

## Single-Bearing Machines (Graphical Method)

### Overview

This technote is designed to facilitate the alignment of single-bearing machines like generators and exciters which have only one shaft bearing housed in the end bell, behind the back feet of the stator housing. The objective is to align the shaft of the generator to the stationary shaft while at the same time preserving the proper clearances between the stator and rotor assemblies. This is often a challenging undertaking, since the shaft (and rotor) is only supported by the rigid coupling at one end and by the bearing on the other end. The coupling must therefore be loosened prior to taking misalignment readings. The feet of the generator support the stator and the bearing only; therefore, moving and shimming the feet affects both the alignment and the air gap between rotor and stator. The procedure to correct both the alignment and air gap simultaneously is straightforward and involves simple graphing. All graphing work must be executed carefully, since the corrections are derived from the graphs. Always maximize the scale of your drawing to the extent possible and use good quality graph paper with a precision printed grid, available from almost any good art or office supply store.

### Procedure

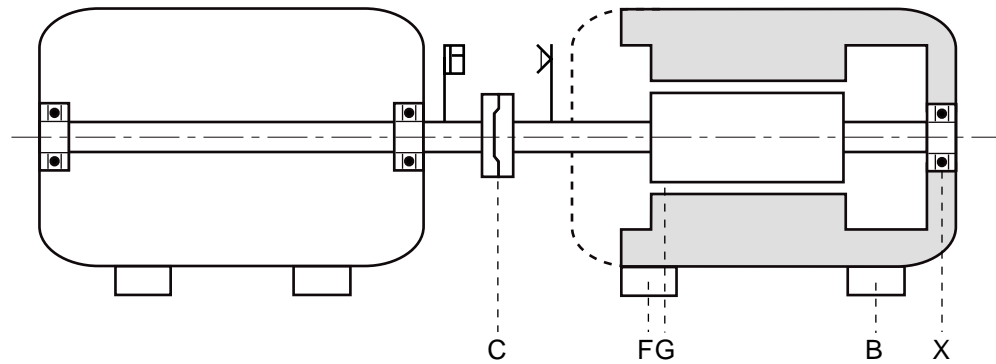
#### Alignment Measurement

The idea is to take alignment readings with the coupling slightly loosened to permit flexibility, then make the air gap between rotor and stator at 12, 3, 6, and 9 o'clock, and plot the relative positions

of rotor, stator, and a stationary reference baseline.

- 1) The first step is to loosen the rigid (usually rabbit fit) coupling's bolts only to the point where the shaft still rests in the rabbit, in order to allow sufficient flexibility to accurately measure the angularity of any existing misalignment, while still keeping the offset near zero. Run a feeler gage between the solid hubs. A gap of .010" or .015" is usually enough. If the coupling is loosened to the point where the coupling hubs disengage and are held only by the bolts, the rotor shaft will drop by the amount of clearance in the fit of the bolts. This will produce a negative vertical offset which it is preferable to avoid, since it adds one step to the procedure for evaluating the quality of your alignment (see the discussion concerning angularity in step 4). Taper fit rabbets will unavoidably produce offset as you slightly separate the hubs. Some single-flex plane couplings will also register offset, so always be sure to check the actual measured alignment conditions at the coupling center.
- 2) Now carefully measure the air gap between rotor and stator using feeler gages at 12, 3, 6, and 9 o'clock. Also measure carefully the distance from this location to the coupling center, as you will need it later.
- 3) In the OPTALIGN's Dimensions mode, enter dimensions as follows: Laser to Prism normally, Laser to Front Foot equals laser to coupling center, and Front Foot to Back Foot equals coupling center to the location of the

C = Coupling Center  
 G = Location where air gaps were measured  
 F = Front Foot of Single-Bearing Machine (Generator)  
 B = Back Foot of Single-Bearing Machine (Generator)  
 X = Location of Bearing



bearing. In the OPTALIGN's Coupling Results mode, enter the distance Coupling Center to Prism normally, and Diameter 10" (as usual). Do *not* enter the distance to any of the actual feet of the generator.

