



Application Note

Bell 230

Main Rotor Track and Balance

Part Number: 11-200-0058

AppNote Number: A-BE230-2020-MR (Rev. 1.1 May 2004)

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Application Note

Application Note Number	A-BE230-2020-MR
Revision	1.1 (From aircraft data Rev. 6)
Function	Main Rotor Track and Balance
Airframe	Bell 230
Engine	N/A
E-Setup Number	A-BE230-2020-MR.asf
ACES Systems Analyzer	Model 2020, Model 2020 with EPS
Firmware Version	2.0 or greater
Procedure	N/A

Introduction

This Application Note covers the required equipment, equipment installation, analyzer setup, data acquisition and solution process for using the ACES Systems Model 2020 with the Enhanced Main Rotor Performance Software option to perform main rotor track and balance on the airframe listed above. General instructions for the use of the Model 2020 can be found in the Model 2020 User Manual #2020OM-01 (P/N 75-900-2020), Enhanced Performance Software (EPS) Operational Supplement #2020OM-01 Supplement 1 (P/N 75-900-2022), and Optical Tracker Operational Supplement #540-OS-1 (P/N 75-900-2021). All procedures for track and balance and all adjustments should be made in accordance with the applicable Maintenance Manual.

A. Required Equipment

The following ACES Systems equipment is required.

Item	Quantity	Description	Part Number
1.	1	Analyzer, Model 2020, Turbo ProBalancer	10-100-2020
2.	2	Sensor, Vibe, Accel, 991D-1	69-100-0075
3.	1	Cable, Sensor 991D-1, 25'	10-320-0162
4.	1	Cable, Sensor 991D-1, 50'	10-320-0163
5.	1	Cable, Magnetic Pickup 25'	10-320-0052
6.	1	Sensor, Magnetic, Passive Speed	75-900-0187
7.	1	Mount, 1/4X28 Sensor, Vibe 1/4" Hole, S/Stl	22-430-0035
8.	1	Mount, 1/4X28 Sensor, Vibe, 5/16" Hole, S/Stl	22-430-0036
9.	1	Tracker, Optical, Model 540-2	75-900-0542*

*This listing shows the latest design parts. It is acceptable to perform this task using previous designs with the appropriate accessories. For compatibility issues, contact ACES Systems.

Optional Equipment

Item	Quantity	Description	Part Number
1.	1	Option, 2020 Enhanced Main Rotor	11-900-0003
2.	1	Tip Targets	As Required
3.	1	Cable, Interf. Assy. Strobe-ACES 2020	10-320-0161
4.	1	Strobelight Model 135M-12	75-900-0194

Miscellaneous Equipment

Tape or tie wraps to secure cables to airframe.

B. Equipment Installation

1. Position the 2020 ProBalancer in cockpit. Connect magnetic pickup cable (PN 10-320-0052) to analyzer Tach 1 connector. Connect other end of cable to azimuth connector on the left-hand side of the center console as shown in figure 1.
2. Install the 991D-1 (PN 69-100-0075) vertical sensor on the left-hand side of the center console using sensor mount (PN 22-430-0035). Ensure that the connector end of the sensor faces down as shown in figure 1. Connect sensor cable (PN 10-320-0162) to 991D-1 sensor. Connect other end of cable to channel A on the ProBalancer.
3. Install 991D-1 (PN 69-100-0075) lateral sensor on the right-hand side of the main transmission on the #2 engine input quill housing using sensor mount (PN 22-430-0036). Sensor should point forward as shown in figure 2. Connect sensor cable (PN 10-320-0163) to sensor and route into cabin area. Secure cable as to prevent contact with hot or rotating components. Connect cable to channel B on the ProBalancer.
4. Install magnetic pickup (PN 75-900-0187) into the stationary swashplate. Adjust gap between the single interrupter and the pickup to 0.06” to 0.10” and secure with jam nut. Connect permanently installed magnetic pickup cable to the pickup as shown in figure 3.

Note

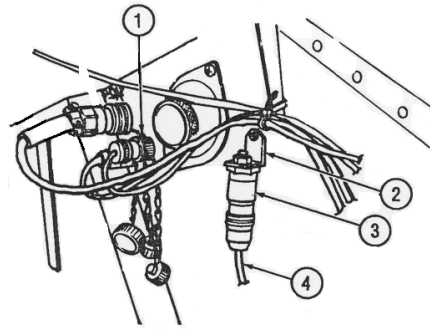
Target blade is forward when the interrupter and magnetic pickup are aligned.

