Piedmont Chapter Vibration Institute
Training Symposium
10 May, 2012

FIELD BALANCING OF ROTATING MACHINERY

PdMS

Balancing Short Course

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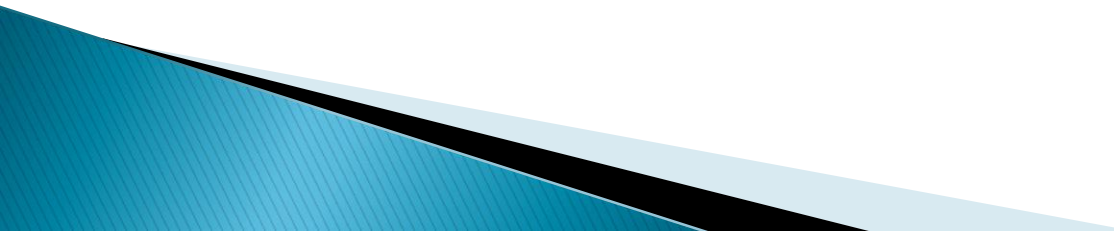Vibration Analyst Category IV
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609-330-3995
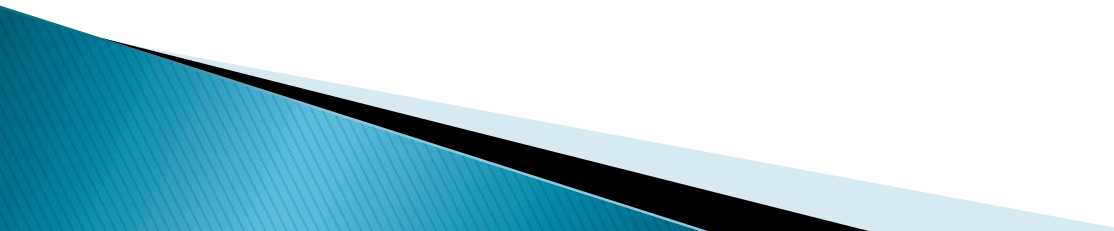Bill.Pryor@PdMSolutions.com

Single Plane Balance

Presentation is going to concentrate on setting up and performing a single plane balance using Vector and Influence Coefficient methods:

1. Setting up for success

2. Trial Weight Selection

3. Trial Weight Placement

4. Single Plane Calculation

SHOP & FIELD BALANCING OF ROTATING MACHINERY

- Is Balance the Problem
- Technique and Strategy
- Unusual Problems
- Mass Unbalance Force
- Rotor Classification
- Balancing Techniques
- Pre-balancing Checks
- Trial Weight Selection & Location

- Balancing Pitfalls
- Single Plane Balancing
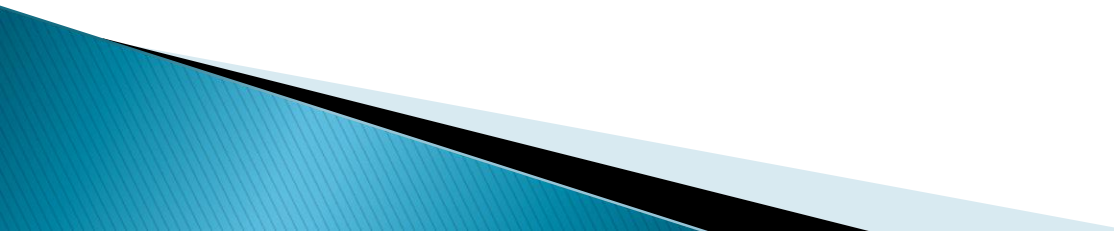- Two Plane Balancing
- Balance Limits
- Conclusions

INTRODUCTION

- Modern Techniques and Instrumentation
- Field Balancing an Indirect Process
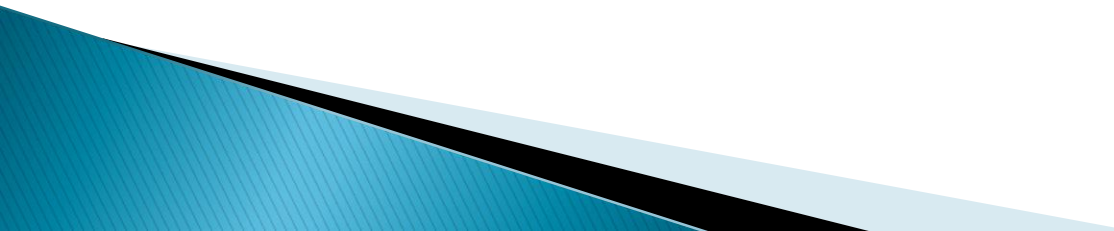- Analyst's Goals
- Beware of Black Boxes and Traps

GENERAL COMMENTS

- Mass unbalance (heavy spot) cannot be measured directly
- High spot (angular location of peak or peak to peak vibration) is used to determine heavy spot
- Balancing is an art and science
  - science in the vector procedures
  - art in selection of balance planes, speeds, measurement locations as well as trial weight sizes and locations
- Balancing is a method of weight compensation to minimize vibration
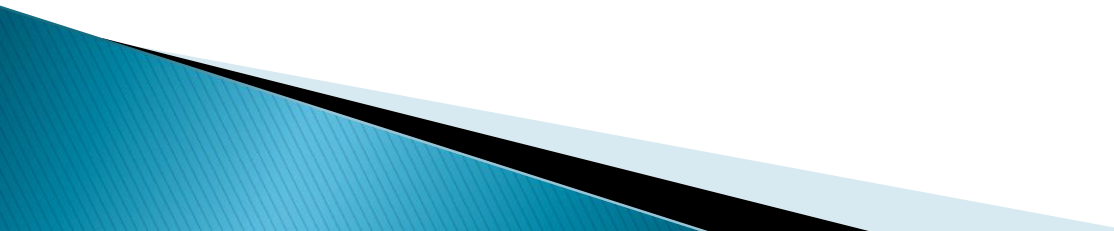- Global weights added to compensate for local unbalances – can introduce stress

FIELD BALANCING

- Is Balance the Problem?
- Beware of false indicators – Misalignment & Resonance
- Unbalance a Rotating Force
- Resonance and Flexible Structures Complicate the Picture

Equipment Required

- Vibration Transducer
- Once–Per–Revolution Sensor
- Filter capable of measuring Speed, Amplitude, and Phase
- Marker or Paint Stick
- Polar Graph Paper and Triangles
- Balance Weights and Scale

Balancing Rules

- Rule #1 – Keep it Simple
- Rule #2 – Be Consistent
- Rule #3 – Do not make up your own rules
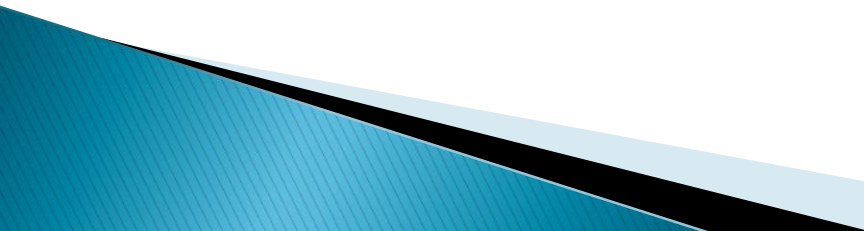- Rule #4 – Remember the 1st 3 rules
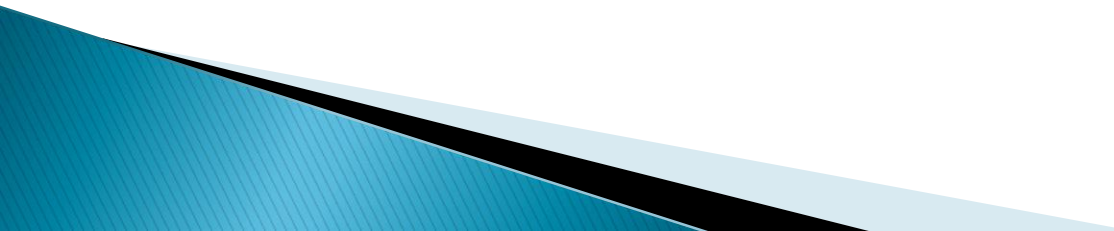
Before Balancing

Before attempting to balance:

Remember there are multiple reasons for a high 1X amplitude component.

Perform a complete analysis prior to balancing to ensure that other mechanical faults are not the cause of the 1X response.
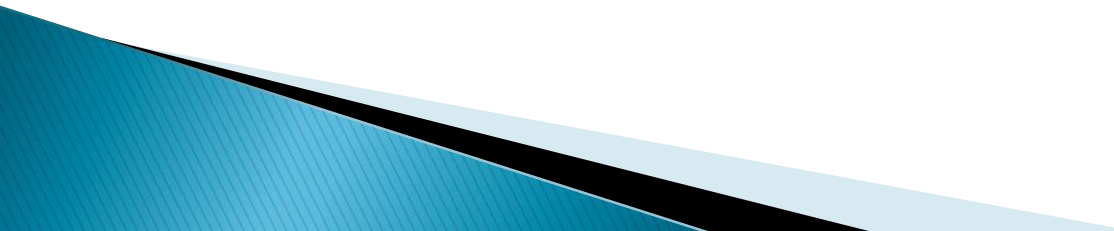
Potential 1X causes

- Misalignment
- Thermal Effects
- Product buildup on rotor
- Erosion or corrosion of rotor
- Bowed, bent, or eccentric shaft
- Bearing or seal wear
- Roller Deflection – Paper Machines
- Machining errors/incorrect assembly
- Not properly balanced in shop
- Looseness in built-up rotor components

BALANCING PITFALLS

- Not mass unbalance
- Loose supports
- Frame misalignment
- Stiffness asymmetry
- Inaccurate data
- Thermal sensitivity
- Resonance
- Unbalance distribution

Always Remember

1. The rotating component did not go out of balance by itself.

2. Remain skeptical during the balancing process and use the balancing procedure as a diagnostic tool.

3. If balance attempt is not working as anticipated – STOP and THINK about what is going on. It may not be unbalance.

Initial Balance Setup

1) Number Fan Blades or Holes 0 to N.
   As an example: if there are 8 Blades, Blade 0 is also Blade 8 (0 to 360 Degrees). Blade #'s will increase in sequence by turning the rotor in the direction of rotation.

2) Install Vibration measurement sensor Inline with Blade 0

3) Install Once-per Rev timing mark and sensor when Blade 0 is inline with measurement sensor.

4) Make a drawing showing blades, transducer placement, and angles. Remember angles increase against rotation.

5) Determine trial weight amount and have weight available.

Setup Drawing
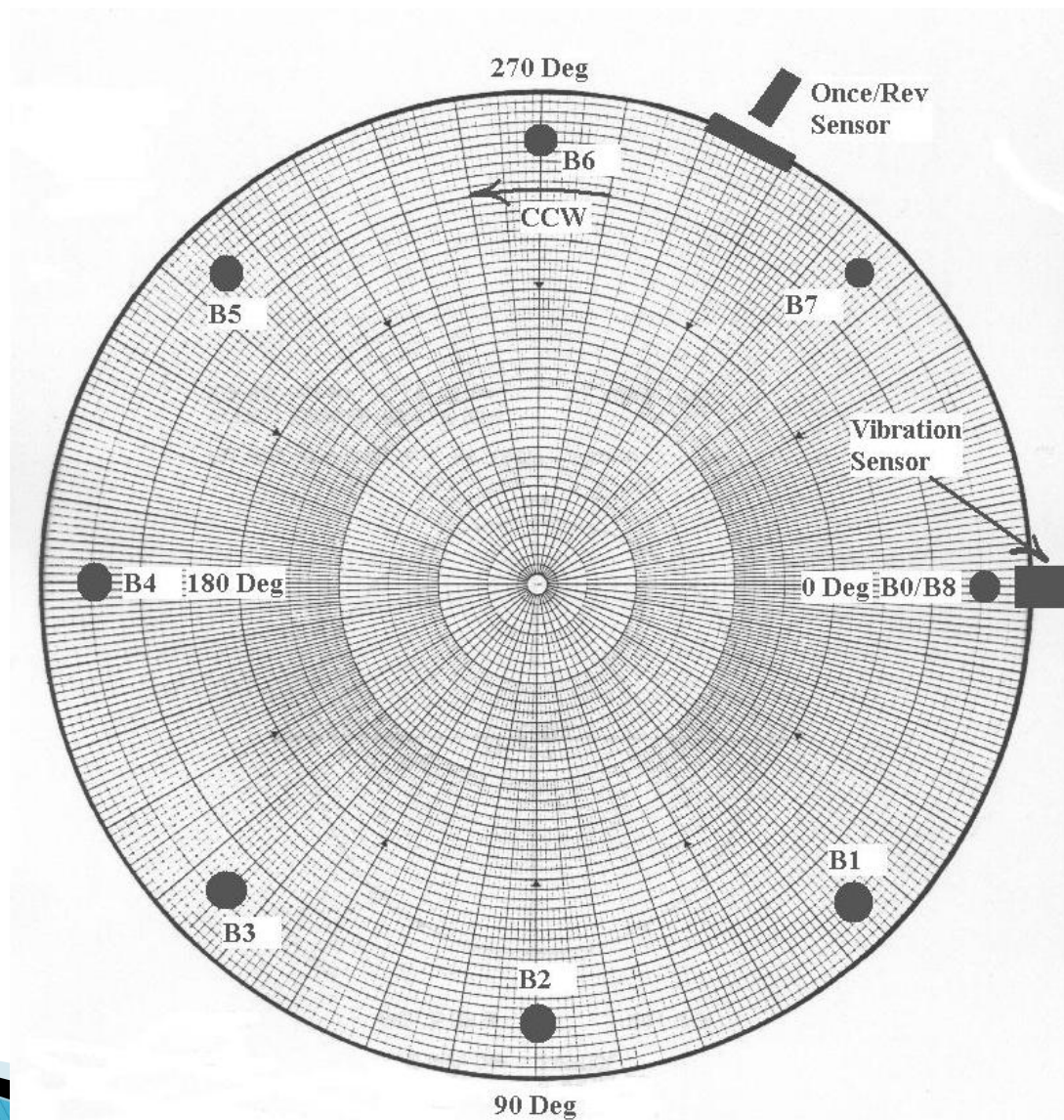
Brief Review – Rotor Balance Problem
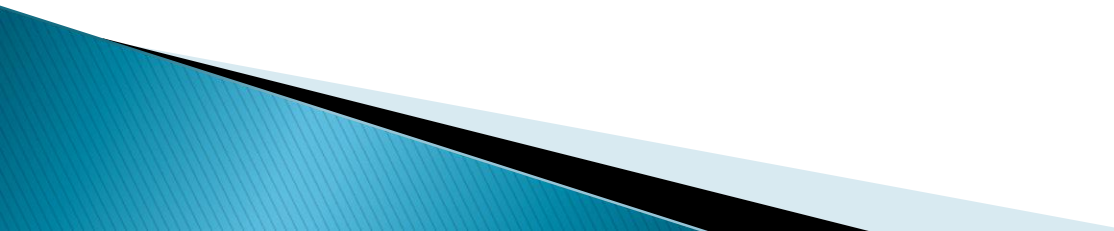
When we balance a rotor there are 2 unknown factors which need to be determined in order to solve a rotor balance problem.
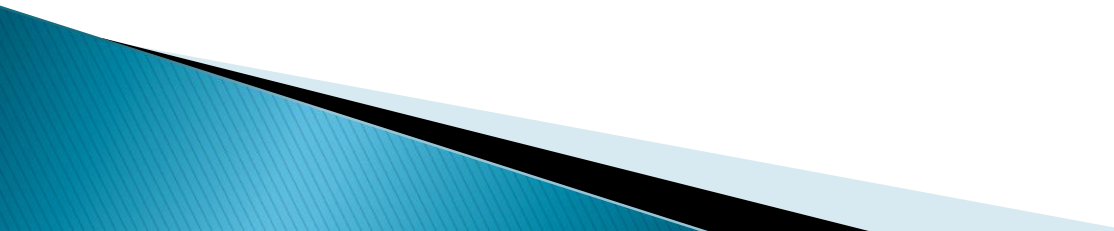
1) The amount of weight required
2) Angle of weight placement

