for the second class weight set will be displayed. Using the example in paragraph 8.7 above, complete the second class weight set using the information exactly as it appears in the screen below.

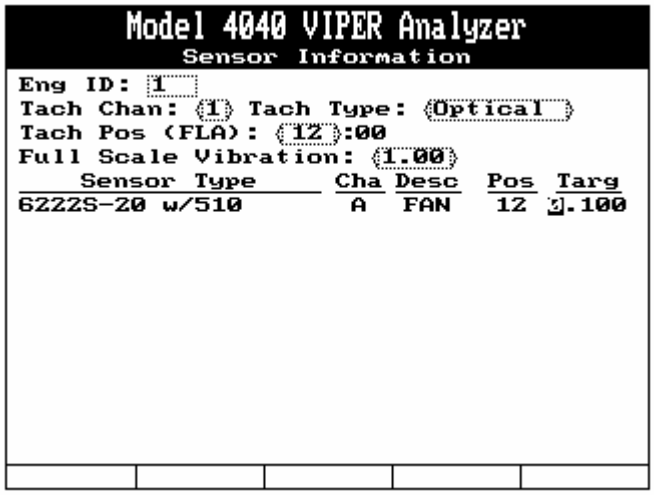


8.9 When all information is completed, press [ENTER] to accept and continue.



8.10 The Sensor Information screen will be displayed. Complete the screen as follows:

8.10.1 In the **Eng ID:** field, use the keypad to enter a single alphanumeric character to identify this engine such as L, R, 1 or 2. . Press the ⇩ key to move to the next field.



8.10.2 In the **Tach Chan:** field, use the use the ⇨ key to select the tach channel you wish to use. This must be the tach channel, 1, 2, 3, or 4, where you connect the tach input cable for the engine being balanced. Press the ⇩ key to move to the next field.

8.10.3 In the **Tach Type:** field, use the ⇨ key to select the type of tachometer you are using. If using a Lasetach or Phototach, select Optical. Press the ⇩ key to move to the next field.

8.10.4 In the **Tach Pos (FLA):** (tachometer position as viewed from forward looking aft), use the ⇨ key to select a clock position where the laser beam strikes the spinner when power to the laser is on. This should be approximately 12:00 for this engine. Press the ⇩ key to move to the next field.

8.10.5 In the **Full Scale Vibration:** field, use the ⇨ key to select the highest amplitude you reasonably expect to experience for this balance job. Amplitude of 1 IPS is sufficient for the AE3007. Press the ⇩ key to move to the next field.

8.10.6 In the **Sensor Type** column, use the ⇨ key to select a sensor from those sensors programmed into your analyzer. If using the 6222S-20 and 510 charge converter programmed into the analyzer at the beginning of this procedure, select it now. Press the ⇩ key to move to the next field.

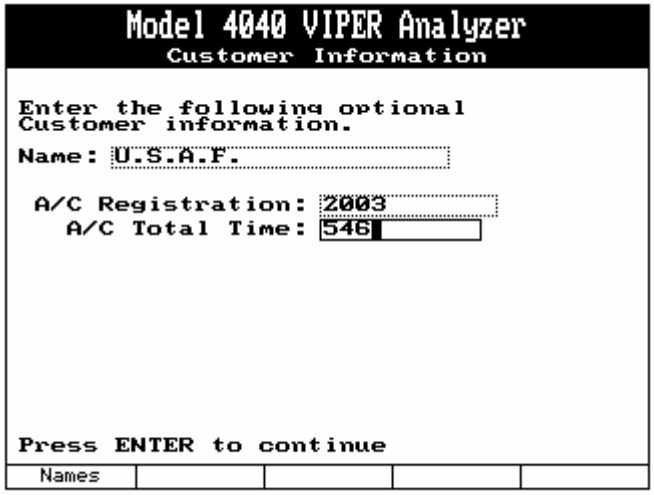
8.10.7 In the **Cha** field, use the ⇨ key to select the channel you will connect the incoming vibration signal to, A, B, C, or D. Press the ⇩ key to move to the next field.

