Machinery Fault Symptom Chart: Reference

fault_symptom_chart_a ver 1.0 by Tom Irvine

Purpose

A lookup aid for vibration diagnosis of rotating machinery. The chart lists common faults with their dominant frequencies (orders of shaft speed, X), direction, phase behaviour, amplitude versus speed, waveform / orbit and notes. The symptom filter ranks the faults that best match the symptoms ticked by the user. It is a guide only: confirm a diagnosis with phase readings, orbits, time waveforms, operating tests and the machine history before acting.

Scoring rule (transparent and simple)

Each fault has key symptoms (weight $w = 2$) and supporting symptoms ($w = 1$); all other symptoms have $w = 0$. For the set O of N ticked symptoms:

$$\text{Explains} = \frac{\sum_{s \in O} w_s}{2N} \qquad \text{Key seen} = \frac{\text{key symptoms in } O}{\text{key symptoms of the fault}} \qquad \text{Score} = 100\,(0.75\,\text{Explains} + 0.25\,\text{Key seen})$$

Explains measures how much of what was observed the fault accounts for; Key seen rewards observing the hallmarks of the fault. Faults are ranked by Score, then by Key seen, then by chart order. Ticking only the key symptoms of a fault gives it a score of 100. Faults with Explains = 0 are not listed. The weights are a judgement based on the references below, not a statistical model.

Symptoms in the filter

1. [Spectrum] High 1X radial (dominant peak)
2. [Spectrum] High 1X axial
3. [Spectrum] High 2X (comparable to or above 1X)
4. [Spectrum] 3X and a few low harmonics (to about 4X)
5. [Spectrum] Many 1X harmonics (to 10X or more)
6. [Spectrum] Half harmonics 0.5X, 1.5X, 2.5X ...
7. [Spectrum] Exact sub-harmonics 1/2X, 1/3X
8. [Spectrum] Sub-synchronous 0.42-0.48X, tracks speed
9. [Spectrum] Sub-synchronous at a fixed frequency (1st critical)
10. [Spectrum] Raised broadband noise floor
11. [Phase] 1X phase H vs V about 90 deg, steady
12. [Phase] 1X phase H vs V about 0 or 180 deg
13. [Phase] Radial 1X in phase at both bearings
14. [Phase] Radial 1X 180 deg out of phase, bearing to bearing
15. [Phase] Axial 1X in phase at both bearings
16. [Phase] Axial phase 180 deg across the coupling
17. [Phase] Radial phase 180 deg across the coupling
18. [Phase] Axial phase 180 deg end to end of the rotor
19. [Phase] Axial phase 180 deg top/bottom of one bearing
20. [Phase] Phase jump 180 deg across a bolted joint
21. [Phase] Phase unsteady from reading to reading
22. [Behaviour] 1X amplitude rises with speed squared
23. [Behaviour] Sharp peak at one speed, phase shifts 180 deg
24. [Behaviour] Highly directional (one radial direction)
25. [Behaviour] Sensitive to oil temperature or load
26. [Behaviour] Drops instantly when power is cut
27. [Waveform] Truncated waveform or flat-spotted orbit
28. [Waveform] Orbit with internal loops (forward whirl)
29. [Waveform] One impact per revolution of one gear
30. [Bearing] Only ultrasonic / spike energy / HFE raised
31. [Bearing] Haystack at a natural frequency, with sidebands
32. [Bearing] Peaks at BPFO, BPFI, BSF or FTF
33. [Gear/belt] Gear mesh frequency (GMF) and harmonics
34. [Gear/belt] Sidebands at a gear speed around GMF
35. [Gear/belt] Belt frequency and harmonics below 1X
36. [Gear/belt] High axial 1X at a sheave (belt drive)
37. [Electrical] Peak at 2 x line frequency (100 / 120 Hz)
38. [Electrical] Pole-pass sidebands around 1X (beating)
39. [Flow] Random HF broadband, varies with flow / NPSH
40. [Flow] Vane / blade pass frequency dominant

Units and notation

No unit system is needed: frequencies are given as orders of shaft speed. 1X = shaft speed: f (Hz) = N (rpm)/60, in English and metric alike. 2FL = twice the line frequency (100 Hz on 50 Hz supply, 120 Hz on 60 Hz). H, V = horizontal and vertical radial directions. GMF = gear mesh frequency (teeth x gear speed). BPFO, BPFI, BSF, FTF = outer race, inner race, rolling element and cage defect frequencies. HFE = high-frequency enveloping / spike energy. NPSH = net positive suction head.