Factors effecting amount of weight

- Speed of the machine
- Radius of weight placement
- Rotor mode shape relative to balance plane selected
- Proximity to Rotor Balance Resonance (Critical Speed)

Trial Weight Determination

Balance trial weight selection should be based on 1 of the following:

A: User experience with the same or like machine.

B: Experience with similarly designed and constructed machine.

C: In the absence of above, a trial weight is calculated to generate a centrifugal force equal to 10% of the rotors weight.   Note: For rotors operating above 3600 some suggest that a calculation yielding 5% of the rotors weight should be used as an initial trial weight.

Trial Weight Calculation

Centrifugal Force: $C_f = m\ r\ \omega^2$

C_f = Centrifugal Force Lb_f
m = Mass of the rotor = Weight/Gravity
    = $Lb/386.4$ in/sec^2
Note 1 G = 32.2 Ft/Sec^2 = 386.4 in/sec^2
r = Weight add radius in inches
ω = Rotor speed in radians

Example of Trial Weight Calculation

Calculate the size of the trial weight needed for an electric AC motor operating at 1785 RPM. The rotor weighs 1800 pounds and the weight can be added to the rotor at a radius of 6 inches.

The easiest way to treat this problem is to break it down into a couple of parts.

1st we want our trial weight to generate a force equal to 10% of the rotor weight. So from our example:

C_f = 1800 Lb Rotor/10 = 180#

Example of Trial Weight Calculation

2nd Our weight add radius is 6"

3rd We need to calculate the speed of the rotor in radians.

$$\omega = \frac{1785 \text{ RPM} * 2\pi}{60 \text{ sec/Min}} = [2\pi(29.75 \text{ Hz})] =$$

[2* 3.14*29.75 Hz] = 186.83 Radians/Sec

Note: 1 Radian = 2π = 360 Degrees

$\omega^2 = (186.83)^2 = (186.83 * 186.83) = 34905.45$ Radians/Sec^2

Example of Trial Weight Calculation

Centrifugal Force: $C_f = m\ r\ \omega^2$

$$m = \frac{--C_f\_\_\_}{r\ \omega^2}$$

$$m = \frac{_____180\#_____}{(6")(34905.45\ \text{radians})} = 0.000859 \quad \frac{--\#\_\_\_}{\text{in/sec}^2}$$

Example of Trial Weight Calculation

$m = W/G$

solving for weight: $W = M * G = (0.000859\ \#/in/sec^2)(386.4\ in/sec^2)$

$W = 0.332\ Lb$

$W = 0.332\ Lb * 16\ Ounce/Lb = 5.3\ Ounce$

Trial Weight Selection

$$W_T = 56375.5 \frac{W}{N^2 r}$$

where:

W_T = trial weight, oz.

r   = eccentricity of trial weight, in.

W = static weight of rotor, lb.

N = speed of rotor, RPM

Trial Weight Selection– Example

$$Wt = \frac{56375.5\ (1800\ \#)}{(1785\ RPM)^2 * 6"} = 5.3\ Oz.$$
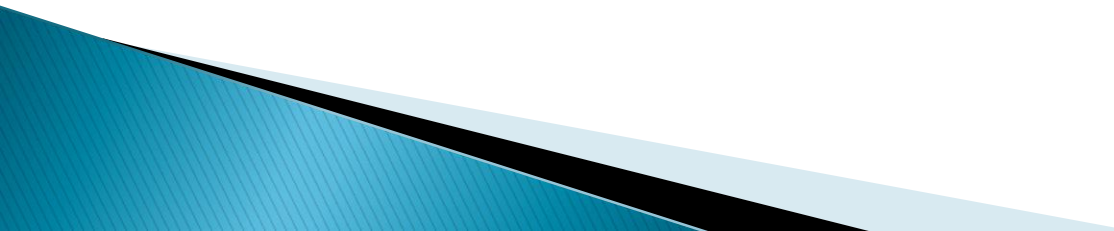
where:

W_T = trial weight, oz.

r   = eccentricity of trial weight, in. = 6"

W = static weight of rotor, lb. = 1800#
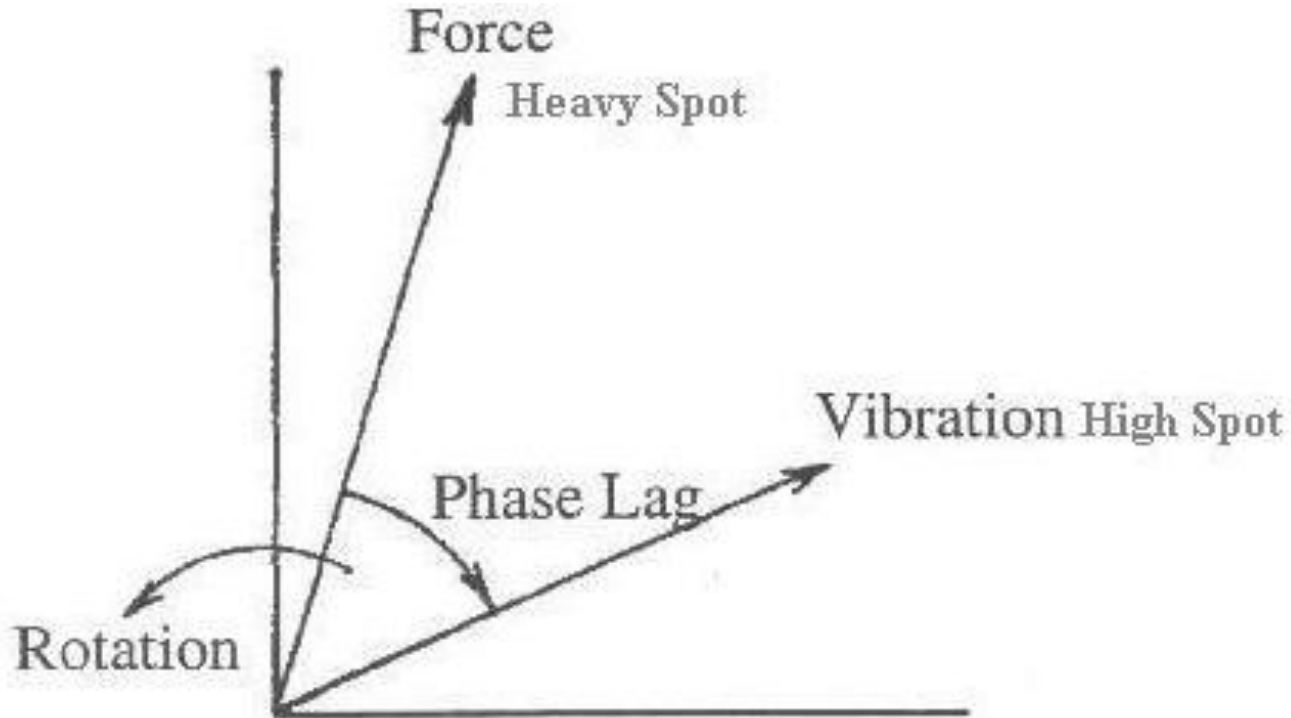
N   = speed of rotor, RPM = 1785 RPM

Factors effecting angle of weight placement

▸ Proximity to Rotor Balance Resonance (Critical Speed)

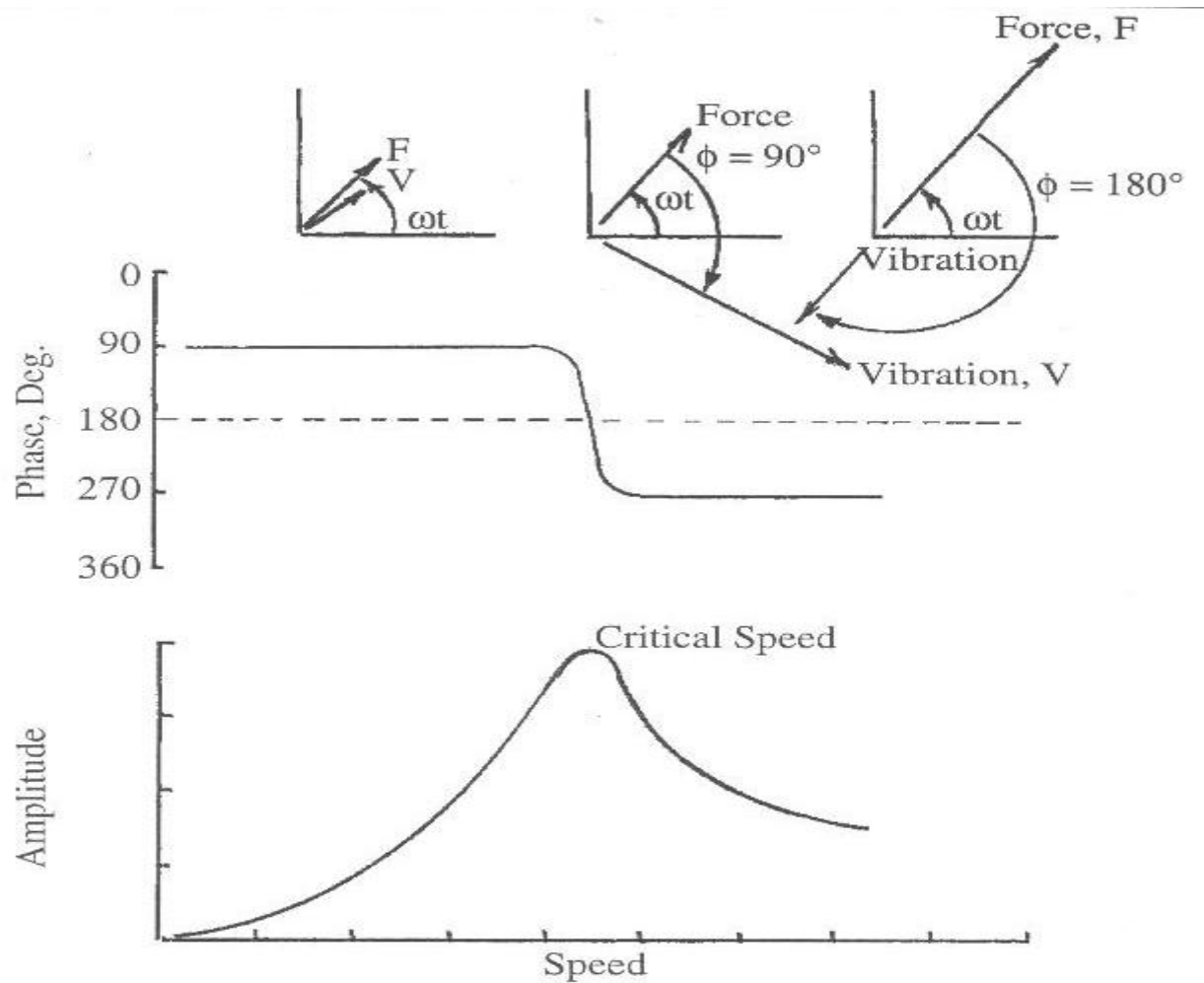(relationship of rotor high spot to heavy spot)

▸ Rotor mode shape

Relationship of rotor high spot to heavy spot

Initially the angular relationship of the Heavy Spot to the High Spot is unknown.

High Spot/Heavy Spot relationship through critical

Trial Weight Placement

- Below resonance add 180^0
- At resonance add 90^0
- Above resonance add 0^0
- If unknown it is usually safe to add 90^0

Remember the purpose of a trial weight is to cause the rotor to display a reasonable amplitude and/or phase change compared to the initial unbalance run. An amplitude and/or phase change is required in order to perform the balancing calculation.   An amplitude change of 10% or phase change of at least 15^0 is desired.