- 4) Now take alignment readings as usual and press RUN. The back foot correction result indicates the position of the bearing relative to the stationary baseline, but with the opposite sign (since it shows the sign of a correction, not position). Ignore front foot results. Now go to Coupling Results. Offset results should hopefully be near zero at the coupling center. Angularity should be compared to tolerances to determine if any alignment corrections need to be made. If offset was *not* zero, assume that it will be when the coupling is made up again, so calculate the angularity manually, *only* for purposes of comparing to tolerances. Calculate angularity manually by dividing the bearing position by the distance from coupling center to bearing location (C to X). Do *not* use the OPTALIGN's displayed angularity result, which *does* take the offset into account.
- 5) Now obtain the actual correction results for the feet of the generator by graphing, as indicated in the following section.

### Graphing

- Begin by laying out your baseline as a straight horizontal line, marking the following locations: Coupling Center (C), Location where air gaps were measured (G), Generator's Front Feet (F), Generator's Back Feet (B), and Bearing Location (X).

- Plot the rotor centerline as being a straight line from the coupling center (C) (if you had no offset) to the bearing's actual position (from the OPTALIGN's back foot correction result) at location (X). (Be careful of the sign— remember that the back foot result is a correction, not a position, so change the sign.) The coupling center is where the rotor and baselines intersect (if we assume zero offset at that point). If you *did* have a measured vertical offset at the coupling center, then plot the rotor line as a line from this offset point to the bearing location. (See graph example 4 for an illustration of this situation).
- Now calculate the difference in air gap top to bottom (top minus bottom) for vertical position, or side to side (3 o'clock minus 9 o'clock) for horizontal position, and plot the stator centerline relative to the rotor centerline. To do this, originate the stator line at the true bearing position at location (X), and position the stator line *one half of the difference* in the air gap away from the rotorline, in the direction of the larger gap. This is the amount by which the stator is shifted out of alignment with the rotor at the axial location where the air gaps were measured (G). When graphing this stator line, you will find that the shift in the direction of the larger gap corresponds with the sign (+ or -) of the difference in air gap that you just calculated. For example: If gap at top is 20 mils, and at the bottom is 50 mils, then the gap difference (top minus bottom) = -30 mils. Thus you would plot the stator line *below* the rotor line, by *one half* of this difference, -15 mils, at G.

- Now derive the actual corrections for the feet of the generator by measuring the distance from the stator line to the baseline at the foot locations (F & B).
- See the four numerical and graphical examples below.

As always, evaluate the quality of your alignment and the need for performing corrections by comparing the

angularity at the coupling to proper alignment tolerances. Remember to consider negative offset if it exists, and factor it out for this evaluation, although not when graphing. Also keep in mind that the accurate measurement of the air gaps between rotor and stator is critical and is very often complicated by difficulty of access, or by differing thicknesses of varnish or paint on the rotor and stator surfaces.

#### GRAPH EXAMPLE 1:

##### Scale:

Horizontal:

1 square = 1"

Vertical:

1 square = 0.002"

##### Locations:

C = Coupling Center

G = Location where air gaps were measured

F = Front Foot of Single-Bearing Machine (Generator)

B = Back Foot of Single-Bearing Machine (Generator)