Note

The double interrupter screws must be removed from the rotating swashplate to prevent erroneous rpm signals.

5. Connect Optical Tracker (PN 75-900-0542) to the Aux/Comm port on the ProBalancer.

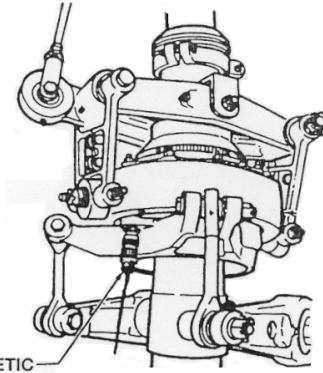
Equipment Installation Diagram



LOOKING INBD
LEFT SIDE PEDESTAL
(NEAR COPILOT KNEE)

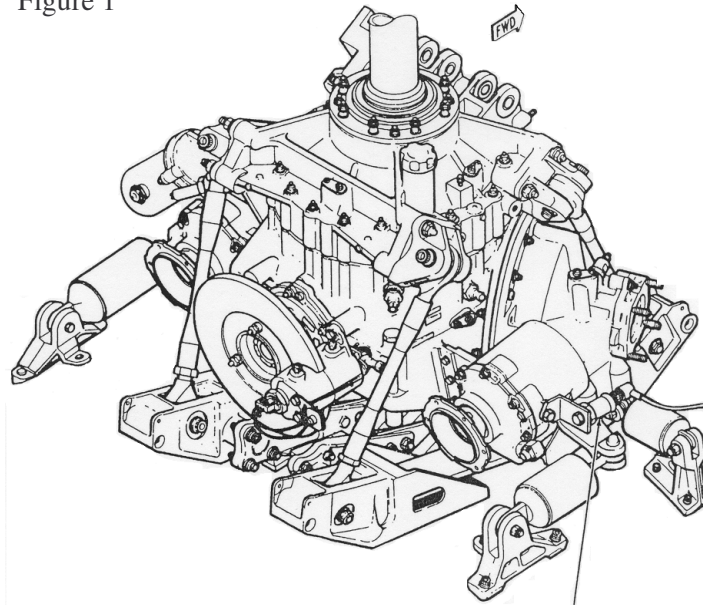
- 1. Magnetic Pickup Cable 10-320-0052
- 2. Sensor Mount 22-430-0035
- 3. 991D-1 Sensor 69-100-0075
- 4. Sensor Cable 10-320-0162

Figure 1



MAGNETIC
PICKUP

Figure 3



BALANCE ACCELEROMETER MOUNTED
HORIZONTALLY, POINTING FORWARD

Figure 2

C. Analyzer Set Up

1. Turn the analyzer [ON].
2. Enter a new setup as follows; from the “Main Menu” select “Main Rotor Track and Balance” and press [ENTER]. From the “Main Rotor Tack and Balance” menu, select “Manage Setups” and press [ENTER]. From the “Manage Setups” menu, select “New” and press [ENTER].
3. The “Main Rotor Setup” screen now appears. Make sure to select the proper “Tach Type”. See User’s Manual paragraph 5.1.1 section 5 if there are tach problems. The regimes are as follows: 100FPG (100% Flat Pitch Ground), 80 ROL (80 KTS Straight and Level readings for combination Roll and Tab (ROL) moves), 80 SHD (80 KTS Straight and Level for adjustments from the shaded (SHD) area of the Main Rotor Track Chart), 140ROL (140 KTS readings for combination Roll and Tab (ROL) moves), 140SHD (140 KTS for adjustments from the shaded (SHD) area of the Main Rotor Track Chart), and 120BNK (for readings in a 1.25 to 1.5 g bank (BNK) at 120 KTS). When completed press [ENTER].