Bump Test – Resonance Identification
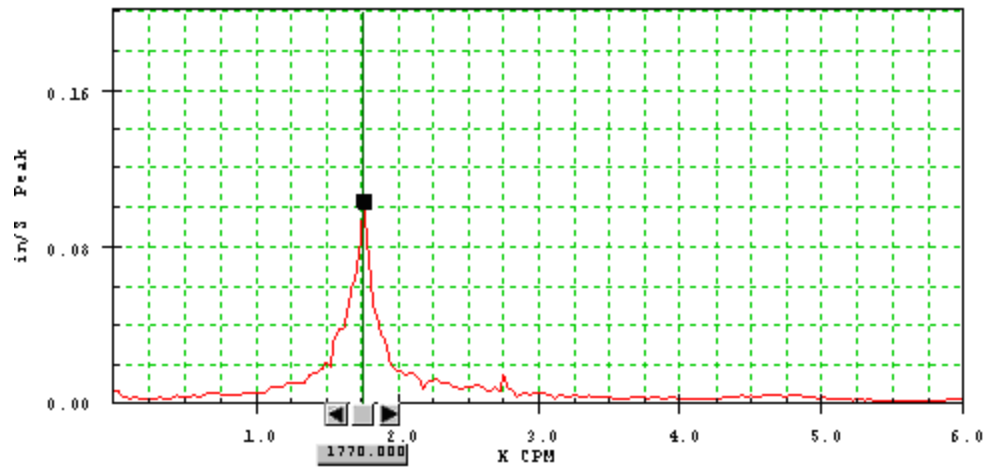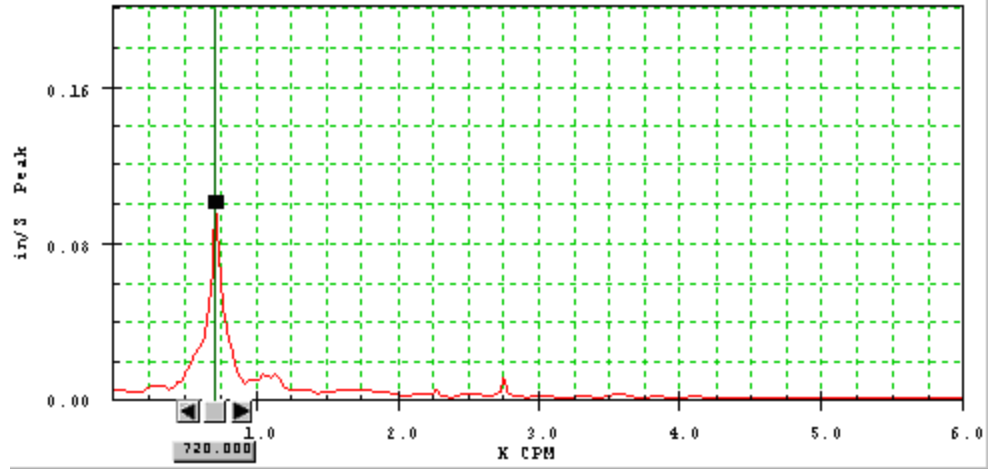
Bode Plot
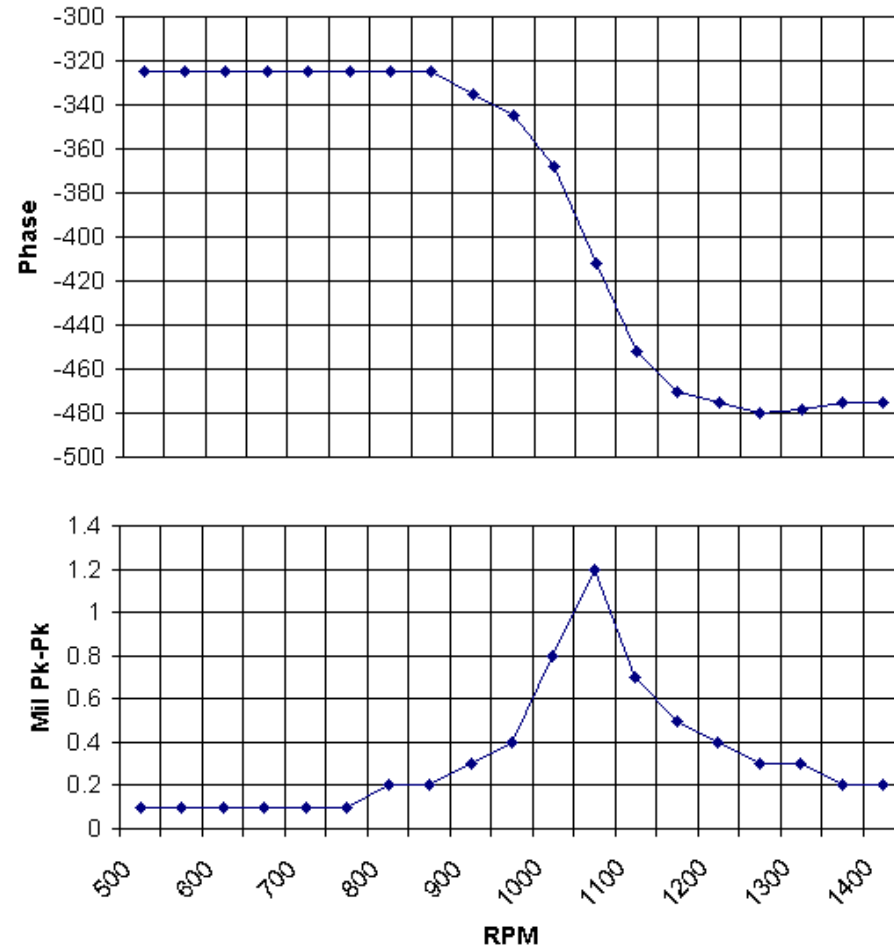
Rotor Mode Shapes – Supported Rotor
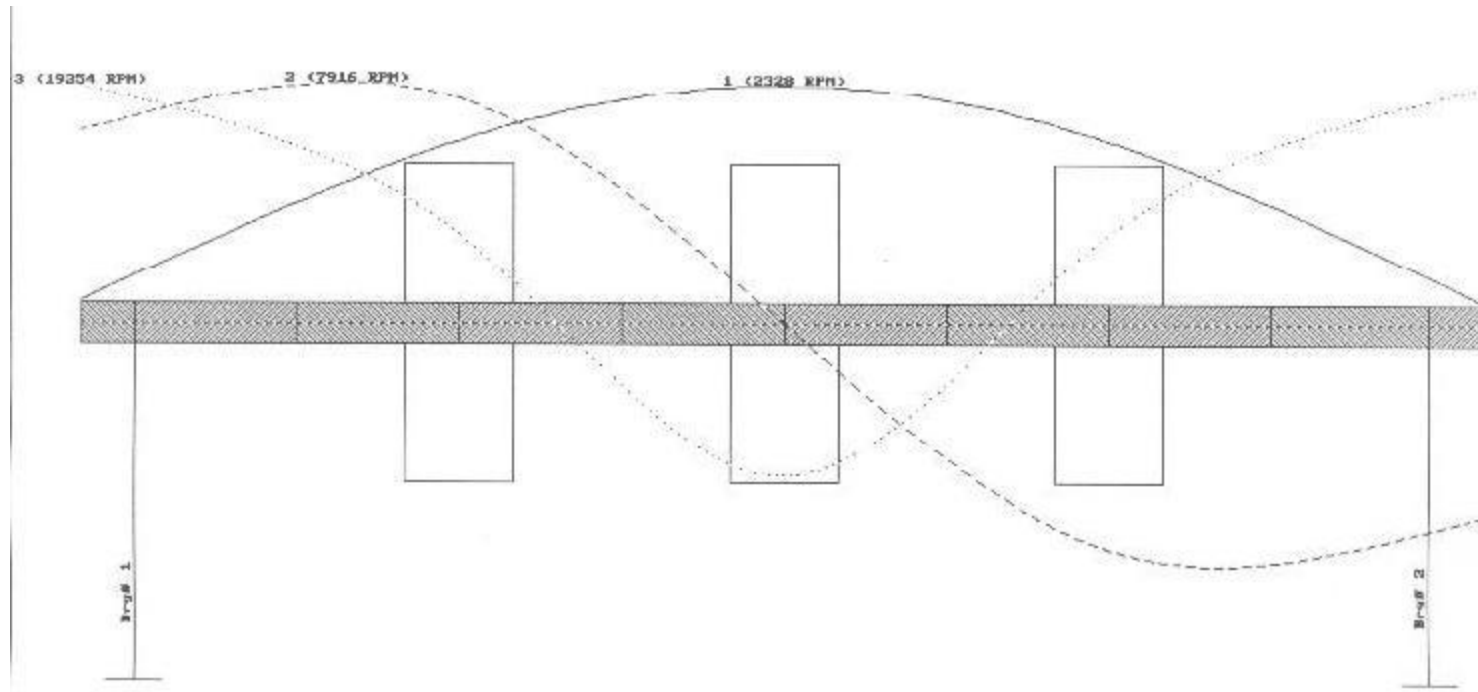
1ST Mode Supported
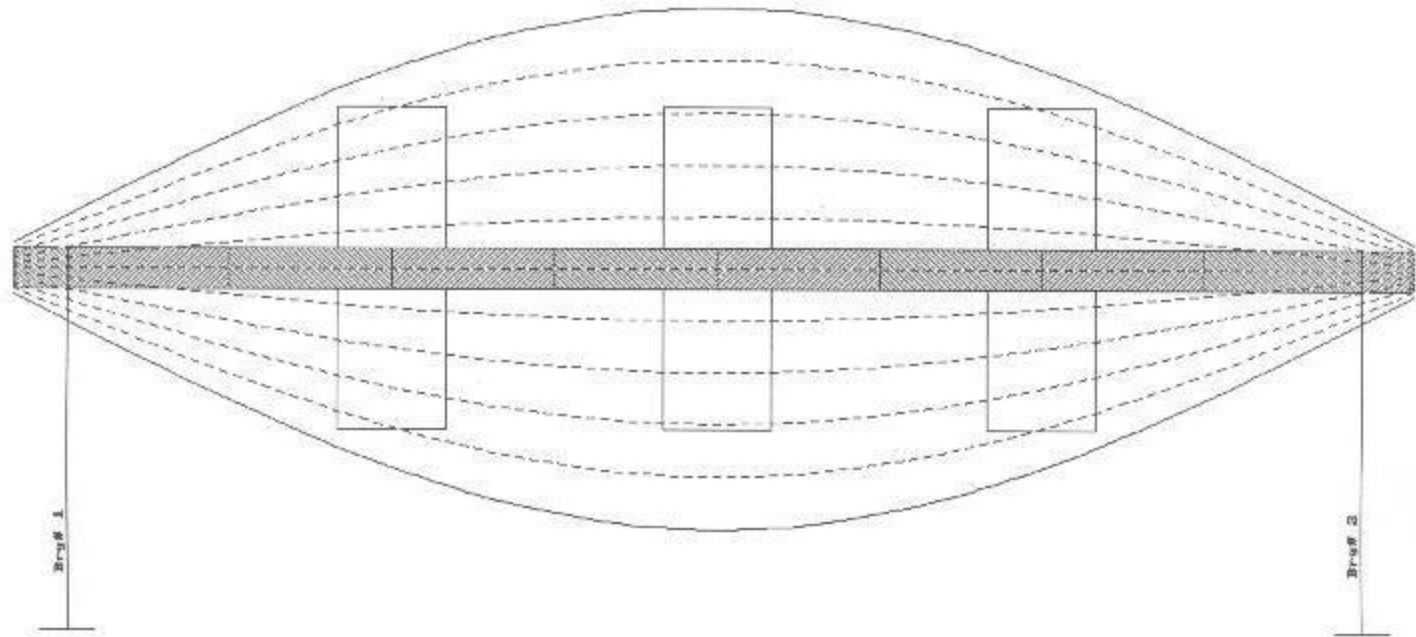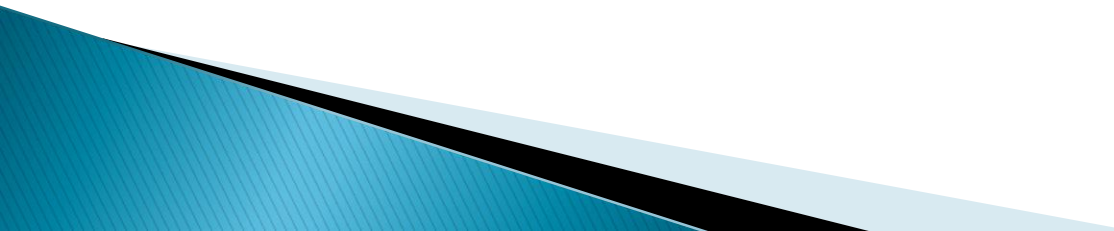
Rotor Mode Shapes – Overhung Rotor
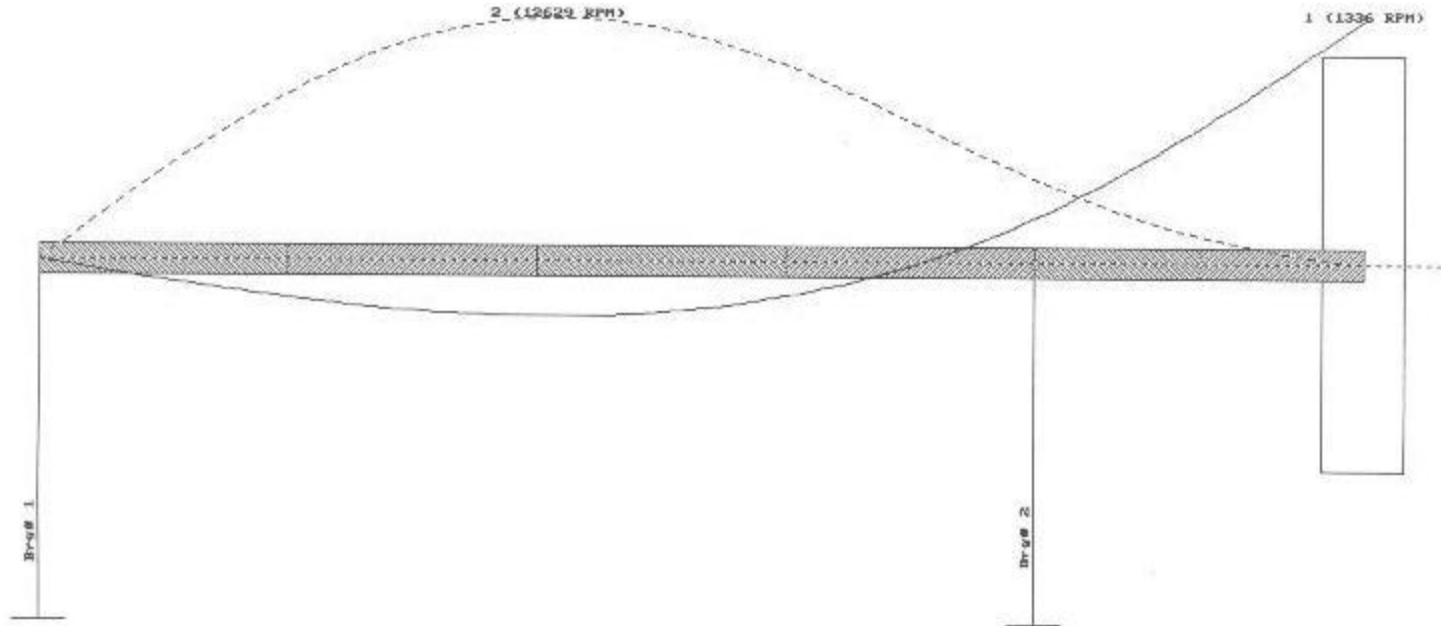
1st Mode Overhung
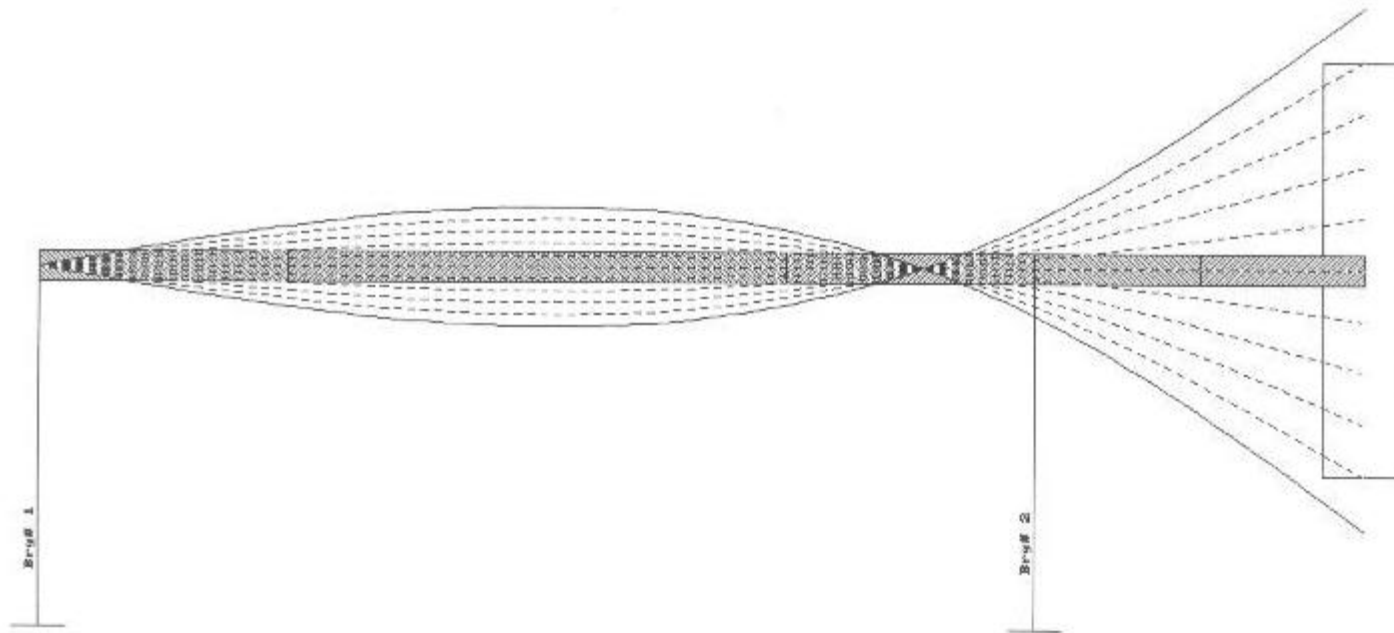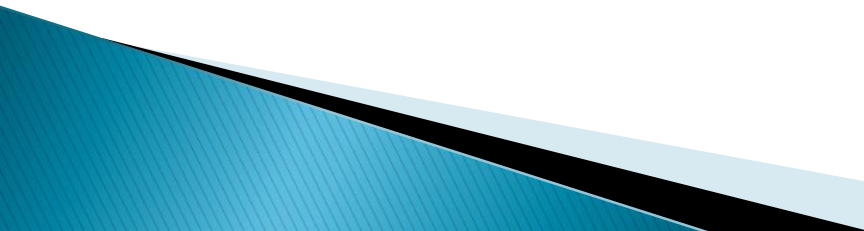
Single Plane Balance Procedure