8.10.8 In the **Desc** field, use the keypad to enter a description of the channel-identified sensor such as Fan. Press the ⇩ key to move to the next field.

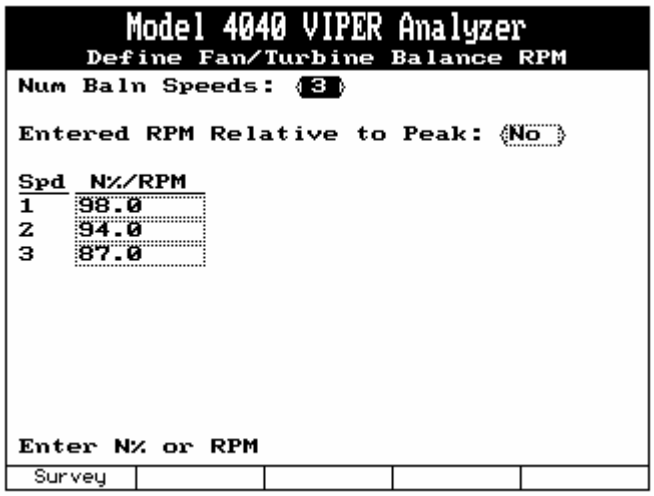
8.10.9 In the **Pos** (position) field, use the ⇨ key to select the approximate clock position of the vibration sensor on the engine as viewed from forward looking aft into the intake. This position should be 12:00 for this engine. If you are not sure of the position, select "UNK" for unknown. The analyzer will compensate for the unknown position and locate it automatically with one additional engine run. Press the ⇩ key to move to the next field.

8.10.10 In the **Targ** (target amplitude) field, use the keypad to input amplitude you wish to achieve as a minimum acceptable using this setup. When all fields are complete, press [ENTER] to accept. The screen below will be displayed asking, "Store this new setup?" Press the [F1] "Yes" key to save or the [F5] "No" key to return to the setup.

8.11 After the setup is stored you may turn the analyzer off or proceed to the balance procedure. If you continue with the balance, the customer information screen below will be displayed. The information on this screen is optional and need not be filled in to continue with the job, however; this information will assist you in your record keeping efforts and greatly reduce the effort in recalling the job later from the analyzers memory or for the AvTrend database. Use the keypad to enter the Name, Aircraft Registration, and total aircraft time. If you have entered other names in the Name field previously, you may press the [F1] key and select from a list containing those stored names. When all fields are complete, press [ENTER] to accept and continue.



8.12 If you elected to Select Balance Speeds in the Job (see item 8.8.11 above) the “Define Fan/Turbine Balance RPM” banner, shown here, will be displayed. Use the ⇨ key to select the number of balance speeds for this job. You may choose up to nine speeds. If you have completed a survey for this engine and know the balance speeds you will use, enter those speeds in the “N% RPM” column. Press the ⇩ key to move to the next field.



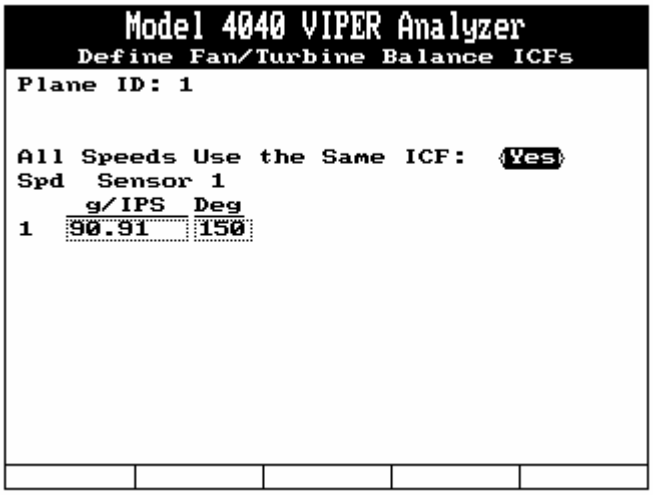
8.12.1 In the **Entered PRM Relative to Peak:** field, use the ⇨ key to toggle the answer field to Yes or No as appropriate indicating whether or not the speeds are relative to the peak vibration of a survey. The yes answer assumes you will enter a single peak speed and additional speeds of that single peak value plus and minus a given variable such as .5%. If this is the case, the three speeds in the example above might be 78.5% - 79%- 79.5%. If you choose several non related speeds at which you intend to balance, select “No” for the “Relative to Peak” answer field, then enter the speeds for balancing. If you have not performed a fan survey and do not have target balance speeds, you may press the [F1]

"Survey" key which will lead you through the process of performing a Press the ⇩ key to move to the next field.

