Precision Balancing with the CMVA 55 Microlog

by John Harrell

Abstract

With the advent of the Microlog CMVA 55, it is possible to achieve precision balance levels in a minimum amount of time. The CMVA 55's time synchronous averaging filters allow accurate results even when the 1X RPM signal is low and embedded in noise. These filters allow the technician to quickly balance machinery, even when background vibration is present or with closely spaced operating speed components (for example, fan banks or centrifuges). In addition, the Static/Couple approach for balancing narrow, overhung, long slender rolls is now possible using the CMVA 55's "built-in" Balancing Wizard™ program, along with the technique described in this paper.

Introduction

The two-plane influence coefficient method of balancing is well known and works well for most balancing problems. It is important to note that any two-plane dynamic balance solution can be separated into a static and couple component. Narrow and overhung rotors are typically difficult to balance using the two-plane approach because they are dominated by static unbalance (see Figures 1A and 1B). Therefore, the approach to balancing these types of rotors is to eliminate the static unbalance first, before trying to correct the couple. This technique is also useful in balancing long flexible rotors, as the static correction can be applied in the center of the rotor (near the center of gravity) which reduces the rotor's flex near its first critical speed (see Figure 1C).

Technique

The CMVA 55 Microlog is capable of solving any dynamic balancing problem using the static couple approach. This technique is described as follows:

- Select the sensor positions **A** and **B**, and correction planes 1 and 2 (Figures 1A, 1B, and 1C).
- Set up the Microlog for two-plane balancing, follow the procedure and calculate the two-plane solution (Figures 2 through 6).
- Using the two-plane solution, compute the static corrections using the **Combine Weight** feature.

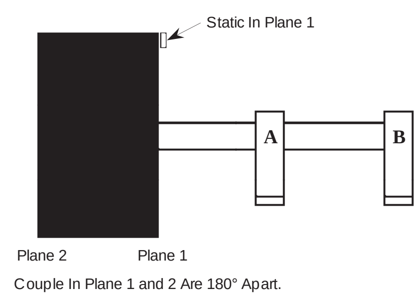

Figure 1A.

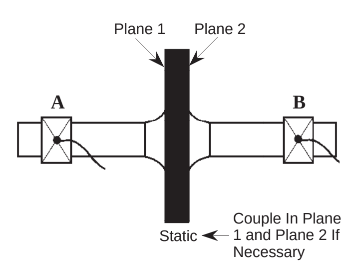

Figure 1B.

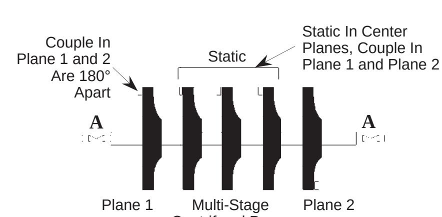

Figure 1C.

Application Note
CM3028

Figures 1A, 1B, and 1C show three types of rotors that respond well to the static/couple approach. Locations for the static and couple weights are shown for each type of rotor.

Two-Plane Procedure

Reference run data establishes a no-weights condition as a reference. Data was taken for both planes 1 and 2 with no weight on the rotor (Figure 2).

A trial weight is added to the rotor at the balance radius. All angles are measured from the reference point (tape, keyway, etc.) considered as zero. Angles increase counter to rotation. The machine is run up to balance speed, and after stabilization, trial run data is collected (Figure 3), see Figure 4 for actual data taken with the trial weight in plane 1.

Trial weight # 1 (4.9 gms at 120° counter to rotation) is installed in plane 1 and data is collected (Figure 4).

➢ *Remember that the trial weight must produce a significant change (either 30° in phase or 30% in the amplitude of vibration) in order for the computations to be accurate. This is referred to as the 30-30 rule. Compare the reference run at point "A" to trial run #1 at point “A”, and note that amplitude changed from 1.8 IPS to 1.1 IPS (>30%) and phase changed from 148° to 178° (30° change) to satisfy the 30-30 rule.*

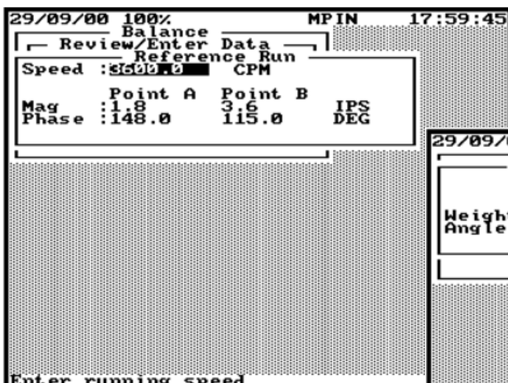

Figure 2. The REFERENCE RUN DATA screen.