1. Acquire initial set of 1X amplitude and phase data. Note: Log 1X data in vertical, horizontal, and axial directions at both bearings.
2. Shut down machine and observe 1X amplitude and phase during shutdown to determine proximity of running speed to resonance.
3. Draw Initial 1X vector on Polar graph paper
4. Lock out machine.

Single Plane Balance Procedure

5. Determine trial weight angular placement. Show trial weight magnitude and placement on polar graph.
6. Attach trial weight to rotor.
7. Release locks
8. Run machine and log 1X amplitude and phase at all locations. (Trial Run).
9. Shutdown machine and lock out equipment.
10. REMOVE TRIAL WEIGHT

Single Plane Balance Procedure

11. Draw Trial Weight vector on polar graph.
12. Perform balance calculations to determine magnitude and angle of corrective weight.
13. Attach weight to machine.
14. Release locks and run equipment.
15. Log 1X amplitude and phase at all locations and evaluate data.

- Did 1X amplitudes decrease at all locations. If not, this may not be just a balance issue.
- Is a trim run required to reduce levels to desired magnitude.
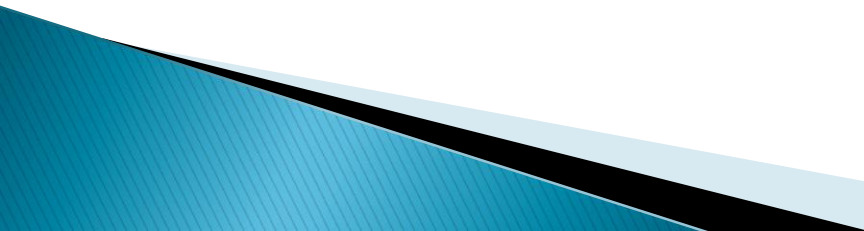
Single Plane Balance Procedure

16. For trim run use Sensitivity/Response Vector to calculate trim balance correction, lock out machine and repeat steps 13−15

Note: If amplitudes do not decrease following trim balance it is probably not a mass unbalance problem. Review data!

Single Plane Balance – Vector Method

1. A = Initial Vibration Response (Mil @ Angle)

2. TW = Trial Weight Placement (Weight @ Angle)

3. B = Trial Weight Vector = A + Effect of Trial Weight (Mil @ Angle)

4. C = Trial Weight Effect = B – A (Draw a line from the head of the A to the head of the B vector. Measure the magnitude of C

5. Calculate the Rotor Sensitivity to weight = S = TW/C (Weight/Mil)

Single Plane Balance – Vector Method

6. Calculate the Correction Weight = (Sensitivity) (Initial Response)

7. Measure the angle between C and A. (This is the number of degrees that weight must be rotated from Trial Weight location)

8. Draw arrow from C to A. (This is the direction to move final balance weight from trial weight location)

9. Show the final balance weight location on the polar graph.

10. Show location of rotor heavy spot on the graph.

Single Plane Balance – Vector Method

11. Measure the angle (Lagging) from the Initial Vector (A) to the location of the installed Corrective Weight (CW). This is the angle of the Sensitivity Vector. The Corrective Weight is at the rotor Light Spot.

12. Combine this measured angle with the calculated rotor sensitivity to weight. (Weight/mil @ Angle). This vector is the Rotor Sensitivity Vector.

13. Save the Sensitivity (S) Vector and use it for Trim and future balance jobs on this machine using the formula $CW = S * A_1$ where A_1 represents a newly measured initial unbalance vector.

Vector Method Example – Steps 1–4
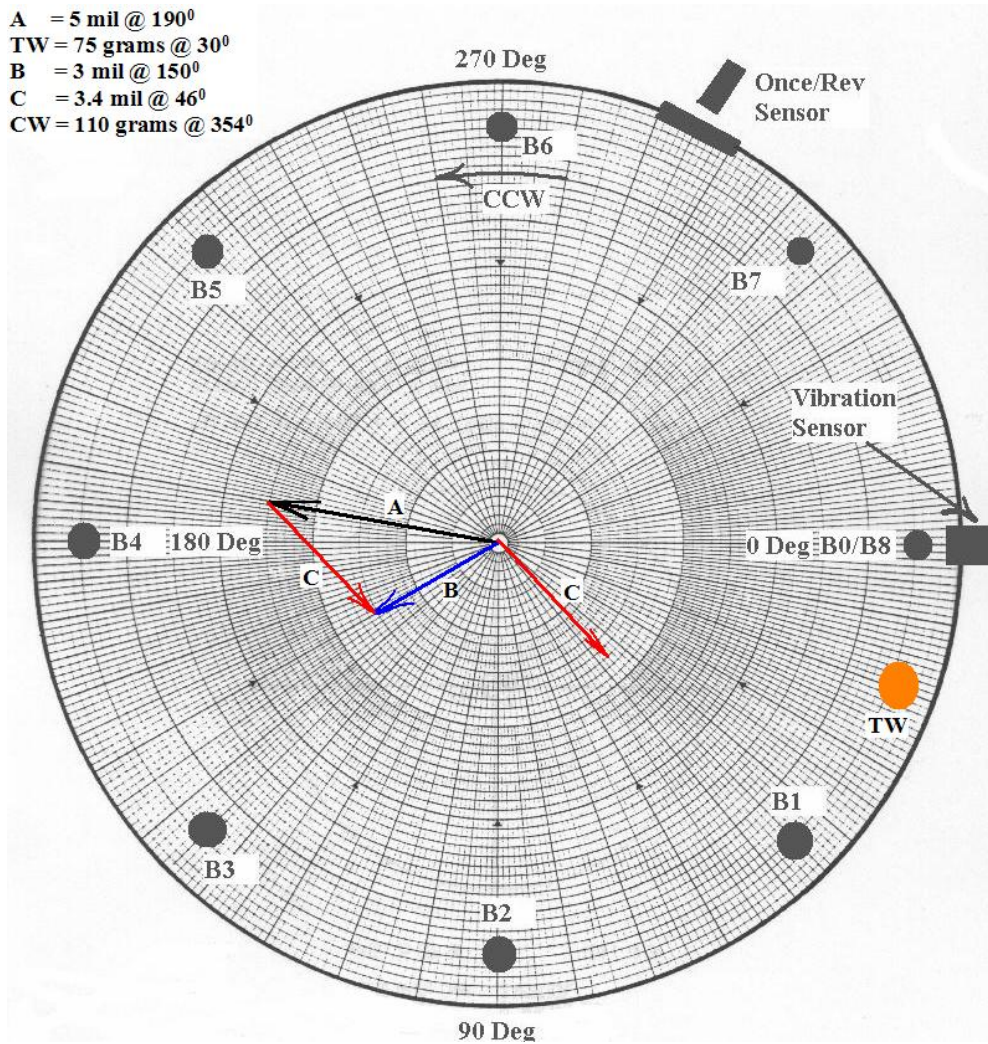
Calculate Weight Sensitivity and Correction Weight Steps 5-6

$$\text{Sensitivity} = S = \frac{\text{Trial Weight}}{C} = \frac{75 \text{ Grams}}{3.4 \text{ mil}} = 22 \frac{\text{gram}}{\text{mil}}$$

$$\text{Correction Weight} = S * A$$
$$= (22 \text{ Gram/mil})(5 \text{ Mil})$$
$$= 110 \text{ Gram}$$

Determine Weight Placement Location and Document Steps 7-10

A = 5 mil @ 190^0
TW = 75 grams @ 30^0
B = 3 mil @ 150^0
C = 3.4 mil @ 46^0
CW = 110 grams @ 354^0

270 Deg

Once/Rev Sensor

B6

CCW

B5

B7

Vibration Sensor

CW

A

B4   180 Deg

C 36^0

U

B   C 36^0

0 Deg B0/B8

36^0 from Trial Weight in CCW direction

TW

B1

B3

B2

90 Deg
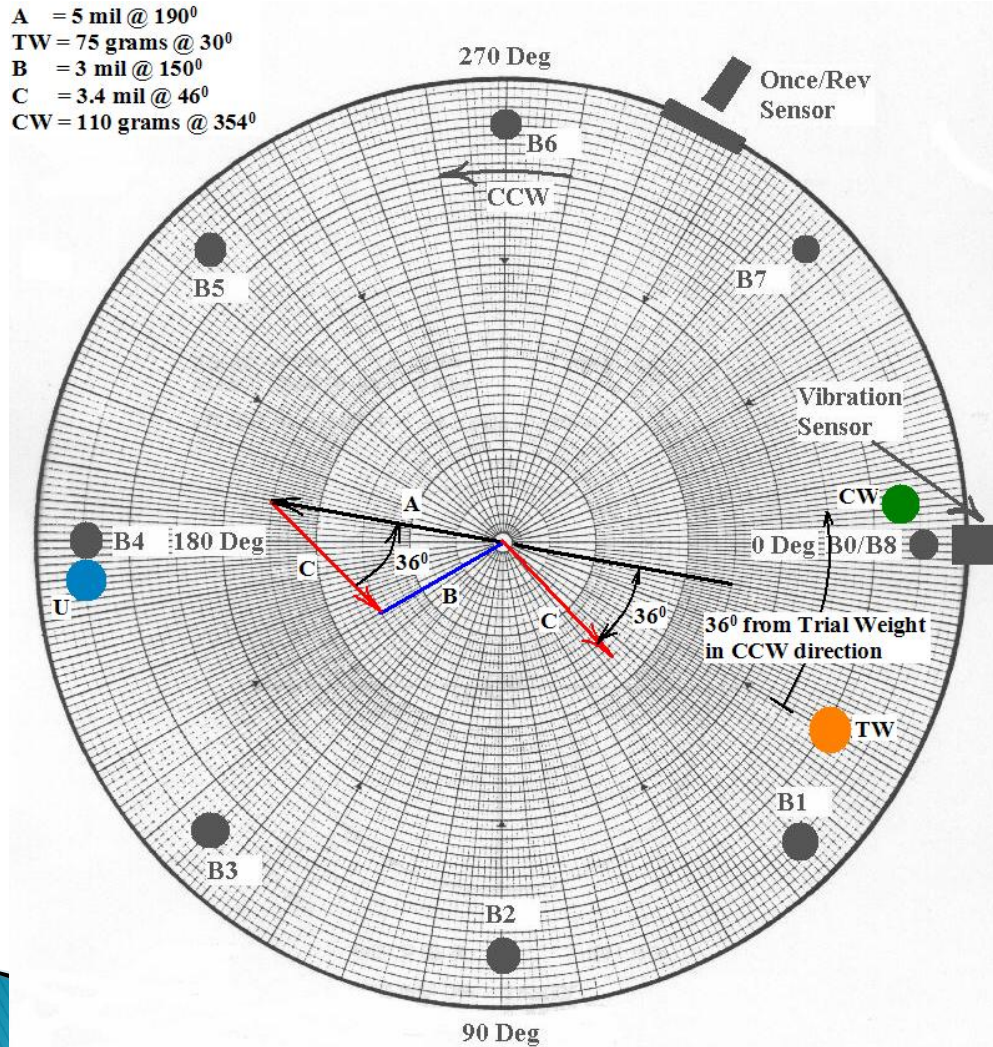
Correction Weight = CW

CW = 110 grams @ 354^0

Heavy Spot = U

U = 110 grams @ 174^0

Measure and Document Rotor Sensitivity Vector
Steps 11–13

A = 5 mil @ 190^0
TW = 75 grams @ 30^0
B = 3 mil @ 150^0
C = 3.4 mil @ 46^0
CW = 110 grams @ 354^0