Model 2020 ProBalancer
Main Rotor Setup

Name: BELL 230
Vertical Chan: A
Lateral Chan: B
Sensor: 9910-1
Tach Type: Mag(Hi)
Tach Chan: 1 WtPos: 4
Blades: 2 Relative to: 1
RPM: 348 Trk Units: in
<< Conditions >>

100FPG	Both	80 ROL	Both
80 SHD	Both	140ROL	Both
140SHD	Both	120BNK	Both

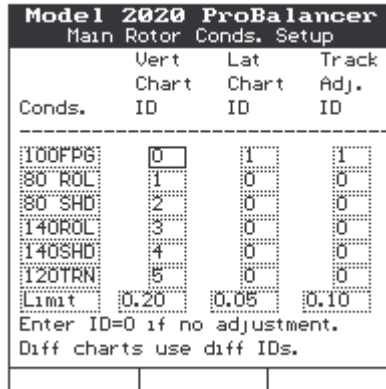
4. The “Tracking Setup” screen will appear next. The information for rotor diameter will be used to compute lead/lag readings. Enter the information as displayed and press [ENTER].

Model 2020 ProBalancer
Tracking Setup

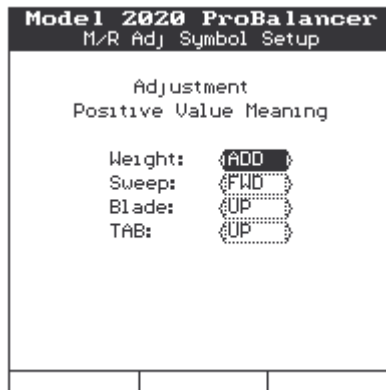
Rotor Diameter: 42.00 (ft)
Lead/Lag Units: in

5. The “Main Rotor Conditions” screen will determine the charts to be used when calculating corrections for a given measurement. Chart “ID’s” of similar measurements with the same

number will average the readings together for use in solutions. The “limit” field under each measurement type will set the point at which the analyzer will determine whether corrections are needed. Enter the information exactly as it appears in the appropriate fields. When completed, press [ENTER].



- The “M/R Adjustment Symbol Setup” screen is displayed next. The function of this screen is to determine the direction of movement for a positive (+) adjustment. The addition of weight will be displayed as a positive result on the solution screens. There are no sweep adjustments. To move the blade up with either Pitch Change Link or Trim Tab the solution screen will present a positive suggestion. Enter the values as shown. When completed press [ENTER].



- The first main rotor chart to define will be the “Vert: 80 ROL” chart. This chart will determine the Pitch Change Notch (N) AND Trim Tab Degree (D) adjustments to perform for in-flight vertical vibration reduction. Enter the information exactly as it appears in the appropriate fields. When completed press [ENTER].

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 80 ROL	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	N+D	
Adj./IPS:	9.00	
Bld/Pos	Adj @	Bld/Pos

T UP	4	:00
B UP	10	:00
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Help		

8. The next chart to define will be the “Vert: 80 SHD” chart. This chart will determine the adjustments to be made when the vibration readings fall within the shaded area of the Main Rotor Track Chart. You will be required to make **EITHER** Pitch Change Link (P) or Trim Tab (T) adjustments. Enter the information exactly as it appears in the appropriate fields. When completed press [ENTER].

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 80 SHD	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	P/T	
Adj./IPS:	9.00	
Bld/Pos	Adj @	Bld/Pos

T UP	1	:00
B UP	7	:00
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Help		

9. The next chart to define will be the “Vert: 140ROL” chart. This chart will determine the Pitch Change Notch (N) **AND** Trim Tab Degree (D) adjustments to perform in-flight vertical vibration reduction. Enter the information exactly as it appears in the appropriate fields. When completed press [ENTER].

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 140ROL	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	N+D	
Adj./IPS:	6.00	
Bld/Pos	Adj @	Bld/Pos

T UP	4	:00
B UP	10	:00
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Help		

10. The next chart to define will be the “Vert: 140SHD” chart. This chart will determine the adjustments to be made when the vibration readings fall within the shaded area of the Main Rotor Track Chart. You will be required to make **EITHER** Pitch Change Link (P) or Trim Tab (T) adjustments. Enter the information exactly as shown and press **[ENTER]** when finished.

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 140SHD	
Chart Type:	(Regular)	
Sweep Only:	(No)	
Adj. Unit:	P/T	
Adj./IPS:	6.00	
Bld/Pos	Adj @	Bld/Pos

T UP	1	00
B UP	7	00
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SwFwd/B1Up/TabUp		
Help		

11. The next chart will define the “Vert: 120BNK” chart. This chart will define the amount of Pitch Change Notch (NCH) adjustments required to improve in-flight vertical vibrations in a 120 KTS 1.25-1.5 G turn.