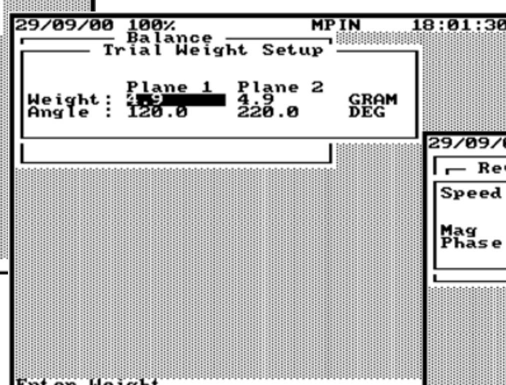

Figure 3. The TRIAL WEIGHT SETUP screen.

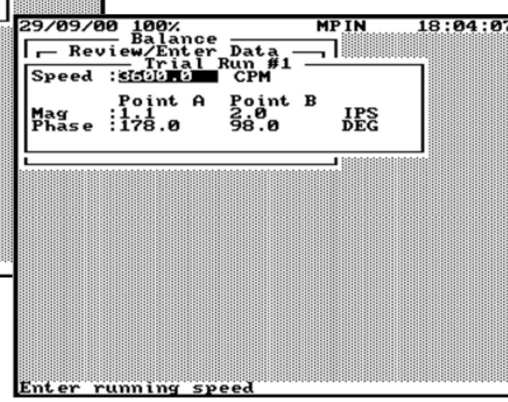

Figure 4. A TRIAL RUN #1 data screen.

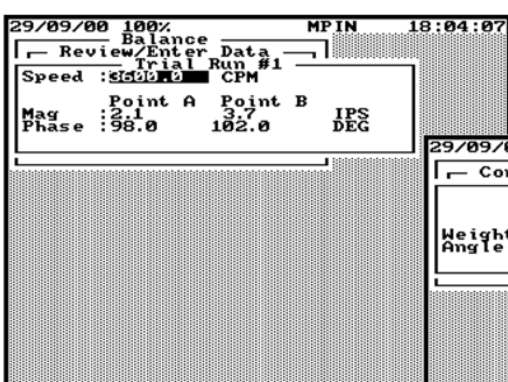

Figure 5. A TRIAL RUN #2 screen.

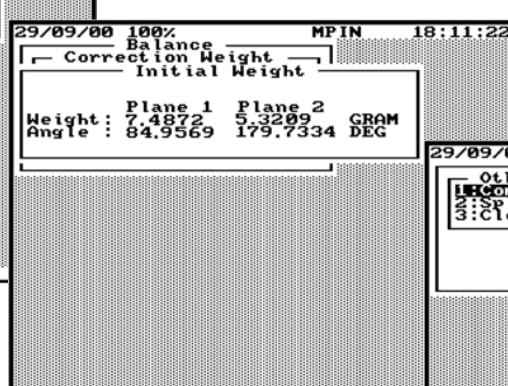

Figure 6. An INITIAL WEIGHT computation.

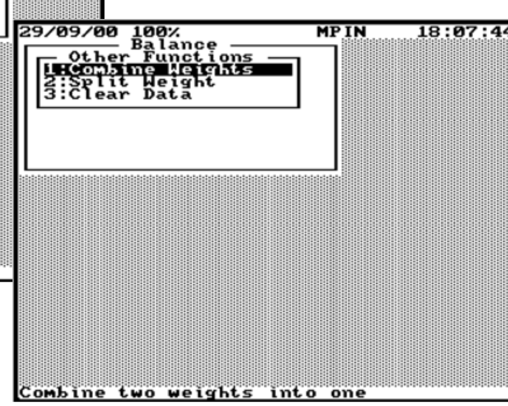

Figure 7. The OTHER FUNCTIONS menu.