Fault chart

1. Unbalance - static (force)

Frequency: 1X, low harmonics. Direction: Radial.
Phase: H vs V ~90 deg; in phase brg to brg. Amplitude vs speed: Rises with speed^2.
Waveform / orbit: Sine 1X; elliptical orbit. Notes: Single-plane balance.
Mass centre offset parallel to the shaft axis. 1X dominates the radial spectrum at both bearings and the two bearings move in phase. Below the first critical the 1X amplitude grows with the square of speed. Phase is steady and repeatable. Usually corrected by single-plane balancing.
Key symptoms: High 1X radial (dominant peak); 1X phase H vs V about 90 deg, steady; Radial 1X in phase at both bearings; 1X amplitude rises with speed squared.

2. Unbalance - couple

Frequency: 1X, low harmonics. Direction: Radial, some axial.
Phase: H vs V ~90 deg; 180 deg brg to brg. Amplitude vs speed: Rises with speed^2.
Waveform / orbit: Sine 1X; elliptical orbit. Notes: Two-plane balance.
Principal inertia axis tilted about the mass centre. Radial 1X at the two bearings is about 180 deg out of phase (rocking). Some 1X axial can appear. A single correction weight cannot fix it: two-plane balancing is needed.
Key symptoms: High 1X radial (dominant peak); 1X phase H vs V about 90 deg, steady; Radial 1X 180 deg out of phase, bearing to bearing; 1X amplitude rises with speed squared. Supporting: High 1X axial.

3. Unbalance - overhung rotor

Frequency: 1X radial and 1X axial. Direction: Radial and axial.
Phase: Axial in phase at both bearings. Amplitude vs speed: Rises with speed^2.
Waveform / orbit: Sine 1X. Notes: Fans, overhung impellers.
Overhung fans and pump impellers. High 1X radial and high 1X axial; the axial readings at the two bearings are in phase. Radial phase can be unsteady. Usually needs static and couple correction in two planes on the overhung rotor.
Key symptoms: High 1X radial (dominant peak); High 1X axial; Axial 1X in phase at both bearings. Supporting: 1X phase H vs V about 90 deg, steady; 1X amplitude rises with speed squared.

4. Misalignment - angular

Frequency: 1X axial, with 2X and 3X. Direction: Axial.
Phase: Axial ~180 deg across coupling. Amplitude vs speed: Load / temperature.
Waveform / orbit: 1X + 2X repeatable. Notes: Check thermal growth.
Shaft centrelines meet at an angle at the coupling. High 1X axial with some 2X and 3X; axial phase about 180 deg (150 to 210 deg) across the coupling. Little speed dependence; changes with load and thermal growth. Usually mixed with offset misalignment. Confirm with a laser or dial alignment check.
Key symptoms: High 1X axial; Axial phase 180 deg across the coupling. Supporting: High 2X (comparable to or above 1X); 3X and a few low harmonics (to about 4X).

5. Misalignment - parallel (offset)

Frequency: 2X radial, often > 1X. Direction: Radial.
Phase: Radial ~180 deg across coupling. Amplitude vs speed: Load / temperature.
Waveform / orbit: 2 peaks per rev; banana orbit. Notes: Severe: 4X-8X too.
Shaft centrelines parallel but offset. High 2X radial, often above 1X, with radial phase about 180 deg across the coupling. Severe offset produces higher harmonics (4X to 8X) that resemble looseness. Preloaded, banana or figure-8 orbits on proximity probes.
Key symptoms: High 2X (comparable to or above 1X); Radial phase 180 deg across the coupling. Supporting: High 1X radial (dominant peak); 3X and a few low harmonics (to about 4X).

6. Bent shaft

Frequency: 1X axial, 2X if bend near coupling. Direction: Axial and radial.
Phase: Axial ~180 deg end to end. Amplitude vs speed: Present at slow roll.
Waveform / orbit: 1X; runout at slow roll. Notes: Measure slow-roll runout.
High 1X axial (2X when the bend is near the coupling). Axial phase about 180 deg from one end of the rotor to the other. Resembles angular misalignment. Slow-roll runout from proximity probes or a dial indicator confirms the bow.
Key symptoms: High 1X axial; Axial phase 180 deg end to end of the rotor. Supporting: High 1X radial (dominant peak); High 2X (comparable to or above 1X).