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 120BNK	
Chart Type:	(Regular)	
Sweep Only:	(No)	
Adj. Unit:	NCH	
Adj./IPS:	6.00	
Bld/Pos	Adj @	Bld/Pos

T UP	1	00
B UP	7	00
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SwFwd/B1Up/TabUp		
Help		

12. The next main rotor chart to define will be the “Lat: 100FPG” chart. This chart will determine the Span Weight (BLS – Balls) and Chord Weight (GMS – grams) adjustments to perform for 100% Flat Pitch Ground (100FPG) lateral vibration reduction. Enter the information exactly as it appears in the appropriate fields. When completed press **[ENTER]**.

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Model 2020 ProBalancer
Main Rotor Chart Setup
Name: [Lat: 100FPG]
Chart Type: [Irregular]
Sweep Only: [No]

Blid/Pos Unit Adj IPS Adj @
-----
T SPAN: BLS 45.00 1.00 1:00
T CHD : GMS 750.00 0.50 10:00
B SPAN: BLS 45.00 1.00 7:00
B CHD : GMS 750.00 0.50 4:00

+Adj = WtAdd/SwFwd/BlUp/TabUp
Help
    
```

13. Last, the “Tracking Influence Setup” screen will appear. This chart will determine the amount of pitch change adjustment required to improve track splits on the ground. The “Adj./in.” sensitivity tells the balancer the amount of Pitch Change Link (PCL) adjustment in Notches (NCH) required to equal one inch of movement at the blade tip. Enter the information exactly as it appears in the appropriate fields. When completed, press [ENTER].

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Model 2020 ProBalancer
Tracking Influence Setup

Conds      AdjName Unit Adj/in
-----
[100FPG]   [PCL] [NCH] [13.00]

+Adj = WtAdd/SwFwd/BlUp/TabUp
    
```

14. Setup complete, press [BACKUP], select “Start Job”, press [ENTER] and then select the “Main Rotor Setup” that was just created.

D. Data Acquisition

1. “Customer Information” screen. It is recommended to complete this screen so that customer information will appear on the printout assisting in identification of the job when it is stored in the analyzer memory. When finished press [ENTER].

Model 2020 ProBalancer Customer Information		
Enter the following optional Customer Information.		
Name:	CUSTOMER NAME	
A/C Registrations:	NI234	
A/C Total Time:	100	
Press ENTER to continue.		
Names		

2. “Tracking Selections” screen. Allows the user to select tracking device for this particular job. Select <Tracker> and enter the additional data as displayed or select <Strobe>. Then press [ENTER].

Model 2020 ProBalancer Tracking Selections		
Track Device:	Tracker	
- For Optical Tracking Only		
Number of Rotations:	50	
Inches To Blade Tip:	135	

3. “Main Rotor Equipment Setup”. Information screen that prompts the user to verify equipment installation has been performed in accordance with channel selections that were specified when building the setup. Press [ENTER].

Model 2020 ProBalancer Main Rotor Equipment Setup		
Install the speed sensor and connect to TACH Channel 1		
Install vertical vibration sensor to vibration channel A		
Install lateral vibration sensor to vibration channel B		
Tach power is	Off	
Tach On		

4. “Start Aircraft” screen. This screen allows the user to view the current main rotor RPM. When the rotor speed is stable and above 50 RPM, press [ENTER].

Model 2020 ProBalancer Start Aircraft		
Run: 1		
Start aircraft per flight manual.		
Rotor Speed: 348		
.		
After speed is greater than 50, press ENTER to continue.		

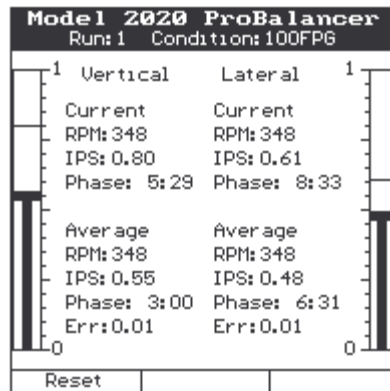
5. “Select Aircraft Condition” screen. Displays the ground and flight regimes that are specified in the setup. Select “100FPG” and press [ENTER].