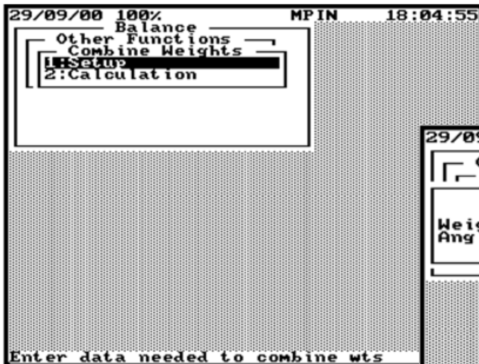

Figure 8. The COMBINE WEIGHTS menu.

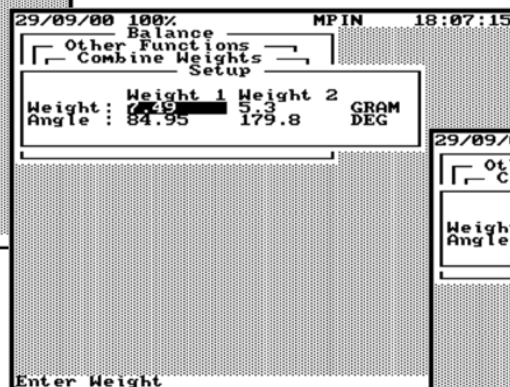

Figure 9. The WEIGHT field.

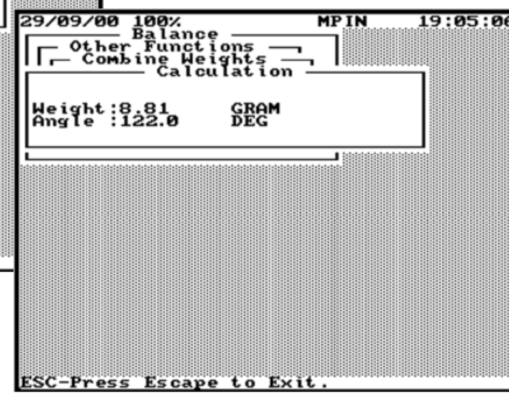

Figure 10. The two-plane static solution.

Trial weight #1 is removed from plane 1 and trial weight #2 (4.9 gms at 220° counter to rotation) is added. Data is collected as shown in Figure 5.

When you enter the **Balance** menu's **5:Correction Weight,** then enter the **1:Initial Weight,** the Microlog computes the influence coefficient from trial run #1, trial run #2, and reference run data. The initial correction weights are also computed (Figure 6).

All weights are removed from the rotor and, instead of adding the computed weights of 7.4 gms at 85° in plane 1 and 5.3 gms at 180° in plane 2, the static correction is computed using the **Combine Weights** feature (see Figures 7–10).

- Do not make the two-plane corrections
- Combine these two correction weights using the **Combine Weights** feature in the **Other Functions** menu (Figures 7–10).
- From the Balance menu, select **Other Functions** (Figure 7).
- From the **Other Functions** menu, select **Combine Weights** (Figure 8).
- Select **Setup** (Figure 9) and enter the values from initial weight computations (Figure 6).
- Combine plane 1 and 2 corrections into static correction (Figure 10).

The computed static weight of 8.8 gms is added to the rotor at 122° counter to rotation. This correction is the static correction and is added at or near the rotor's center of gravity.

- Press **ESCAPE** to return to the **Combine Weights** menu.

Calculations

From the Combine Weights menu, select Calculation. After

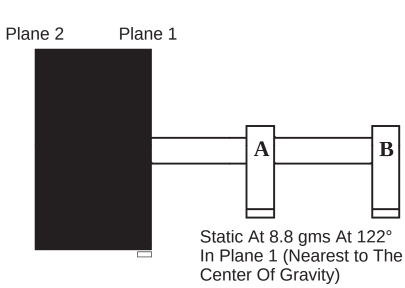

Figure 11A.

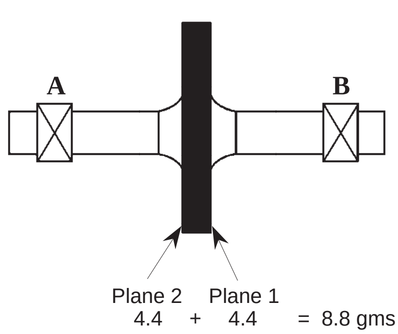

Figure 11B.