8.12.2 In the **Peak Speed:** field, enter the speed of the highest peak vibration of the survey. You may enter either a %RPM or the actual RPM. The analyzer will make the distinction. Press the ⇩ key to move to the next field.

8.12.3 The **Spd** column will contain a number of rows relative to the number of balance speeds you specified. Immediately to the right of those numbers, in the **N%RPM** column, use the keypad to enter the balance speeds. If you wish to conduct a Fan Vibration Survey at this point to determine the balance speeds, press the [F1] "Survey" key and follow the directions on screen. When all fields are complete as necessary, press [ENTER] to accept and continue.

8.12.4 The Define Fan / Turbine Balance ICFs banner screen will be displayed. In the **All Speeds Use the Same ICF:** field, use the ⇨ key to toggle the answer field to Yes. If you have individual coefficient influences for each speed, answer No, otherwise answer Yes. Press the ⇩ key to move to the next field.



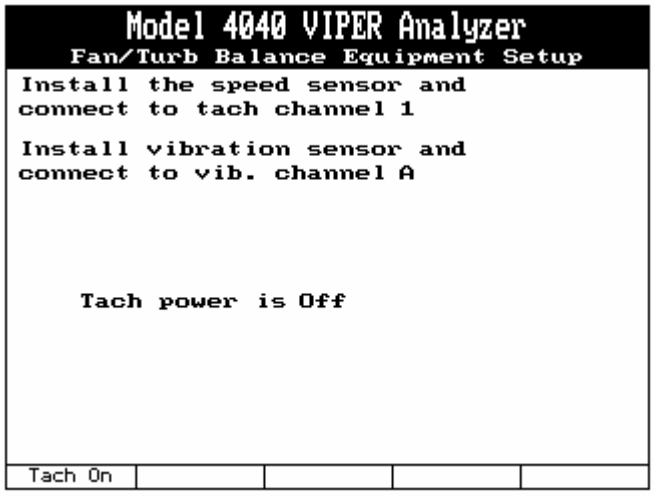
8.12.5 In the **g/IPS** column, use the keypad to enter the influence in grams per IPS. This value should be approximately 90.91 for the AE3007H. If you do not know the influence, leave it at zero. The analyzer will require one extra run to automatically calculate an influence for the engine. Press the ⇩ key to move to the next field.

8.12.6 In the **Deg** field, use the keypad to enter the phase lag, if known. 150 degrees is an approximate vale for this field. If you do not know the phase lag, leave this field at zero. The analyzer will calculate the phase lag automatically during the job. Press [ENTER] to accept your settings and proceed.

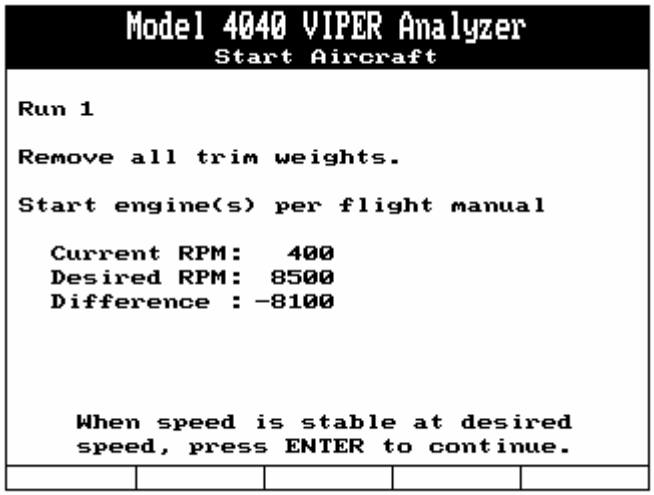
8.13 The Fan / Turb Balance Equipment Setup screen will be displayed. Follow the on screen instructions for installing and attaching sensors and cables. Notice that there is a message near the center of the screen reading "Tach power is off". This indicates the tachometer circuit is currently not powered for alignment of the Lasetach. If you are ready to align the Lasetach, press the [F1] "Tach On" key to power the laser and proceed tot he LASER