Model 2020 ProBalancer Select Aircraft Condition		
[]	100FPG	
[]	80 ROL	
[]	80 SHD	
[]	140ROL	
[]	140SHD	
[]	120TRN	
End Run		Chk Track

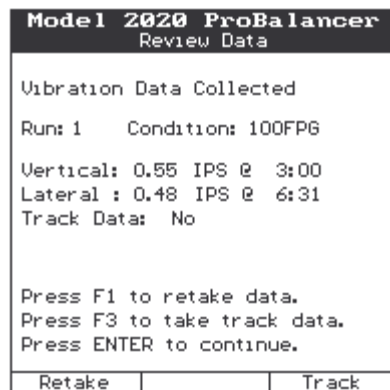
Note

At any time during the flight, if the vibration levels are found to be too severe to continue, the user has the option to “End Run” [F1] and solve for vibration data acquired to that point.

6. “Acquiring Vibration Data” screen. This screen is displayed during the vibration acquisition. When the RPM, IPS and Clock readings under “Average” show minimum change, press [ENTER].

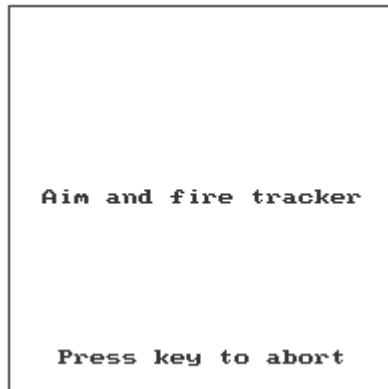


7. “Review Data”. This screen allows the user to view the vibration readings that were acquired during the regime. Press **[ENTER]** to continue or **[F3]** to take track readings.

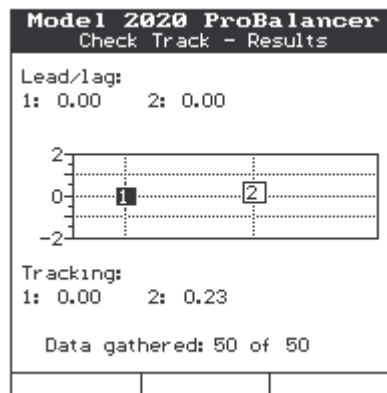


8. The “Track Screen” will appear prompting the user to aim and fire the tracker.
- To aim the tracker, raise the tracker smoothly up towards the rotating rotor disk while observing the LEDs on the back of the tracker.
 - Raise the tracker until the three green LED lights are illuminated.
 - Raise the tracker further to verify the upper set of three red LEDs illuminate. Illumination of the three upper LEDs verifies there is enough contrast to operate the tracker. If the upper set of red LEDs does not illuminate, there is not enough contrast for the tracker to operate properly.
 - If sufficient contrast is verified, slowly lower the tracker to a point where the center green LED is illuminated. Hold the tracker steady in this position.

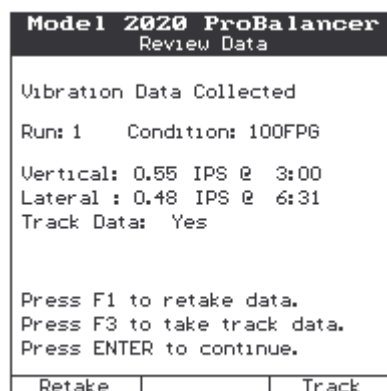
- e. To activate the tracker, press and release the trigger one time. It is not necessary to hold the trigger down. Continue to hold the tracker steady (green lights illuminated) while acquiring data (pulsating amber light).
- f. When the amber light extinguishes, data acquisition is complete and you may lower the tracker.



- 9. The track data will now appear on the screen. The track split will be shown. If the “Data Gathered” is less than 75% of the total defined in paragraph D.2 “Number of Rotations” above, press [ENTER] and then “Track” [F3] to retake the track reading. After successfully gathering enough data, press [ENTER] to continue.



- 10. The “Review Data” screen will reappear, if the readings are acceptable, press [ENTER] to continue. If the readings are unsatisfactory, use “Retake” [F1] to return to paragraph D.5 above. Use “Track” [F3] to return to paragraph D.8 above to retake track readings only.



11. Repeat sequence through all flight regimes. After all data is acquired press the “Adjust” [F2] button, shut down the aircraft and review the solution options.