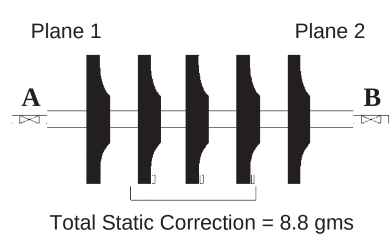

Figure 11C.

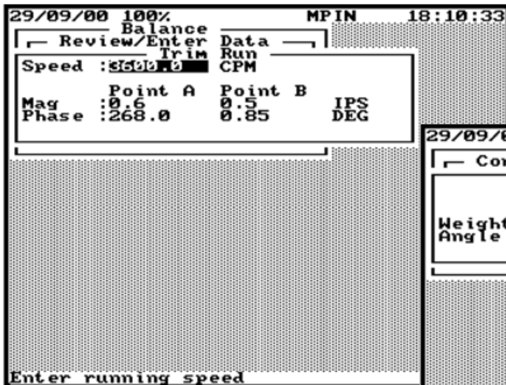

Figure 12. A TRIM RUN data screen. Readings after adding static correction weight.

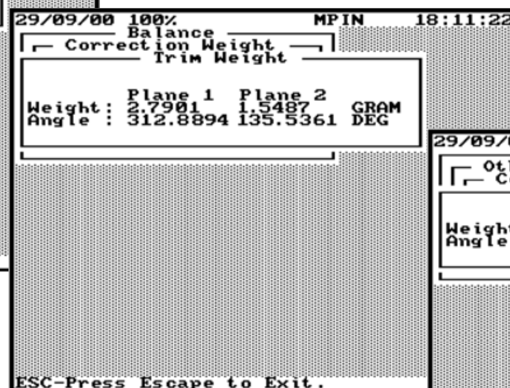

Figure 13. A TRIM WEIGHTS computation.

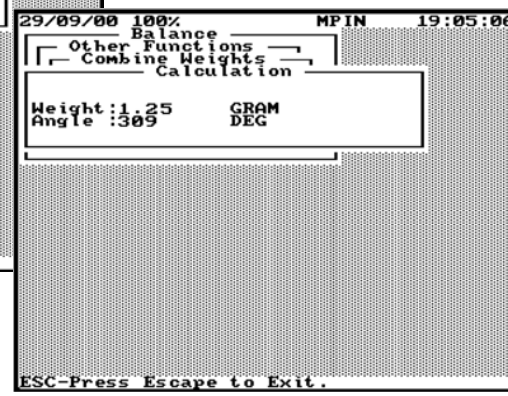

Figure 14. The combine weights CALCULATION.

a moment of computation, the Microlog displays the combined weight and angle (Figure 10).

This combined weight is the static weight correction. This weight should be placed in plane 1, or in the plane nearest the center of gravity, or distributed axially about the center of gravity plane (Figures 11A, 11B, and 11C).

To summarize:

Plane 1 correction (7.49 gms at 84.9°) + plane 2 correction (5.3 gms at 179.8°).

Sum = Combined Weight = 8.8 gms at 122° = Static Correction.

- Do not make the couple corrections at this time.
- Continue in the trim mode and calculate the trim weights for planes 1 and 2 (Figures 12-13).

After adding the static correction weight, the rotor is run up to balancing speed and readings are taken. Instead of adding the trim corrections in planes 1 and 2, the static trim correction is computed using the **Combine Weights** feature (Figure 12). This static trim correction is added in the rotor's center of gravity plane.

After entering **5:Correction Weight** from the **Balance** main menu and **2:Trim Weight,** the Microlog computes the trim weights (Figure 13).

Instead of adding these trim weights, (Figure 13) combine the plane 1 and 2 corrections into static corrections. The results are shown in Figure 14.

- Again, using the **Combine Weights** program, add the two trim weights. This weight should be placed in plane 1, or in the plane nearest the center of gravity, or distributed axially about the center of gravity plane (Figure 14).
- When the static unbalance is acceptable, apply the couple correction. The couple correction is the dynamic solution for planes 1 and 2. In other words,

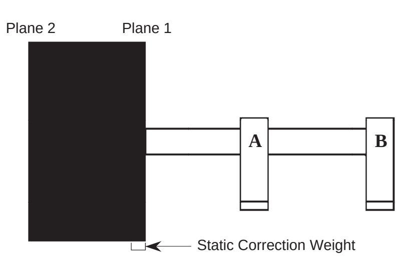

Figure 15A.