270 Deg

Once/Rev Sensor

B6

CCW

B5

B7

Lag angle from A to CW = 164^0

Vibration Sensor

A

CW

B4   180 Deg

36^0

0 Deg B0/B8

C

B

U

C

36^0

36^0 from Trial Weight in CCW direction

TW

B1

B3

B2

90 Deg
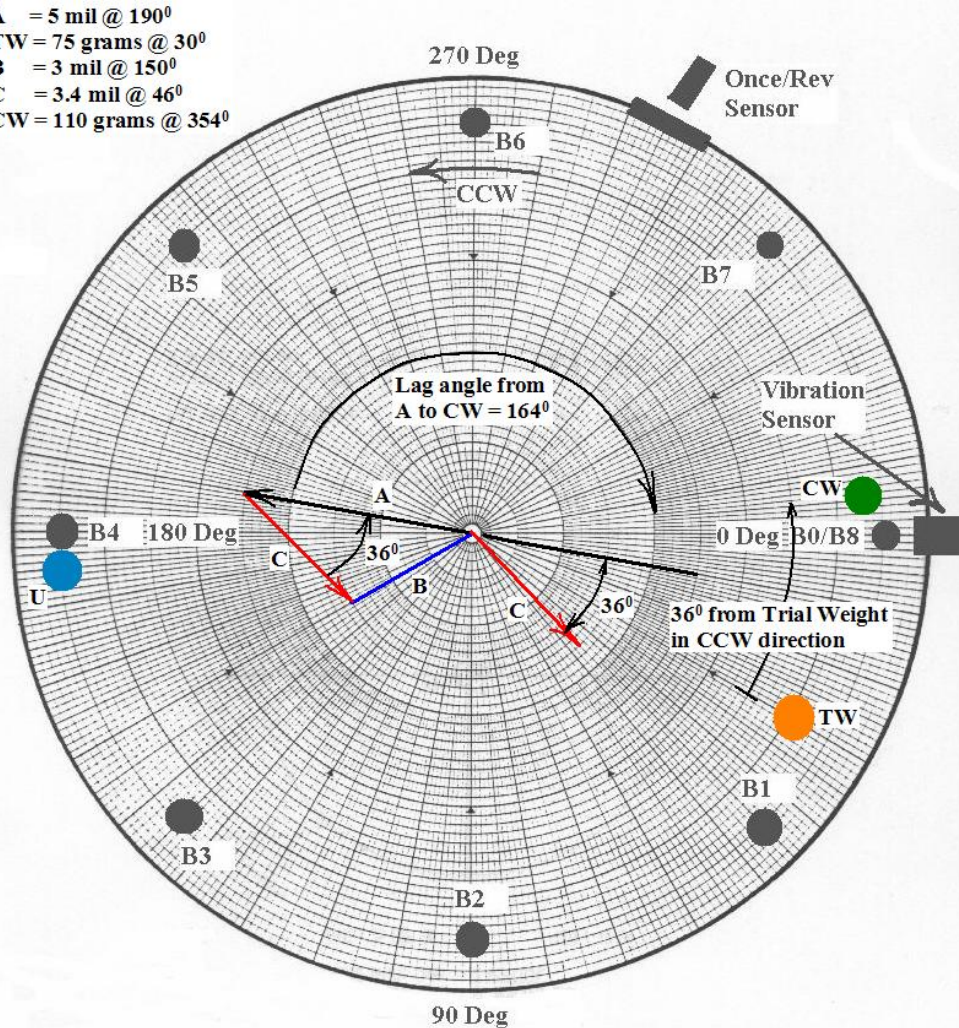
Rotor Sensitivity = S

S = 22 Grams/mil @ 164^0

Proof:

CW = S * A_1

CW = (22 gram/mil @ 164^0)(5 mil @ 190^0)

CW = 110 gram @ 354^0

Single Plane Balance – Influence Coefficient

1. A = Initial Vibration Response (Mil @ Angle)

2. TW = Trial Weight Placement (Weight @ Angle)

3. B = Trial Weight Vector = A + Effect of Trial Weight (Mil @ Angle)

4. C = Trial Weight Effect = B – A (Draw a line from the head of the A to the head of the B vector. Measure the magnitude of C

5. Calculate the Unbalance Influence Coefficient

R_{11} = ___C (mil @ Angle)__   Response at plane 1 to weight at plane 1
          TW (weight @ Angle)

Single Plane Balance – Influence Coefficient

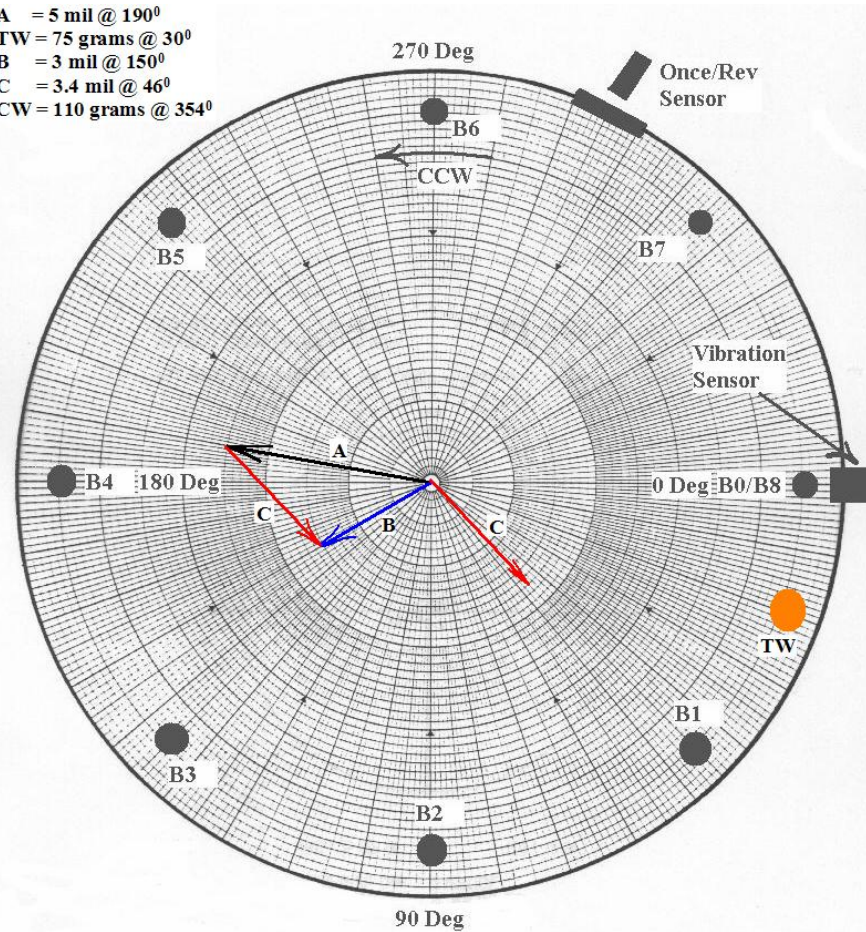6. Calculate the location of the Heavy Spot

    $$U_{11} = \frac{A \; (mil \; @ \; Angle)}{R_{11} \; (mil/weight \; @ \; Angle)} \quad \text{Unbalance at Plane 1}$$

7. Weight Add Solution = $U_{11} + 180^0$ (Light Spot)

8. Show location of Heavy Spot and Light Spot on graph

9. Save Influence Coefficient for future balance work on this equipment

Influence Coefficient Balance Example

Influence Coefficient Balance Example

$$R_{11} = \frac{C \text{ mil @ angle}}{TW \text{ weight @ angle}} = \frac{3.4 \text{ mil @ } 46^0}{75 \text{ gram @ } 30^0}$$

$$= .04533 \text{ mil/gram @ } 16^0$$

$$U_{11} = \frac{A \text{ mil @ angle}}{R_{11} \text{ mil/gram @ angle}} = \frac{5 \text{ mil @ } 190^0}{.04533 \text{ mil/gram @ } 16^0}$$

$$= 110 \text{ gram @ } 174^0$$

$$\text{Wt Add} = U_{11} + 180^0 = 110 \text{ gram @ } 174^0 + 180^0$$

$$= 110 \text{ gram @ } 354^0$$

Influence Coefficient Balance Example

A   = 5 mil @ 190^0
TW = 75 grams @ 30^0
B   = 3 mil @ 150^0
C   = 3.4 mil @ 46^0
CW = 110 grams @ 354^0
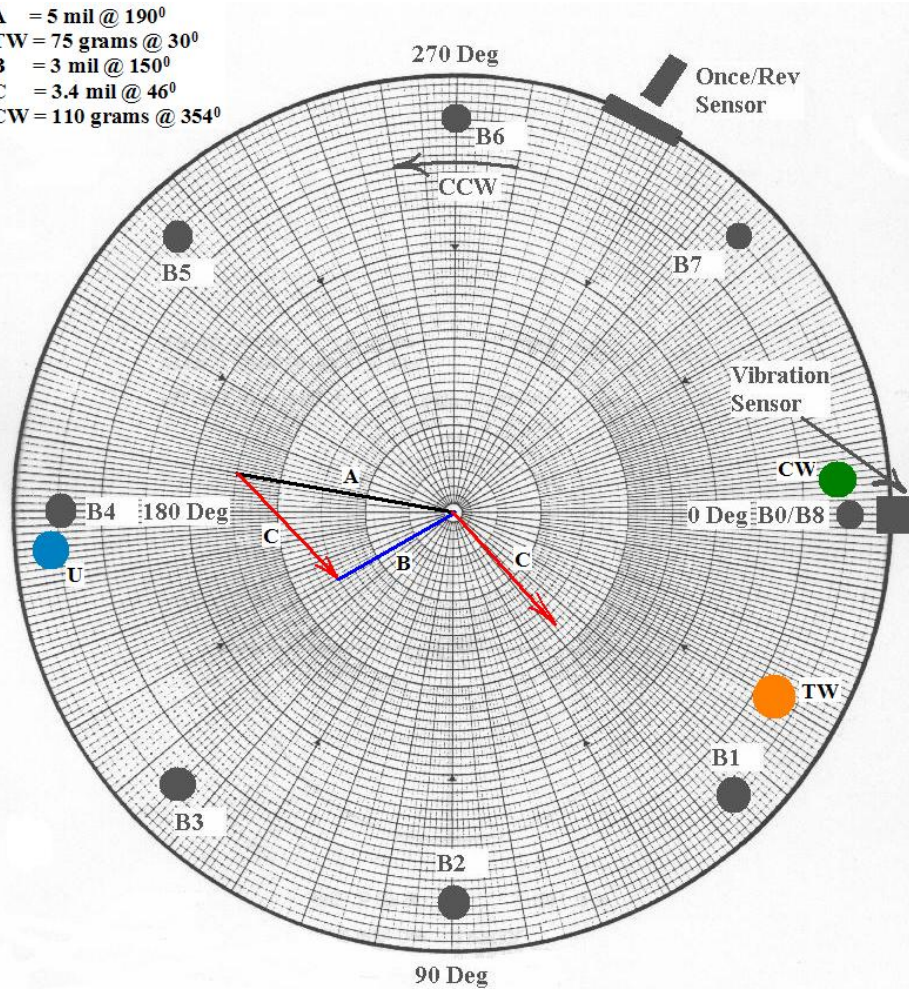
Influence Coefficient - Diagnostics

The Influence Coefficient provides powerful insight into a rotor behavior.

1. The influence Coefficient for a given rotor should not change over the life of the equipment. Changes in magnitude or angle indicate changes in rotor/support condition or may be the result of external forces such as misalignment.

2. The angle of the Influence Coefficient documents the relationship of the Rotor Heavy Spot (Force) to the Rotor High Spot. Hence, the angle documents where a rotor is running relative to its Critical Speed.

