Shaft Alignment: Reverse Dial and Rim & Face Methods

shaft_alignment_a ver 1.0 by Tom Irvine

Coordinates and sign convention

x is measured along the shaft from the coupling center toward the movable machine (motor). In each plane the movable centerline relative to the stationary centerline extended is $y(x) = Y_0 + a\,x$, Y_0 = offset at the coupling center, a = angularity (slope). Vertical: + = movable shaft high. Horizontal: + = toward 3 o'clock, clock viewed from behind the movable machine looking at the stationary machine.

TIR: zero the indicator at 12 o'clock and read at 6 (vertical), or zero at 9 and read at 3 (horizontal). Plunger pushed in = positive. A rim indicator on shaft A touching shaft B reads $R = -2\,(y_B - y_A)$ at its plane.

Equations

1. Sag correction (vertical only) $R_v = R_{v,\text{read}} - s, \qquad s = 6$ o'clock reading of the bracket on a rigid bar
2. Reverse dial, planes $x_M = c, \qquad x_S = c - D$
3. Reverse dial, readings $y(x_M) = -\dfrac{R_M}{2}, \qquad y(x_S) = +\dfrac{R_S}{2}$
4. Reverse dial, solution $a = \dfrac{y(x_M) - y(x_S)}{D} = -\dfrac{R_M + R_S}{2D}, \qquad Y_0 = y(x_M) - a\,x_M$
5. Rim & face, rim $y(x_R) = -\dfrac{R_R}{2}, \qquad x_R = c$
6. Rim & face, face $a = -\dfrac{F}{d}, \qquad Y_0 = y(x_R) - a\,x_R$
7. Feet positions $x_F = c + L_F, \qquad x_B = c + L_B$
8. Feet corrections $\Delta_F = -(Y_0 + a\,x_F), \qquad \Delta_B = -(Y_0 + a\,x_B)$

R_M: bracket on the stationary shaft, reading the movable rim at plane M. R_S: bracket on the movable shaft, reading the stationary rim at plane S. D = distance between the planes, c = coupling center to plane M (or rim plane). F: face TIR on the movable hub face (facing the stationary machine) at tip-circle diameter d. L_F, L_B = plane M (or rim plane) to the front and back feet. Vertical: $\Delta > 0$ add shims, $\Delta < 0$ remove. Horizontal: $\Delta > 0$ move toward 3 o'clock. Sag cancels in the horizontal TIR (3 − 9 o'clock). Both shafts are rotated together; axial float is assumed zero.

Tolerances (short flexible couplings, offset at the coupling center)

Speed	**Offset excellent**	**Offset acceptable**	**Angular excellent**	**Angular acceptable**
rpm	mils (mm)	mils (mm)	mils/in (mm/100 mm)	mils/in (mm/100 mm)
900	3.0 (0.0762)	6.0 (0.1524)	1.2 (0.12)	2.0 (0.20)
1200	2.5 (0.0635)	4.0 (0.1016)	0.9 (0.09)	1.5 (0.15)
1800	2.0 (0.0508)	3.0 (0.0762)	0.6 (0.06)	1.0 (0.10)
3600	1.0 (0.0254)	1.5 (0.0381)	0.3 (0.03)	0.5 (0.05)

Source: US DOE Advanced Manufacturing Office, *The Importance of Motor Shaft Alignment*, Motor Systems Tip Sheet #4, Table 1 (read from the energy.gov PDF). That table prints the angular columns under the heading "Spacer Couplings". The app uses the row for the next tabulated speed at or above the running speed (900 rpm row below 900 rpm; 3600 rpm row above 3600 rpm with a warning). Excellent: ≤ excellent value; acceptable: ≤ acceptable value. OEM limits govern. Metric: 1 mil = 0.0254 mm, 1 mil/in = 0.1 mm/100 mm. Metric results are checked against the same mil limits.

Other tables differ, e.g. ANSI/ASA S2.75-2017 Part 1 at 1800 rpm: 1.6 mils / 0.3 mils/in (precision), 3.0 / 0.6 (standard), 6.0 / 1.2 (minimal), from a public summary (MRO Magazine); check against the standard.

Soft foot

Loosen one hold-down bolt at a time with a dial indicator on that foot. A rise > 0.002 in (2 mils), or > 0.05 mm in metric, is flagged. This is a common field criterion, not confirmed here from a primary standard. Correct soft foot before shimming.

Units and assumptions

English: dimensions in, readings, sag and soft foot mils (0.001 in), offset and corrections mils, angularity mils/in.
metric: dimensions mm, readings mm, offset and corrections mm, angularity mm/100 mm.
Small angles; rigid brackets apart from the measured sag; the movable machine is moved, the stationary machine is fixed; no thermal growth targets (corrections align the cold centerlines). The 4-reading validity rule (12 + 6 = 3 + 9) is not checked.

References: US DOE Motor Systems Tip Sheet #4 (above); J. Piotrowski, *Shaft Alignment Handbook*, 3rd ed., CRC Press (reverse indicator and face-rim methods, graphical plotting); ANSI/ASA S2.75-2017 Part 1, *Shaft Alignment Methodology*.