Model 2020 ProBalancer		
Select Aircraft Condition		
[x]	100FP6	
[x]	80 ROL	
[x]	80 SHD	
[x]	140ROL	
[x]	140SHD	
[x]	120TRN	
End Run	Adjust	Chk Track

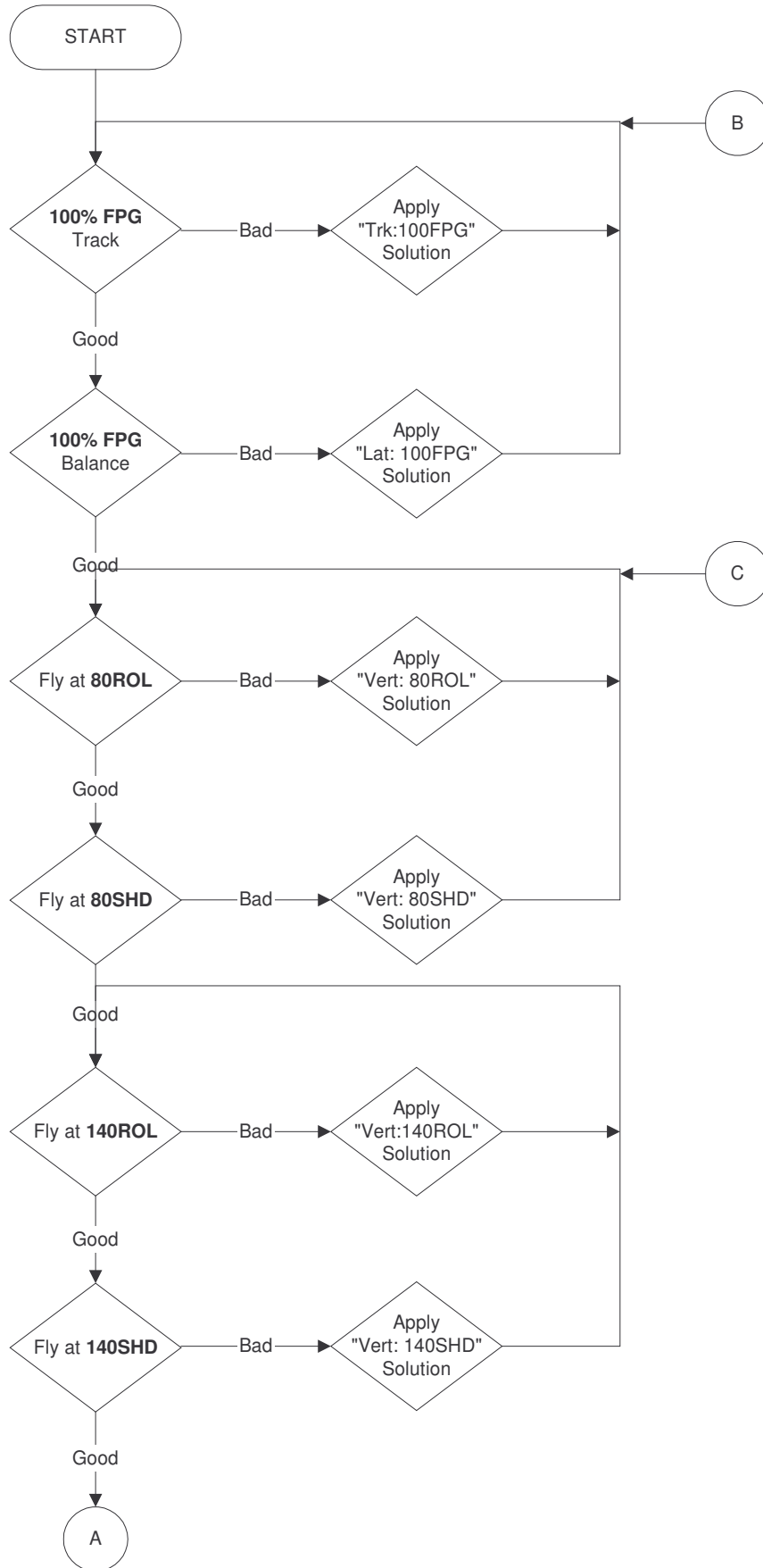
Note

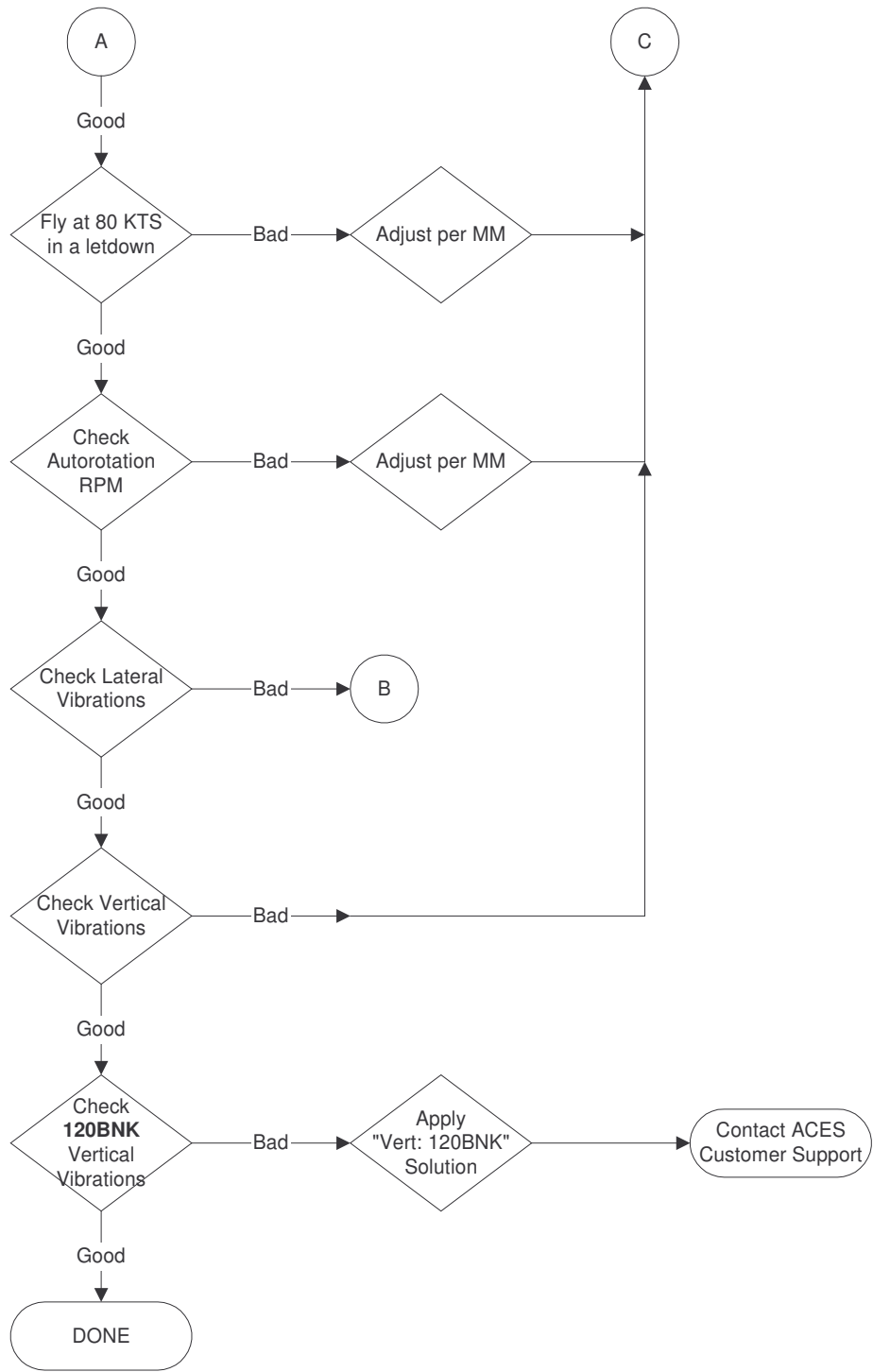
It is important to remember that when installing or removing weights and recording their positions the influence used for the next run will be updated by the result from the previous run’s solution. Therefore, be as accurate as possible when recording adjustments made regardless whether the recommended solution is implemented. The only entries on these screens should reflect the actual solution implemented.