Example 1: Well below Resonance

1) $A =$ Initial Vibration Response (2.3 Mil @ 42^0)

2) $TW =$ Trial Weight Placement (60 Gm @ 74^0)

3) $B = A +$ Effect of Trial Weight (4.3 Mil @ 57^0)

4) $C = B - A =$ Effect of Trial Weight (2.2 Mil @ 73^0)

5) $R_{11} = \dfrac{2.2 \text{ Mil @ } 73^0}{60 \text{ Gm @ } 74^0} = 0.036$ mil/Gm @ 359^0

6) $U_{11} = \dfrac{2.3 \text{ Mil @ } 42^0}{0.036 \text{ mil/Gm @ } 359^0} = 63.9$ Gm @ 43^0

7) Weight Add Solution $= U_{11} + 180^0 = 63.9$ Gm @ $\mathbf{223^0}$

Example 1 : Graphical Solution
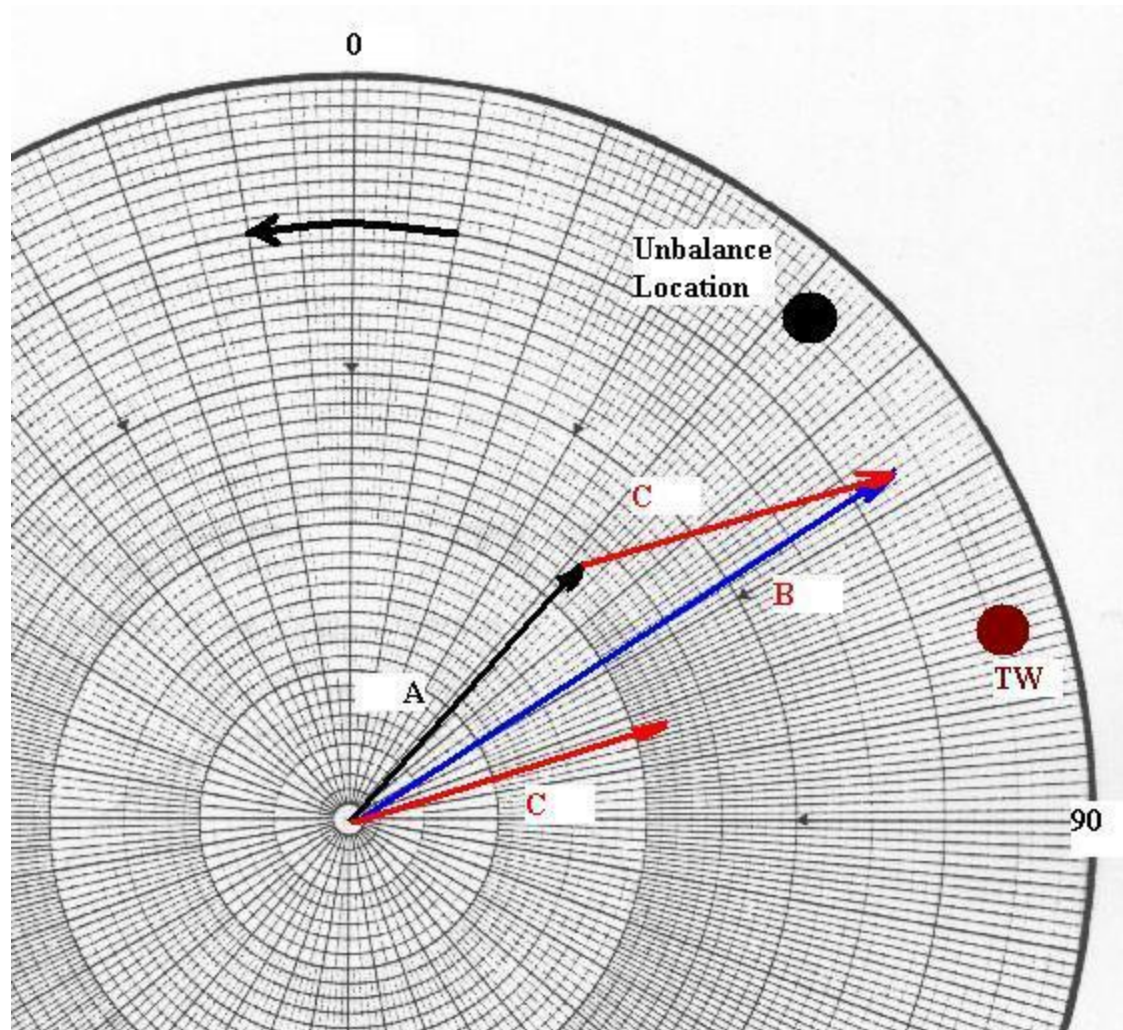
Example 2: Rotor at Resonance

1) A = Initial Vibration Response (5.7 Mil @ 168^0)

2) TW = Trial Weight Placement (5 Gm @ 270^0)

3) $B = A +$ Effect of Trial Weight (3.3 Mil @ 155^0)

4) $C = B - A =$ Effect of Trial Weight (2.59 Mil @ 4^0)

5) $R_{11} = \dfrac{2.59 \text{ Mil @ } 4^0}{5 \text{ Gm @ } 270^0} = 0.519$ mil/Gm @ 94^0

6) $U_{11} = \dfrac{5.7 \text{ Mil @ } 168^0}{0.519 \text{ mil/Gm @ } 94^0} = 10.98$ Gm @ 74^0

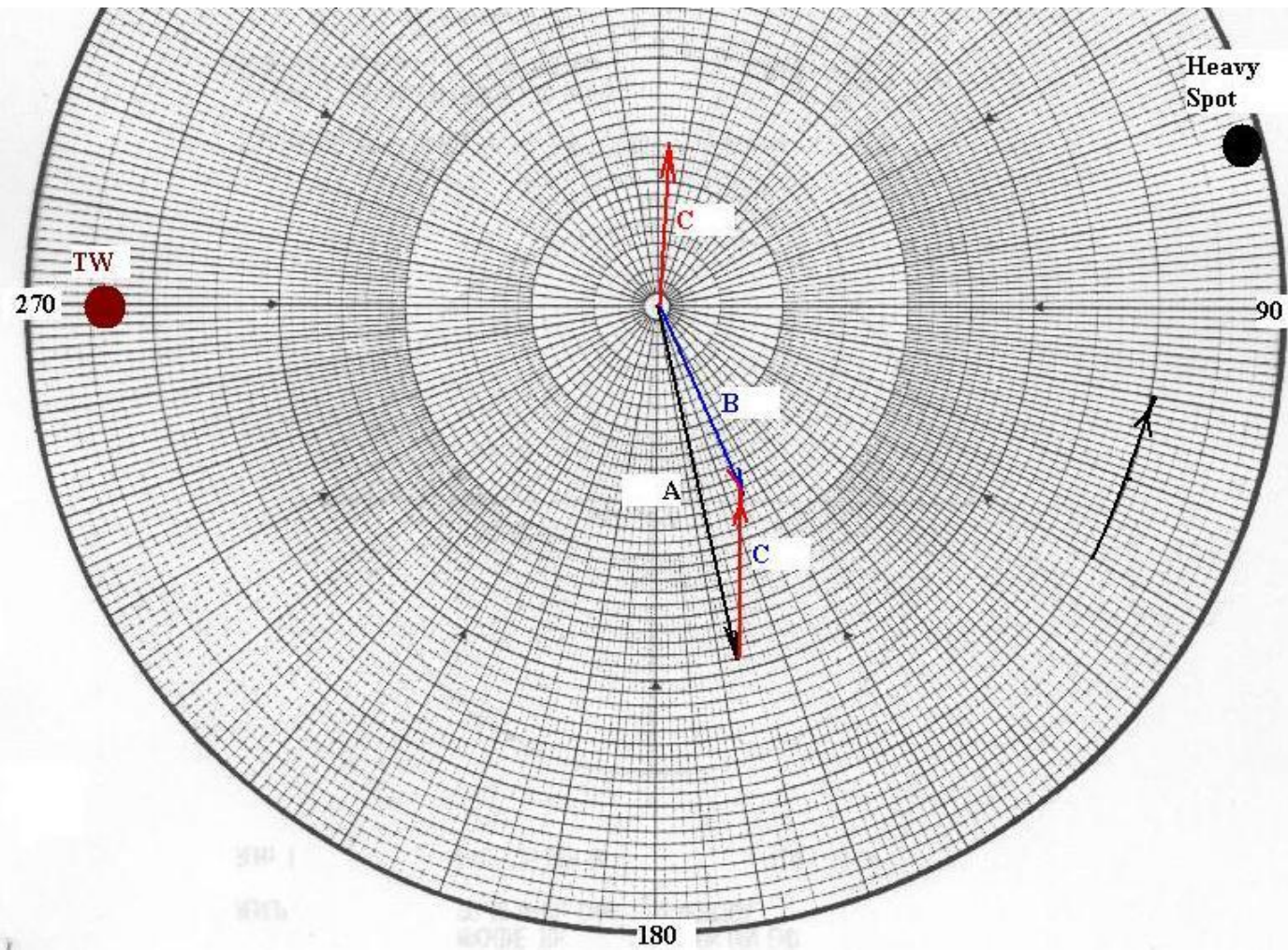7) Weight Add Solution $= U_{11} + 180^0 = 13.26$ Gm @ 254^0

Example 2: Graphical Solution

Example 3: Rotor above Resonance

1) A = Initial Vibration Response (4.9 Mil @ 264^0)

2) TW = Trial Weight Placement (5 Gm @ 270^0)

3) $B = A +$ Effect of Trial Weight (3.0 Mil @ 259^0)

4) $C = B - A =$ Effect of Trial Weight (1.93 Mil @ 92^0)

5) $R_{11} = \dfrac{1.93 \text{ Mil @ } 92^0}{5 \text{ Gm @ } 270^0} = 0.386$ mil/Gm @ 182^0

6) $U_{11} = \dfrac{4.9 \text{ Mil @ } 264^0}{0.386 \text{ mil/Gm @ } 182^0} = 12.7$ Gm @ 82^0

7) Weight Add Solution $= U_{11} + 180^0 = 12.7$ Gm @ 262^0

Example 3: Graphical Solution
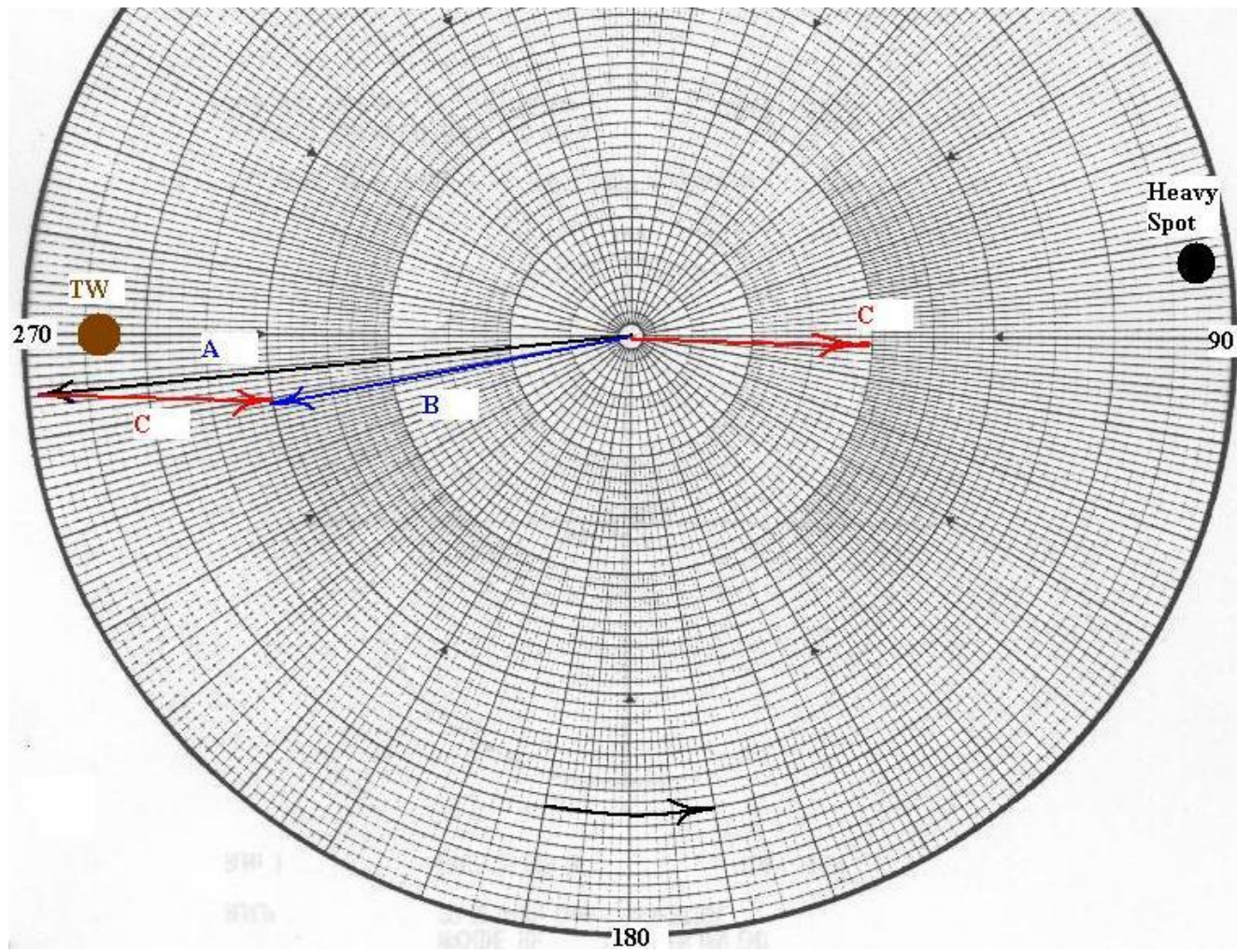
Example 4: Initial Condition – Static and Couple