X = Location of Bearing

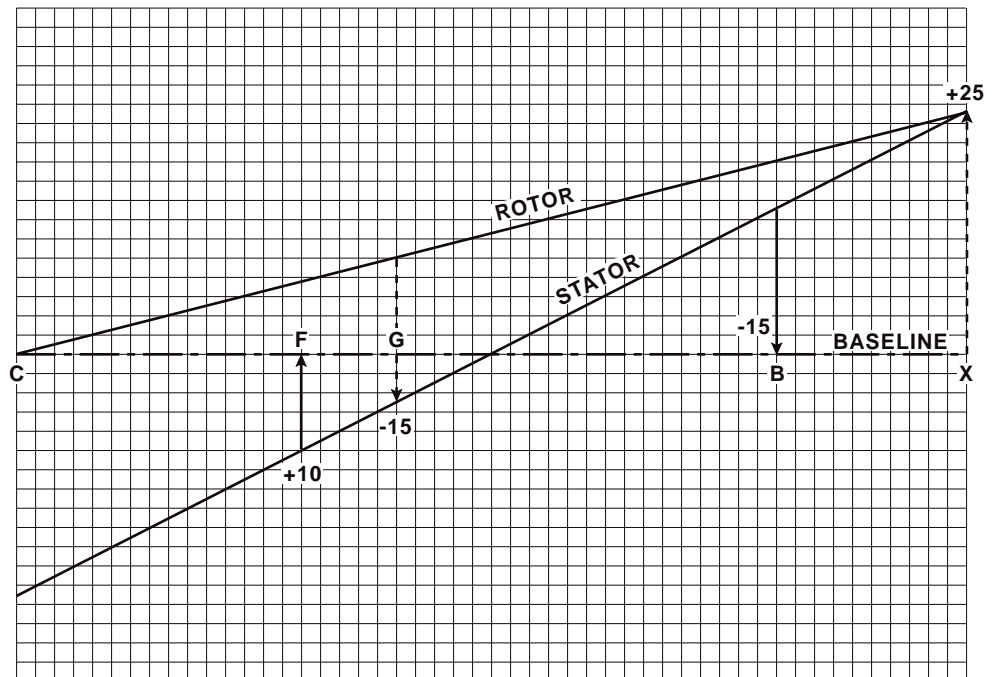
##### Dimensions:

C to X = 50"

C to F = 15"

C to G = 20"

F to B = 25"



##### Measured Results (Vertical):

Vertical Offset: Zero.

OPTALIGN Back Foot Correction:  $-.025"$ . (So actual bearing position is  $+.025"$  high)

Gap at 12 o'clock:  $.020"$

Gap at 6 o'clock:  $.050"$

The gap difference is  $-.030"$ . Therefore, the stator is shifted one half of this difference ( $-.015"$ ) towards 6 o'clock, at G.

##### Calculated Corrections from Graph (Vertical):

F =  $+.010"$  (Shim up Front Foot of Generator 10 mils)

B =  $-.015"$  (Remove shims under Back Feet 15 mils)

These corrections will align the machine to the stationary machine and even out the air gap between rotor and stator simultaneously.

**GRAPH EXAMPLE 2:**

Scale:

Horizontal:  
1 square = 1"

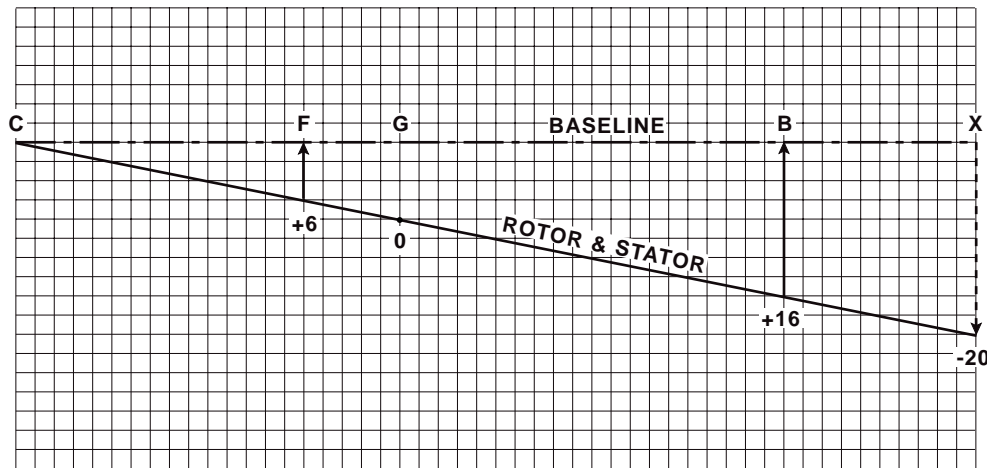
Vertical:  
1 square = 0.002"