ALIGNMENT section at the end of this document. When the laser alignment is complete, return to this point and continue.

8.14 If the laser alignment is complete, press [ENTER] to continue. The power indication for the tach may be left in either the on or off position when exiting this screen.

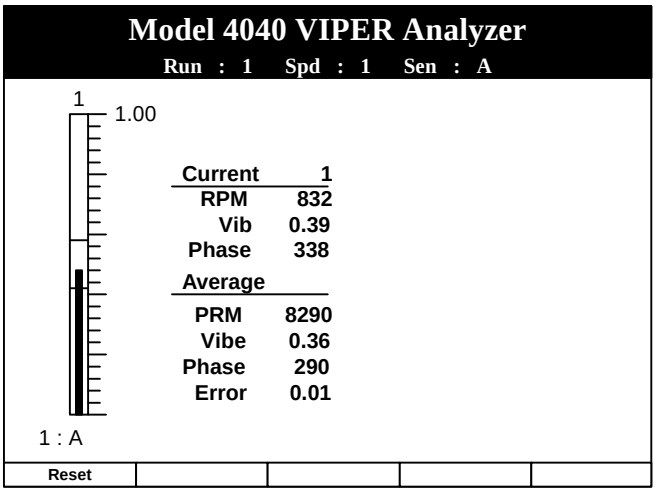


8.15 The Start Aircraft banner screen will be displayed. The Run number is indicated at the top left of the screen followed by the information message “Remove all trim weights.” Insure all previously installed trim balance weights have been removed. Start the engine(s) and watch for the Current RPM indication on the analyzer screen. When an indication of RPM is noted, allow the engine to warm up to normal operating temperature then accelerate the engine until the Current RPM and the Desired PRM on screen match as closely as possible. The Difference indication will show how many RPM difference there is between the Current and the Desired RPM. When the speeds are matched, allow the engine to stabilize for a short time and make any minor adjustments necessary, and then press [ENTER] to continue.