Initial Condition
#5 Brg - 4.9 mil @ 80
#6 Brg - 1.7 mil @ 200

Static: 2.2 mil@ 100
Couple:
#5 Brg= 2.9 mil @ 66
#6 Brg= 2.9 mil @ 246
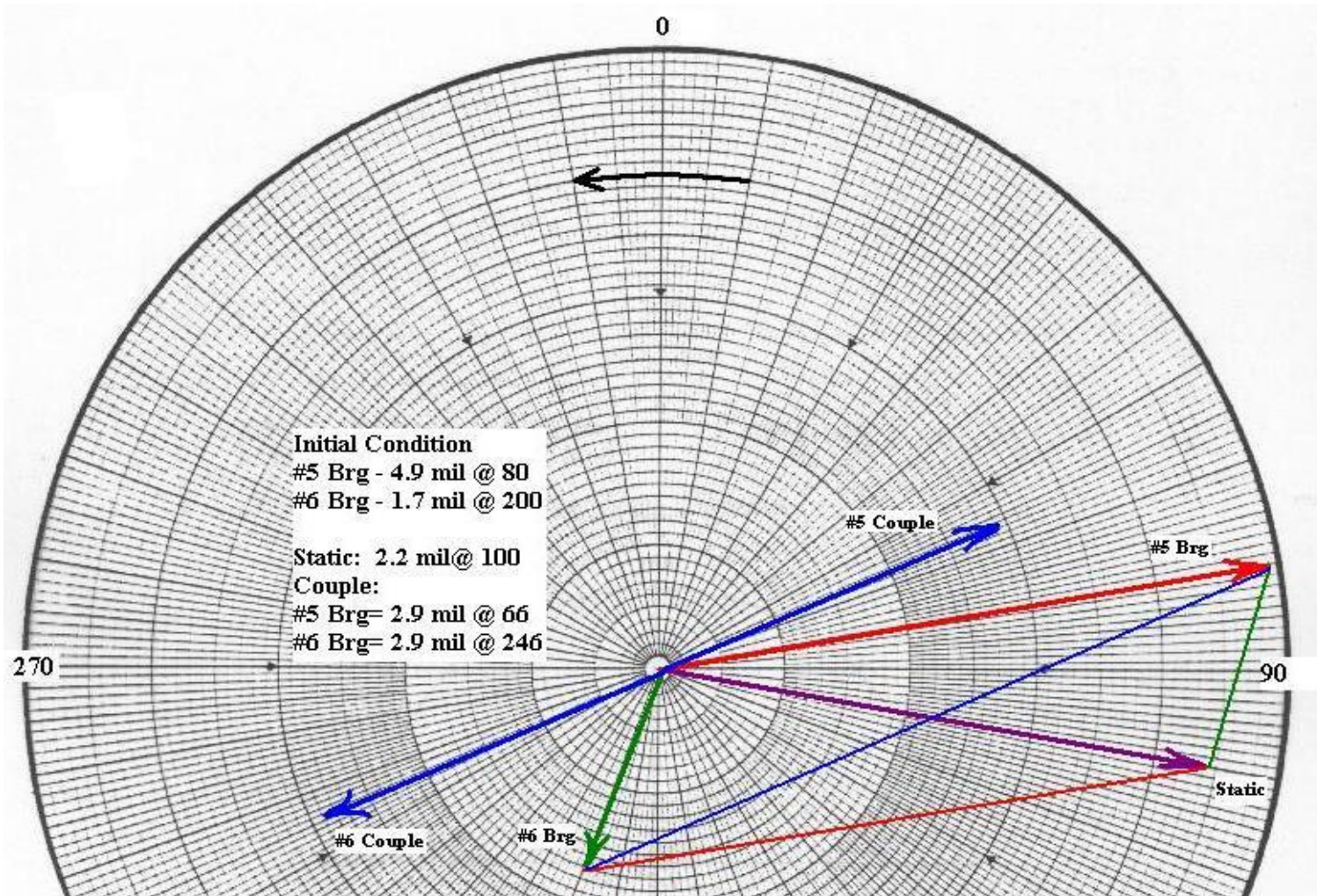
Example 4: Single Plane Balance – Modal Pair
Based On #5 Bearing

1) A = Initial Vibration Response (2.9 Mil @ 66^0)

2) TW = Trial Weight Placement (18 Oz @ 190^0)

3) $B = A$ + Effect of Trial Weight (0.8 Mil @ 73^0)

4) $C = B - A$ = Effect of Trial Weight (2.2 Mil @ 244^0)

5) $R_{11} = \dfrac{2.2 \text{ Mil @ } 244^0}{18 \text{ Oz @ } 190^0} = 0.122$ mil/Oz @ 54^0

6) $U_{11} = \dfrac{2.9 \text{ Mil @ } 66^0}{0.122 \text{ mil/Gm @ } 54^0} = 23.8$ Oz @ 12^0

7) Weight Add Solution = $U_{11} + 180^0$ = Brg #5 23.8 Oz @ 192^0

   Brg #6 23.8 Oz @ 12^0

Example 4: Trial Run Graph
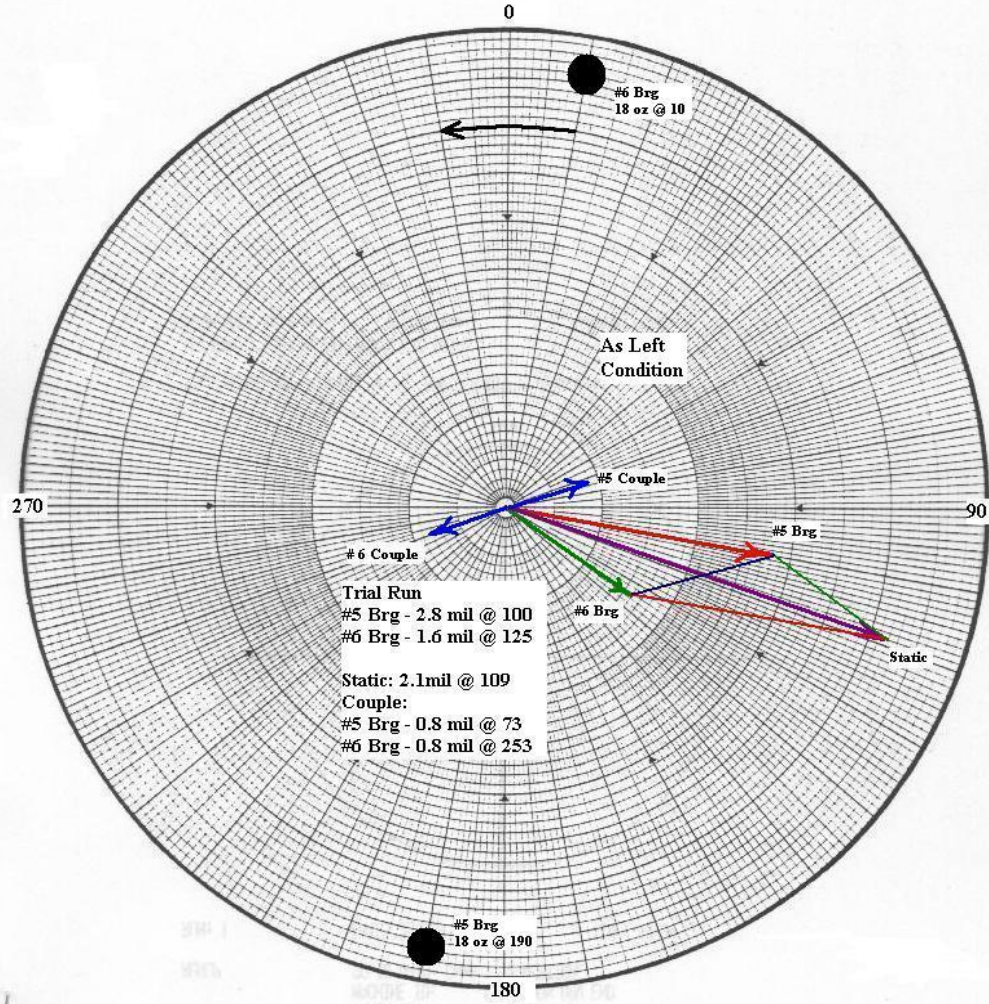
Example 5 – 2 Plane Balance

Initial Unbalance
  A1 = S11 U1 + S12 U2
  A2 = S21 U1 + S22 U2

A1 = Vibration Response at bearing #1
A2 = Vibration Response at bearing #2

U1 = Unbalance at Plane #1
U2 = Unbalance at Plane #2

S11 = Sensitivity of unbalance at Plane #1 to Location #1
S21 = Sensitivity of unbalance at Plane #1 to Location #2
S12 = Sensitivity of unbalance at Plane #2 to Location #1
S22 = Sensitivity of unbalance at Plane #2 to Location #2

2 Plane Balance

W1 = Trial weight at Plane #1
B11 = Vibration at Brg #1 with TW at Plane #1
B21 = Vibration at Brg #2 with TW at Plane #1

W2 = Trail weight at Plane #2
B12 = Vibration at Brg #1 with TW at Plane #2
B22 = Vibration at Brg #2 with TW at Plane #2

2 Plane Balance

Effect of Trial Weights W1 and W2 at each measurement plane

C11 = B11 – A1   Response at Brg #1 to W1
C21 = B21 – A2   Response at Brg #2 to W1
C12 = B12 – A1   Response at Brg #1 to W2
C22 = B22 – A2   Response at Brg #2 to W2

Calculate the Sensitivity (Influence Coefficient)
S11 = C11 / W1
S21 = C21 / W1
S12 = C12 / W2
S22 = C22 / W2

2 Plane Balance

Amount of unbalance at each plane

$$U1 = (S22\ A1 - S12\ A2) / (S22\ S11 - S12\ S21)$$
$$U2 = (S11\ A2 - S21\ A1) / (S22\ S11 - S12\ S21)$$

Note: For weight add solution 180^0 needs to be added to calculated unbalance vectors.

Example 5 – 2 Plane Balance

Balance Data

$A1 = 2.8 \text{ mil} @ 211$
$A2 = 5.0 \text{ mil} @ 105$

$TW1 = 60 \text{ gr} @ 180$
$B11 = 4.3 \text{ mil} @ 224$
$B21 = 6.9 \text{ mil} @ 76$

$TW2 = 60 \text{ gr} @ 135$
$B12 = 2.0 \text{ mil} @ 254$
$B22 = 4.6 \text{ mil} @ 111$