Locations:

- C = Coupling Center
- G = Location where air gaps were measured
- F = Front Foot of Single-Bearing Machine (Generator)
- B = Back Foot of Single-Bearing Machine (Generator)
- X = Location of Bearing

Dimensions:

- C to X = 50"
- C to F = 15"
- C to G = 20"
- F to B = 25"



Measured Results (Horizontal):

Horizontal Offset: Zero.

OPTALIGN Back Foot Correction: +.020". (So bearing position is -.020" towards 9 o'clock)

Gap at 3 o'clock: .035"

Gap at 9 o'clock: .035"

The gap difference is zero. Therefore, the stator is in line with the rotor.

Calculated Corrections from Graph (Horizontal):

F = +.006" (Move Front Feet of Generator 6 mils towards 3 o'clock)

B = +.016" (Move Back Feet of Generator 16 mils towards 3 o'clock)

Since the rotor and stator are already aligned with each other, these corrections are necessary only to align the whole machine to the stationary machine!

**GRAPH EXAMPLE 3:**

Scale:

Horizontal:  
1 square = 1"

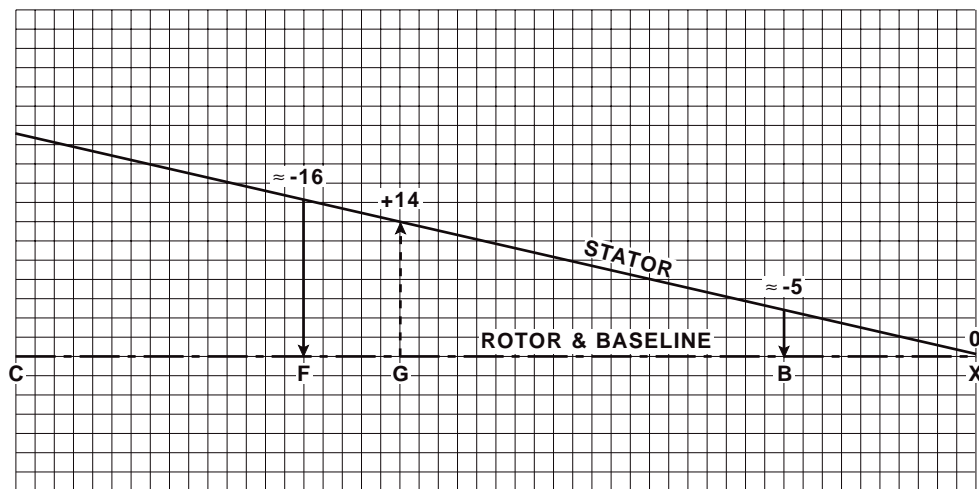
Vertical:  
1 square = 0.002"

Locations:

- C = Coupling Center
- G = Location where air gaps were measured
- F = Front Foot of Single-Bearing Machine (Generator)
- B = Back Foot of Single-Bearing Machine (Generator)
- X = Location of Bearing

Dimensions:

- C to X = 50"
- C to F = 15"
- C to G = 20"
- F to B = 25"



Measured Results: (Vertical or Horizontal, generic example)

Offset: Zero.

OPTALIGN Back Foot Correction: .000" (Therefore the rotor is aligned with the stationary reference baseline).

Gap at 12 or 3 o'clock: .045"

Gap at 6 or 9 o'clock: .017"

The gap difference is +.028". Therefore, the stator is shifted in the positive direction relative to the rotor by one half of the difference (+.014").