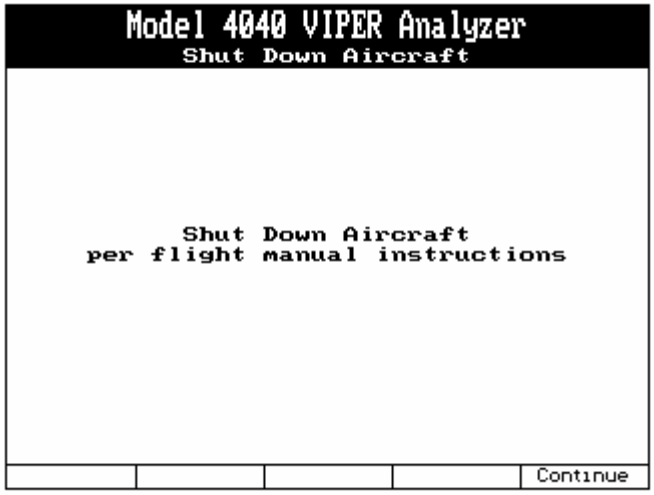


B. Data Acquisition

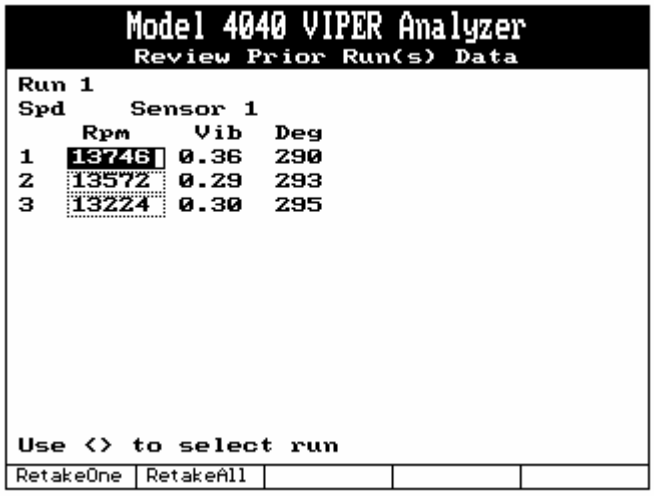
9.0 The Run 1, Spd 1, Sen 1 banner screen shown below will display the information for the first run. Indications of the Current and Average RPM, Vibration amplitude, and phase angel are displayed to the right of the converging scale. See the Viper 4040 User manual, chapter 20, Reading Spectrum and Scales for a detailed description of how to read the converging scale. After indications are stable, press [ENTER] to accept the collected data and continue. This screen will repeat for each of the speeds specified for balance. When all speeds are collected, the screen will automatically proceed to the shutdown message below in 11.17.



9.1 The Shutdown Aircraft message will be displayed. Press the [F5] “Continue key to acknowledge and proceed with a normal engine shutdown procedure.

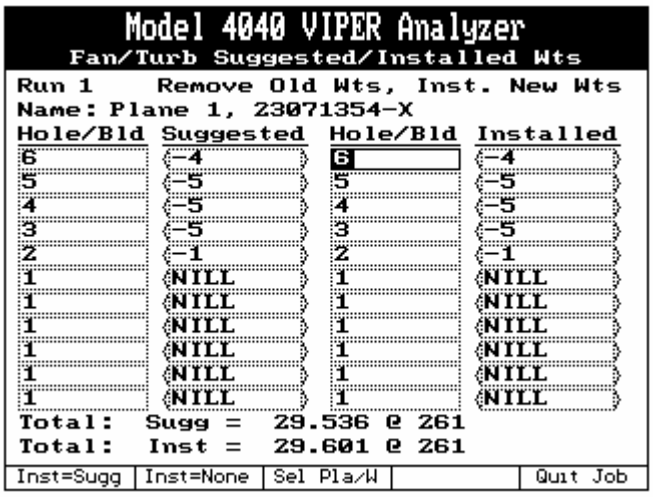


9.2 The Review Prior Run(s) Data will be displayed for your review of the data collected up to this point. You may view data from all runs by scrolling through the available run data using the ⇦ and ⇨ keys. Optionally you may use the [F1] and [F2] keys to Retake one or all data as required. When you are satisfied with the review, press [ENTER] to continue.

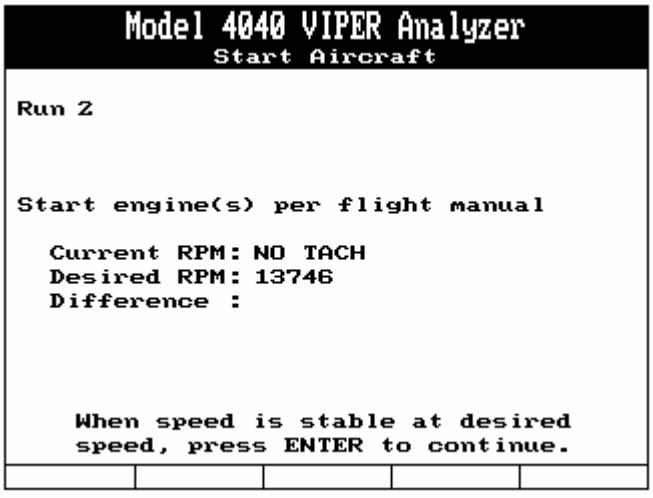


9.4 The Fan / Turb Suggested / Installed Wts screen will be displayed. Notice the first line of text in the screen shows the Run number and the message “Remove Old Wts, Inst. New Wts.” Remove all previously installed trim weights for the previous run and install the weights in the “Suggested” column in the hole numbers indicated to their immediate left. The right side of the screen reflects what you actually installed. Be sure the information in the Hole/Bld and Installed column are correct before exiting this screen. If you install the exact suggested weight, you need only press the [ENTER] key to exit this screen with that information. If you installed different weights or installed weights in different holes than those suggested, use the arrow key to navigate the matrix and indicate your exact installation. This is very important in that the analyzer will use this