C11 Direct Effect Wt at Plane 1
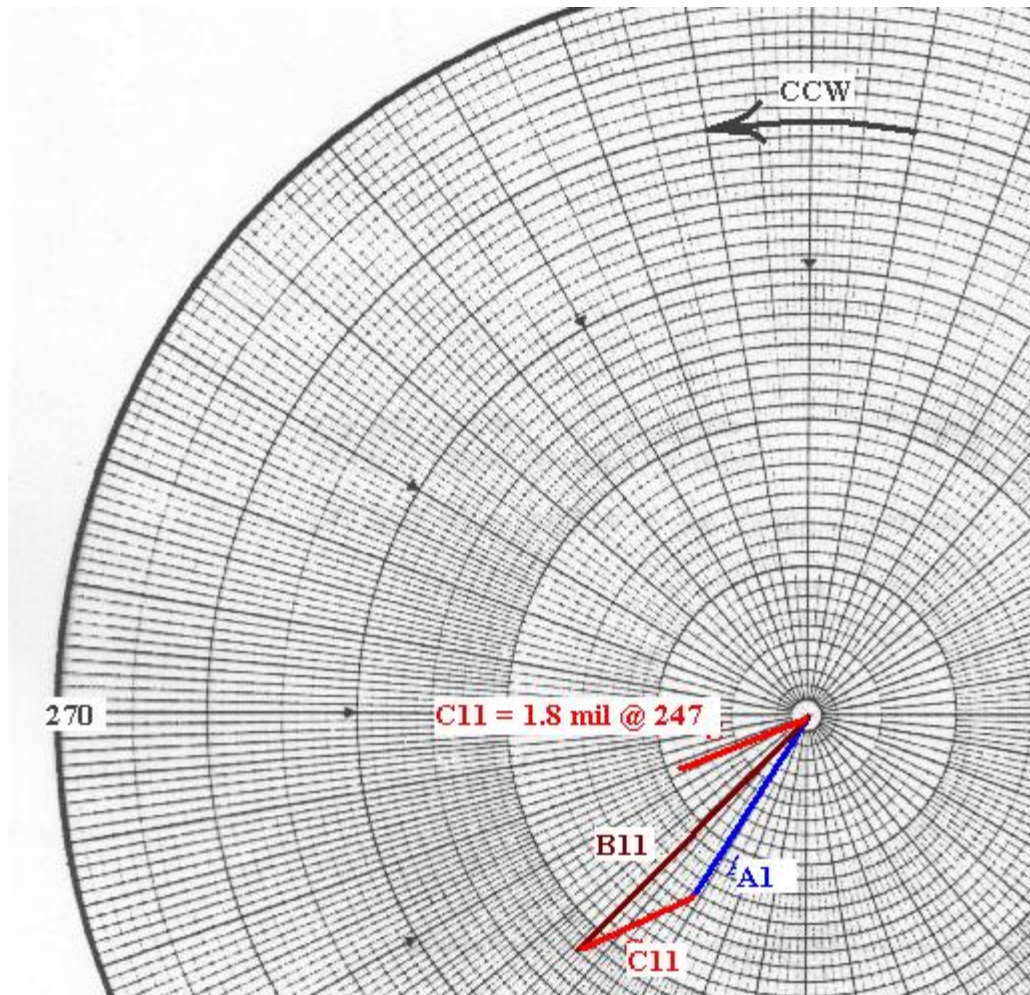
C12 Cross Effect wt at Plane 1
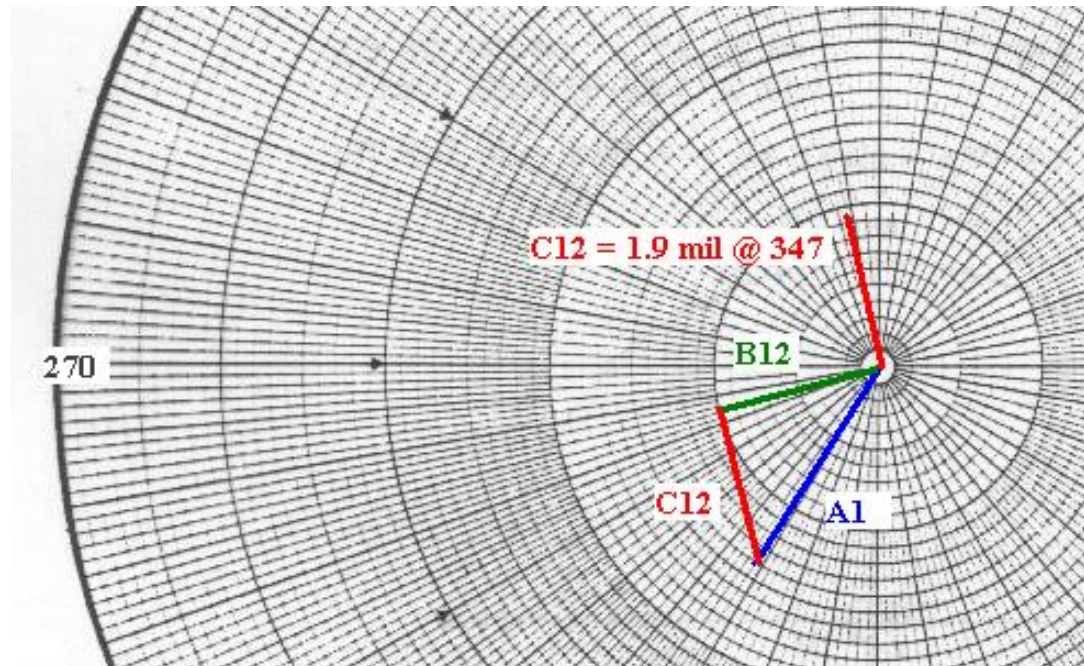
C21 Cross Effect Wt at plane 2
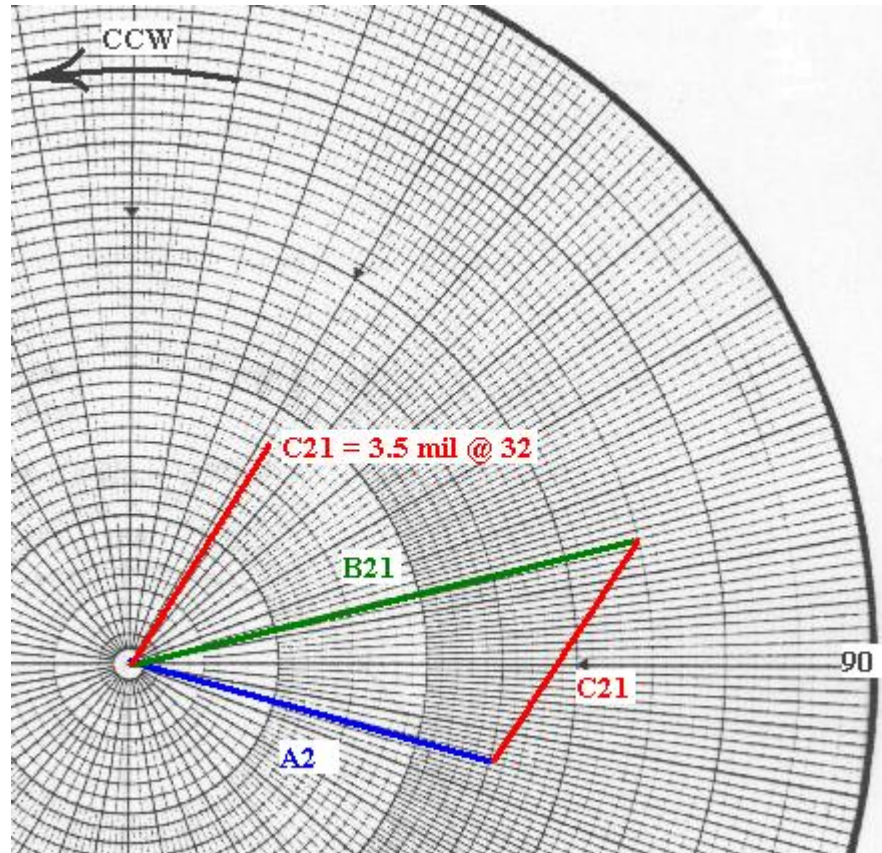
C22 – Direct Effect Wt at Plane 2
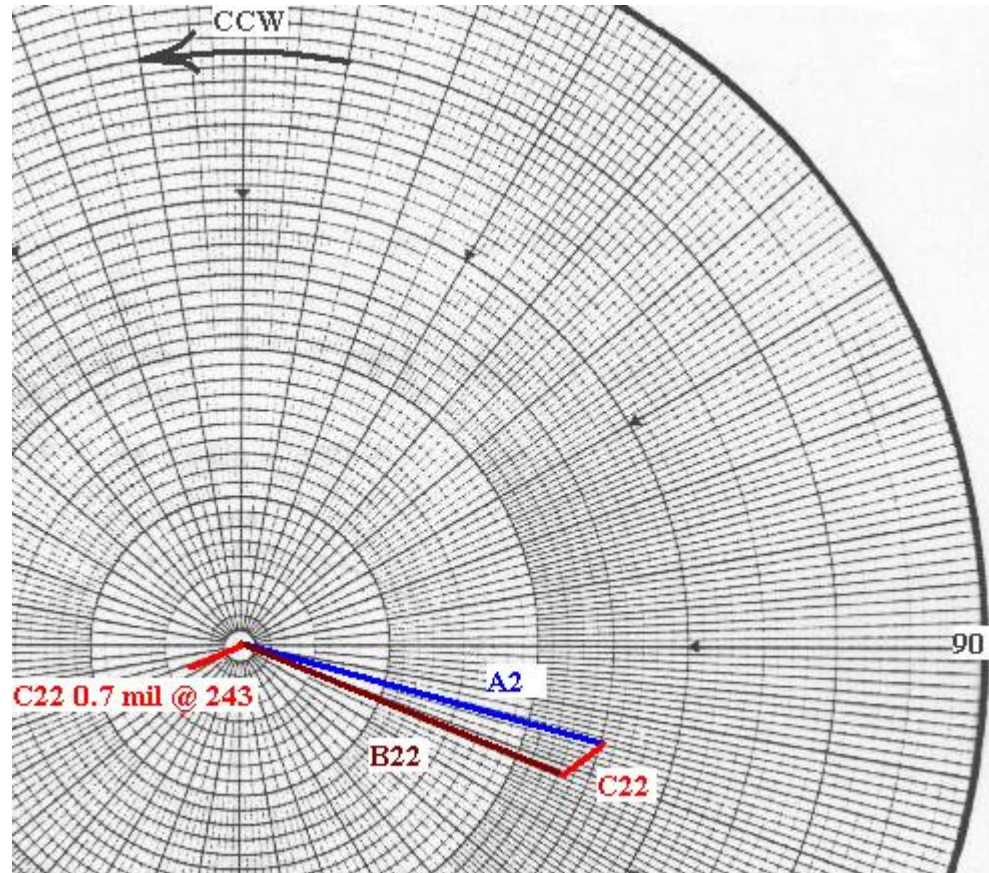
2 Plane Balance Influence Coefficients

$C11 = 1.8$ mil @ 247
$C21 = 3.5$ mil @ 32

$S11 = 0.030$ mil\gr @ 67
$S21 = 0.058$ mil\gr @ 212

$C12 = 1.9$ mil @ 347
$C22 = 0.7$ mil @ 243

$S12 = 0.032$ mil\gr @ 212
$S22 = 0.012$ mil\gr @ 108

Calculated Solution:
Plane 1 = 82 gr. @ 80
Plane 2 = 106 gr. @ 159

BALANCING TOLERANCES

- Shop
  - API
  - ISO G1.0
  - Force

- Field

BALANCING TOLERANCES – SHOP

API / NAVY

$$\frac{4W}{N} \text{ oz in}$$

BALANCING STANDARDS

NAVY/API

$$U_r = \frac{4W}{N} \text{ (oz.–in.) residual unbalance}$$

W = weight of rotor at journal, lb.

N = speed of rotor, RPM

U_r = residual unbalance, oz.–in.

BALANCING STANDARDS (cont.)

EXAMPLE: 1,000 lb. journal WT @ 6,000 RPM

$$U_r = \frac{4\,(1,000)}{6,000} = 0.667 \text{ oz.--in.}$$

$$e\,Pk = \text{eccentricity} = \frac{.667 \text{ oz.} - \text{in.}}{1,000 \text{ lb. x } 16\,\frac{\text{oz.}}{\text{in.}}} = 41.67 \text{ micro} - \text{inches}$$

vibration Pk--Pk = 2 x e = 2 x .00004167 = 83.33 μ in. =
0.083 mils Pk to Pk

BALANCING STANDARDS (cont.)

ISO   1.0 mm/sec. = G1.0 (on the rotor not pedestal)

$$\text{Velocity} = \frac{1.0 \text{ mm/sec.}}{25.4 \text{ mm/in.}} = 0.0394 \text{ IPS}$$

$$e = \text{Displacement} = \frac{V}{2\pi f}$$

$$e = \frac{0.0394 \text{ IPS}}{2\pi \times \frac{6,000}{60}} = 62.6 \text{ micro inches}$$

Balancing machine limit ~ 20 micro inches

BALANCING TOLERANCES – FORCE

$$F < \frac{1}{10} \text{ Rotor WT}$$

$$F = Me \left(\frac{2\pi N}{60} \right)^2$$

1/10 g BALANCE LIMIT

$F \quad = \quad me\omega^2$

$F \quad = \quad \dfrac{W}{g} e \left(\dfrac{2\pi N}{60} \right)^2$

$W_b \quad = \quad U_r = g \dfrac{W}{10} \left(\dfrac{60}{2\pi N} \right)^2 \text{ lb.} - \text{in.}$

$U_r \quad = \quad 1.6 \, g \, W \left(\dfrac{60}{2\pi N} \right)^2 \text{ oz.} - \text{in.}$

$G = 386.1 \text{ in.}/\text{sec.}^2 \quad W = \text{rotor WT, lb.} \quad N = \text{RPM of rotor}$
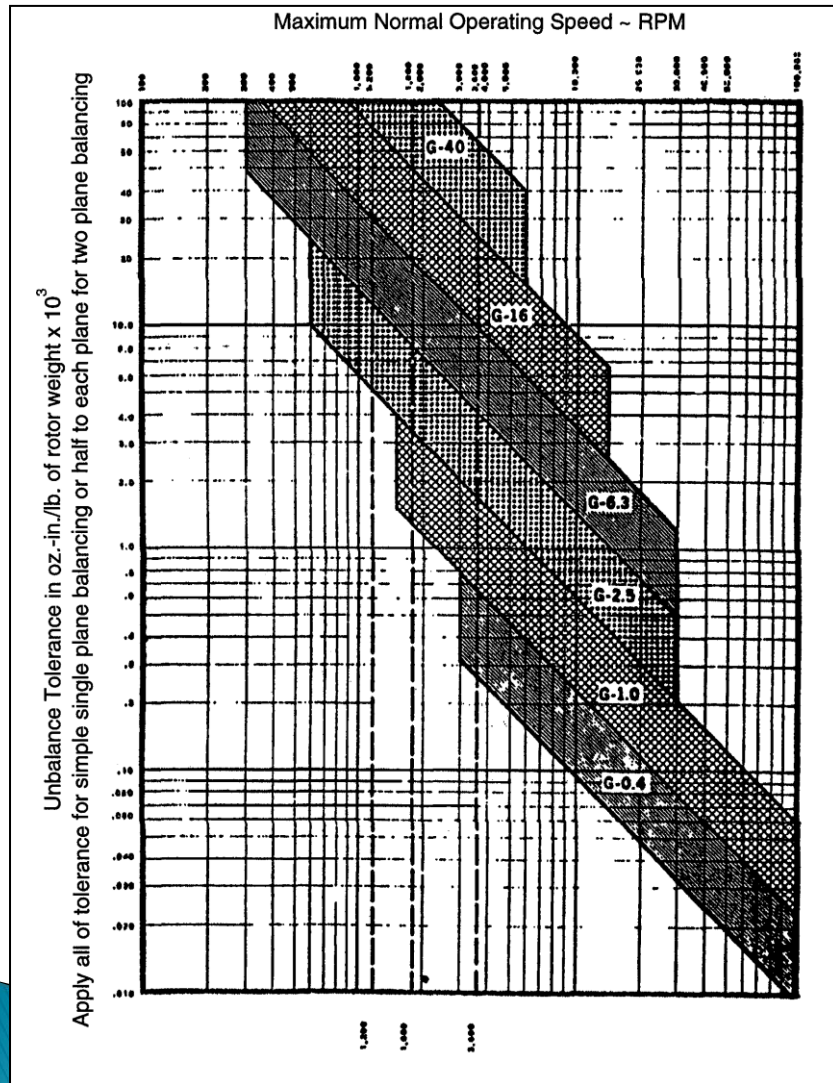
1/10 g BALANCE LIMIT (cont.)

EXAMPLE: 2,000 lb rotor @ 6,000 RPM

WT per journal 1,000 lb.

$$U_r = 1.6 \times 386.1 \times 1,000 \left(\frac{60}{2\pi \, 6,000} \right)^2$$

$$U_r = 1.57 \text{ oz.} - \text{in.} \quad \text{or} \quad U_r \times \frac{453.4}{16} = 44.4 \text{ gm} - \text{in.}$$

ISO STANDARD FOR RIGID ROTOR BALANCE

Unbalance Tolerance Guide for Rigid Rotors*

Based on VDI Standard by the Society of German Engineers, Oct. 1963

*Reprinted from IRD Mechanalysis, Inc. Application Report No. 111, Dynamic Balancing

ISO STANDARD FOR RIGID ROTOR BALANCE

ROTOR CLASSIFICATION (Balance Quality)	ROTOR DESCRIPTION (Example of General Types)
G 40	Passenger car wheels and rims
G 16	Automotive drive shafts Parts of crushing and agricultural machinery
G 6.3	Drive shafts with special requirements, Rotor of processing machinery, Centrifuge bowls, Fans, Flywheels, Centrifugal pumps, General machinery and machine tool parts, Standard electric motor armatures
G 2.5	Gas and steam turbines, Blowers, Turbine rotors, Turbo generators, Machine tool drives, Medium and bigger electric motor armature with special requirements, Armature of fractional hp motors, Pumps with turbine drive
G 1 Precision Balancing	Jet engine and super charter rotors, tape recorder and phonograph drives, Grinding machine drives, Armatures of fractional HP motors with special requirements
G 0.4 Ultra Precision Balancing	Armatures, shafts and precision grinding machines

ACCEPTABLE VIBRATION LEVELS FOR FIELD BALANCING

$$\text{allowable vibration} = V_{per} = \frac{T}{W_t \times R} \times \frac{6.015\ GW}{N}$$

where V_{per} = mils pk to pk

T = effect vector, mils pk to pk

$W_t \times R$ = trial wt (oz.) x radius (in.)

G = ISO grade

W = weight of rotor (lb.)

N = Speed, RPM

EXAMPLE PROBLEM

<u>Example</u>

Calculate the allowable vibration level for a fan. The fan operates at 1,800 RPM and weight 6,590 lb. A trial weight of 6.5 oz created an effect vector of 10 mils. Assume the radius of the balance weight is 40 inches and the ISO chart is used (G 6.3).

$$V_{per} = \frac{10 \text{ Mils}}{6.5 \text{ x } 40} \text{ X } \frac{6.015 \text{ x } 6.3 \text{ x } 6{,}590}{1{,}800}$$

$$V_{per} = 5.3 \text{ mils pk to pk}$$