Calculated Corrections from Graph:

F ≈ -.016"

B ≈ -.005"

Since the rotor is already aligned to the stationary machine, these corrections are necessary only to align the stator to the rotor and even out the air gaps!

**GRAPH EXAMPLE 4:**

Scale:

Horizontal:  
1 square = 1"

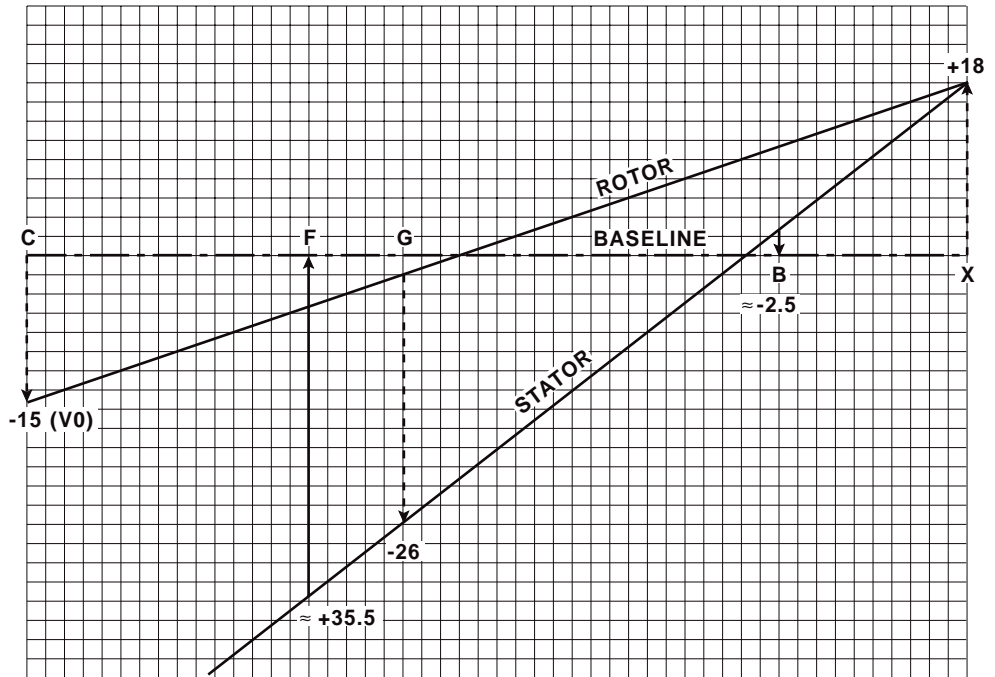
Vertical:  
1 square = 0.002"

Locations:

- C = Coupling Center
- G = Location where air gaps were measured
- F = Front Foot of Single-Bearing Machine (Generator)
- B = Back Foot of Single-Bearing Machine (Generator)
- X = Location of Bearing

Dimensions:

- C to X = 50"
- C to F = 15"
- C to G = 20"
- F to B = 25"



Measured Results: (Vertical)

Vertical Offset:  $-.015''$ .

OPTALIGN Back Foot Correction:  $-.018''$  (Bearing Position is  $+.018''$ ).

Gap at 12 or 3 o'clock:  $.012''$

Gap at 6 or 9 o'clock:  $.064''$

The gap difference is  $-.052''$ . Therefore, the stator is shifted down relative to the rotor by one half of the difference ( $-.026''$ ).

Calculated Corrections from Graph:

$F \approx +.0355''$

$B \approx -.0025''$

The angularity for alignment purposes is considered to be only  $.018''$  over 50" ( $.36$  mils per inch) since we assume zero offset when the coupling bolts are tight. If the angularity tolerance only allows  $.2$  mils per inch you should perform the corrections. Note that in graphing we do take the offset into consideration since the air gaps were measured with the coupling bolts loosened.