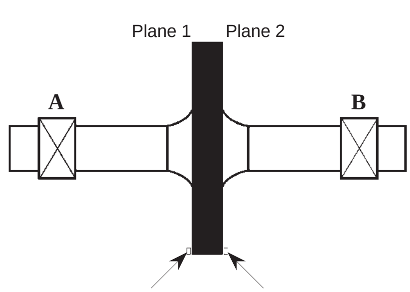

Figure 15B.

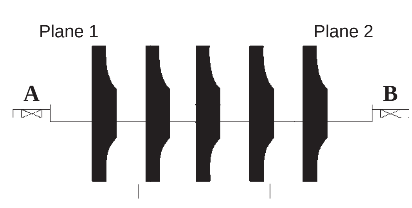

Figure 15C.

when the static unbalance has been reduced to 0, the only unbalance left in the rotor is the couple; two equal weights that are 180° apart in planes 1 and 2.

- Continue, in the trim mode correcting the couple until the rotor is balanced.
- If the static component increases during the procedure, correct it immediately following procedures given earlier.

Figures 15A, 15B, and 15C show the locations (planes) where the initial and trim static weights should be placed.

Figures 16A, 16B, and 16C show the locations where the couple correction weights should be placed.

➢ *Remember if the static component increases during this procedure, correct the static immediately.*

To summarize:

The key to the Static/Couple approach is to correct the static first. This static correction should be applied on or about the rotor's center of gravity. For a multistage rotor, the static corrections may be divided between the center two or three stages. For a narrow impeller, the static corrections could be split in half and applied on either side of the impeller. For overhung, attach static weight in plane (plane 1) nearest the inboard bearing (A).

Use the CMVA 55's Combine Weight feature to derive the static component. The vector sum of the plane 1 and 2 corrections is the static correction. After the static unbalance has been removed, the remaining dynamic unbalance is simply the couple. If desired, the couple component is calculated using the **Combine Weight** feature, remembering that the couple corrections is 1/2 the vector difference of the plane 1 and 2 corrections. [plane 1 + (–plane 2)] / 2 (Figure 17).

Balance Report

As a final step, the two-plane Balance Report is generated by entering the **Balance** menu's **8:Report** option (Figure 18).

Summary

The Static/Couple approach using the method described in this paper can add a new dimension to your condition monitoring balancing program. The CMVA 55 can be used both in the field and in the shop to solve all types of balancing problems. By virtue of the sophisticated Digital Tracking Filter, the Microlog can be readily used to precision balance equipment.

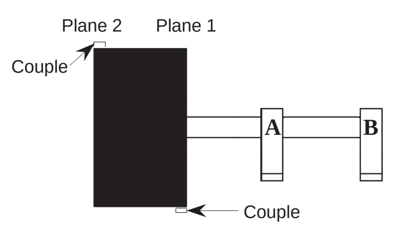

Figure 16A.

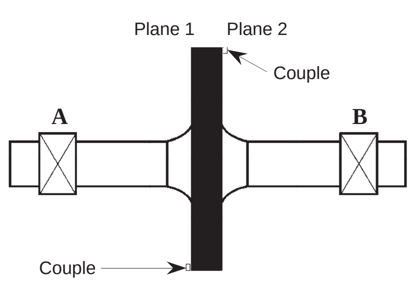

Figure 16B.

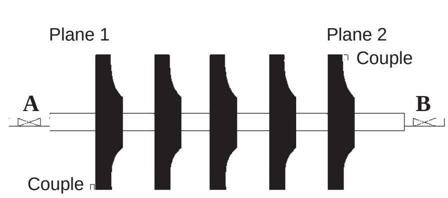

Figure 16C.