information to calculate an influence for all subsequent runs. Notice the the function keys at the bottom of the screen are labeled for the options of "Inst=Sugg" (install the suggested weights in the suggested holes), "Inst=None" (Install None or no weights), "Sel Pla/W" (select a different Plane or weight set), and "Quit Job" When all fields are complete, press [ENTER] to accept and continue.



9.5 The Start Aircraft banner screen will be displayed for the next sequential run as indicated in the upper left portion of the screen. From this point, the sequence of events from paragraph 9.0 through 9.5 repeat until the fan vibration is reduced to an acceptable level. Normally this goal will be attained in one to three runs.



LASER ALIGNMENT

1. Rotate the fan until the reflective tape on the spinner is positioned at the 9:00 position for number 1 (left engine) or 3:00 for the number 2 (right engine). Clock position is from the Front of the engine, looking aft into the intake.

2. Ensure the Lasetach is securely mounted and connected as described in Equipment Setup. Also check to make sure the Lasetach is securely mounted to the Swivel Head of the Lasetach Mount. (See figure 3 below). If it is loose, tighten by turning the Lasetach clockwise on the mounting stud while holding the Swivel head with the other hand.

3. Remove the plastic aperture cap from the Lasetach.

4. Turn the Laser **ON/OFF** switch on top of the Lasetach to the **ON** position.

5. The **BEAM ON** indicator (red) light adjacent to the Laser **ON/OFF** switch should now be illuminated.

6. Place the open palm of your hand in front of the aperture. The laser beam should be visible on your palm.

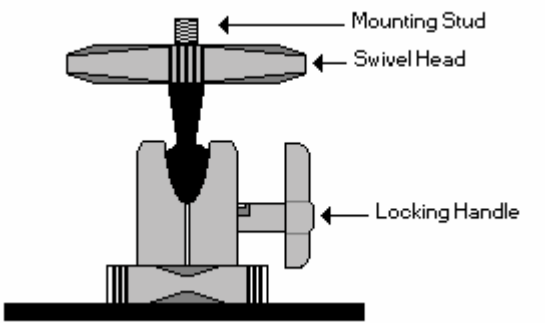
WARNING

Do not look into the aperture of the Lasetach. Avoid direct eye exposure. Eye damage may occur due to direct exposure to laser radiation.

7. Loosen the Locking Handle of the Lasetach mount (see figure below) so that the Lasetach swivels with a slight friction. Using the “gunsight” method, sight along the side of the Lasetach using one hand while holding the Locking Handle with the other. If you have trouble acquiring the laser beam visually, you may use a free hand to sight on. No injury will occur as a result of the laser being projected on your skin. You may also choose to have someone hold a sheet of white bond paper near the target for easier acquisition. When the laser beam strikes the tape, it will be very visible. When the laser is on target, center the beam on the length of the tape and immediately tighten the Locking handle by turning it clockwise. Release both hands and recheck the alignment.

8. The laser should now be approximately in the center of the two-inch span of the tape. If minor adjustments are necessary, loosen the Locking Handle only SLIGHTLY. Make adjustments as necessary and re-tighten.

9. When satisfied with the laser position, rotate the fan several times. When the tape passes through the laser position, the GATE (green) light on the Lasetach should turn on as the tape enters the beam and off as it exits. If this test is successful, return to the cockpit and select the opposite Tach. Repeat steps **1.** through **9.** above for the second Lasetach. When complete, return to the cockpit and continue with the Equipment Setup section of this document.



Application Note

Northrup Grumman RQ-4A Global Hawk

Fan Trim Balance

Part Number: 11-200-0161

AppNote Number: A-NG-RQ-4A-4040-FB

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