12. The analyzer will present all of the solutions possible from the data gathered. It is possible for the analyzer to give two adjustments that would adversely affect the other. The user is ultimately responsible for determining which adjustments to implement and which to discard. If a suggested correction is determined unnecessary, use “Inst=None” [F2] to eliminate data in the “Installed” column. Make the desired adjustments to the rotor system as called for by analyzer and press [ENTER]. The user will now be prompted to start the engine and continue with run #2.

E. Sample Solutions

In order to simplify the solution process, the following pages contain a flowchart and explanations of suggested solutions. It is NOT necessary to obtain readings for ALL regimes. In following the flow chart, at the point where the first adjustment becomes visible, see paragraph D.11, it is possible to shut the aircraft down and make an adjustment. The analyzer was NOT designed to make multiple solutions during one run. It is strongly recommended to follow the flow chart and implement one solution at a time. A thorough understanding of the appropriate polar charts is necessary for making combination moves.





1. The following solution is from the “Trk: 100FPG” chart. The suggested track solution would be to adjust the Blank blade Pitch Change Link (PCL) DOWN 3.90 NCH (Notches).

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Trk:100FPG, PCL, NCH		
Bld/Pos	Suggested	Installed

T UP	0.00	0.00
B UP	-3.90	-3.90
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

2. The “Lat: 100FPG” chart suggestion follows. The suggestion to decrease the lateral vibration is to install 20.92 BLS (Balls) in the Blank Span and 179.06 GMS (Grams) in the Blank Chord locations.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Lat:100FPG, BLS, GMS		
Bld/Pos	Suggested	Installed

T SPAN	0.00	0.00
T CHD	0.00	0.00
B SPAN	20.92	20.92
B CHD	179.06	179.06
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

3. The following solution is from the “Vert: 80 ROL” chart. The suggestion to reduce vertical vibrations is a combination of adjusting the Target PCL (Pitch Change Link) up 3.61 N (Notches), adjusting the Target Inboard Tab down 3.61 D (Degrees), and adjusting the Blank Inboard Tab up 3.61 D (Degrees).

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert: 80 ROL, N+D		
Bld/Pos	Suggested	Installed

T UP	3.61	3.61
B UP	0.00	0.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

4. The following example is from the “Vert: 80 SHD” chart. Adjustments here are suggestions for fine corrections only and use PCL (P) notches and the small section of the outboard trim tab (T). For coarse adjustments to the large tab see the Main Rotor Track Chart in the Maintenance Manual. The suggested solution is to adjust **EITHER** the Target Pitch Change Link (P) up 2.22 Notches **OR** the Small Outboard Tab (T) of the Target Blade up 2.22 Degrees. As an alternate solution, the Blank blade may be adjusted down by the same quantities.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 2		
Name: Vert: 80 SHD, P/T		
Bld/Pos	Suggested	Installed

T UP	2.22	2.22
B UP	0.00	0.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

5. The suggestion from the “Vert: 140ROL” chart follows. In this suggestion, the recommendation is to adjust the Target PCL up 3.58 N (Notches), the Target Inboard Tab down 3.58 D (Degrees), and the Blank Inboard Tab up 3.58 D (Degrees).

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 2		
Name: Vert: 140ROL, N+D		
Bld/Pos	Suggested	Installed

T UP	3.58	3.58
B UP	0.00	0.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

6. The following solution is from the “Vert: 140SHD” chart. Adjustments here are suggestions for fine corrections only and use PCL (P) notches and the small section of the outboard trim tab (T). For coarse adjustments to the large tab see the Main Rotor Track Chart in the Maintenance Manual. The suggested solution is to adjust **EITHER** the Blank Pitch Change Link (P) up 1.19 Notches **OR** the Small Outboard Tab (T) of the Blank Blade up 1.19 Degrees. As an alternate solution, the Target blade may be adjusted down by the same quantities.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert: 140SHD, P/T		
Bld/Pos Suggested Installed		
T UP	0.00	0.00
B UP	1.19	1.19
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

- The final chart shows the adjustments from the “Vert: 120BNK” chart. In this case, the move should only be made if it is possible to reduce the vertical vibration in a turn without moving the vertical vibration in forward flight beyond its limit. This screen suggests turning the Blank Blade PCL up 2.04 NCH (Notches). It is also possible to adjust the Target Blade down 2.04 NCH.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 4		
Name: Vert: 120BNK, NCH		
Bld/Pos Suggested Installed		
T UP	0.00	0.00
B UP	2.04	2.04
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job