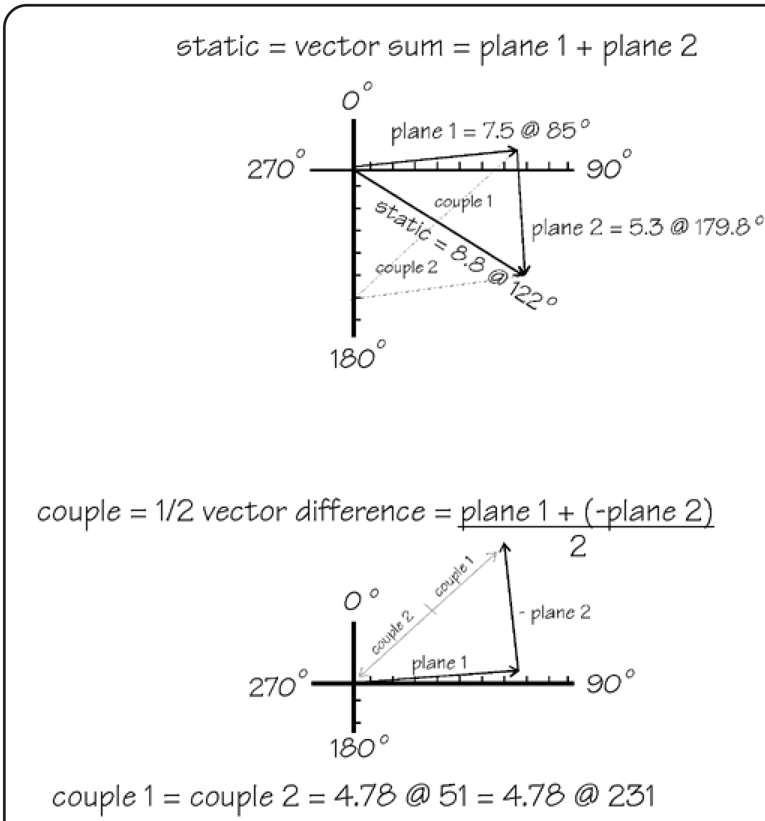

Figure 17. Vector Diagrams Showing the Static and Couple Solutions.

SKF®

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Balance Report

ID: BALANCING POINT WEIGHTS LEFT IN FOREVER:NO

Trial Weights

	Point A	Point B	
Weight:	4.9	4.9	GRAM
Angle :	120.0	220.0	DEG

Runout

	Point A	Point B	
Mag :	0.0	0.0	IPS
Phase :	0.0	0.0	DEG

Data

Reference Run

Speed : 3600.0 CPM

	Point A	Point B	
Mag :	1.8	3.6	IPS
Phase :	148.0	115.0	DEG

Trial Run #1

Speed : 3600.0 CPM

	Point A	Point B	
Mag :	1.1	2.0	IPS
Phase :	178.0	98.0	DEG

Trial Run #2

Speed : 3600.0 CPM

	Point A	Point B	
Mag :	2.1	3.7	IPS
Phase :	98.0	102.0	DEG

Trim Run

Speed : 3600.0 CPM

	Point A	Point B	
Mag :	0.6	0.5	IPS
Phase :	268.0	0.85	DEG

Influ Coefficient

Plane 1

	Point A	Point B	
Mag :	0.2061	0.3644	GRAM/IPS
Angle :	175.0138	194.1131	DEG

Plane 2

	Point A	Point B	
Mag :	0.3409	0.1699	GRAM/IPS
Angle :	182.3673	165.3559	DEG

Correction Weight

Initial Weight

	Point A	Point B	
Weight:	7.4873	5.3209	GRAM
Angle :	84.957	179.7334	DEG

Trim Weight

	Point A	Point B	
Weight:	2.7901	1.5487	GRAM
Angle :	312.8894	135.5361	DEG

Figure 18. A two-plane Balance Report.

Terminology

Center of Gravity – The position on the shaft where the total distributed mass can be considered as a point mass.

Couple Unbalance – Results when statically balanced weights are 180° apart at opposite ends of a rotor and cause rocking action during rotation.

Critical Speed – A rotor speed which generates high vibration amplitudes. If the speed corresponds to a resonance frequency of the system, it is called the balance resonance speed.

Dynamic Unbalance – A combination of both static and couple unbalance.

Flexible Rotor – A rotor where the shaft natural modes are excited by rotational unbalance forces.

Influence Coefficient – In a balancing procedure, a scaling vector called the influence coefficient is computed to relate the unbalance force vector to the measured displacement and phase. The amplitude of this vector defines a rotor sensitivity of weight/mil at the balance speed, and at the exact placement of the measuring transducer. The phase is the system lag of the vibration signal to the transducer.

Plane 1 – Balance plane nearest measurement Point A.

Plane 2 – Balance plane nearest measurement Point B.

Static Unbalance – Occurs when the shaft center of gravity is displaced from the rotation axis through bearing centers. A statically unbalanced shaft placed on knife edges will roll to rest with the weight at the bottom.