Fault chart (continued)

7. Looseness - type A (structural)

Frequency: 1X dominant. Direction: Radial, directional.
Phase: ~180 deg jump across joint; H vs V 0/180. Amplitude vs speed: Little speed effect.
Waveform / orbit: One pulse per rev. Notes: Base, bolts, soft foot.
Structural looseness or weakness of feet, baseplate or foundation: loose hold-down bolts, cracked grout, soft foot, distorted frame. 1X dominant and highly directional (often vertical). Phase changes about 180 deg between bolt, foot, base and foundation; compare readings across each joint.
Key symptoms: High 1X radial (dominant peak); Phase jump 180 deg across a bolted joint; Highly directional (one radial direction). Supporting: 1X phase H vs V about 0 or 180 deg.

8. Looseness - type B (pedestal)

Frequency: 0.5X, 1X, 2X, 3X; 2X often highest. Direction: Radial.
Phase: Jump across loose joint. Amplitude vs speed: Erratic.
Waveform / orbit: Two pulses per rev. Notes: Pillow-block bolts, cracks.
Loose pillow-block or pedestal bolts, a cracked frame or bearing pedestal. Spectrum shows 0.5X, 1X, 2X and 3X with 2X often largest; the waveform shows about two pulses per revolution. Phase jumps across the loose joint.
Key symptoms: High 2X (comparable to or above 1X); Half harmonics 0.5X, 1.5X, 2.5X ...; Phase jump 180 deg across a bolted joint. Supporting: High 1X radial (dominant peak); 3X and a few low harmonics (to about 4X); Highly directional (one radial direction); 1X phase H vs V about 0 or 180 deg.

9. Looseness - type C (fit)

Frequency: Many harmonics, half harmonics, raised floor. Direction: Radial, varies.
Phase: Unsteady, changes each start. Amplitude vs speed: Non-linear, erratic.
Waveform / orbit: Truncated, impacting. Notes: Bearing loose on shaft / in housing.
Improper fit between parts: bearing loose in its housing or on the shaft, excessive bearing clearance, loose impeller. Many harmonics of 1X (often to 10X), half harmonics (0.5X, 1.5X, 2.5X), and a raised noise floor. Phase is unstable from reading to reading and can change at each start.
Key symptoms: Many 1X harmonics (to 10X or more); Half harmonics 0.5X, 1.5X, 2.5X ...; Phase unsteady from reading to reading. Supporting: Raised broadband noise floor; 3X and a few low harmonics (to about 4X); Truncated waveform or flat-spotted orbit.

10. Rotor rub

Frequency: Sub-harmonics 1/2X, 1/3X; many harmonics. Direction: Radial (axial if face rub).
Phase: Unsteady; slow spiral (thermal bow). Amplitude vs speed: Varies with speed, temp, time.
Waveform / orbit: Clipped; flat-spotted orbit. Notes: Seals, close clearances.
Contact between rotor and stator (seals, packing, close clearances). Exact sub-harmonics (1/2X, 1/3X) and many harmonics; can excite natural frequencies. Truncated waveform and flat-spotted orbit; full annular rub can drive reverse precession. Heating at the rub spot can bow the shaft, so the 1X vector slowly rotates.
Key symptoms: Exact sub-harmonics 1/2X, 1/3X; Truncated waveform or flat-spotted orbit. Supporting: Many 1X harmonics (to 10X or more); Half harmonics 0.5X, 1.5X, 2.5X ...; Phase unsteady from reading to reading; Raised broadband noise floor.

11. Oil whirl (fluid-film bearing)

Frequency: 0.42-0.48X, tracks speed. Direction: Radial.
Phase: Not locked to 1X. Amplitude vs speed: Above onset speed.
Waveform / orbit: Inside loops; forward orbit. Notes: Light load, large clearance.
Fluid-film instability in a lightly loaded or worn journal bearing. Sub-synchronous forward whirl at 0.42 to 0.48X that tracks speed (exactly 0.5X points to other causes). Orbit with internal loops. Sensitive to oil temperature, viscosity and load. Fixes: change load or clearance, pressure-dam, lobed or tilting-pad bearings.
Key symptoms: Sub-synchronous 0.42-0.48X, tracks speed; Orbit with internal loops (forward whirl). Supporting: Sensitive to oil temperature or load.

12. Oil whip

Frequency: Fixed sub-sync at 1st critical. Direction: Radial.
Phase: Not locked to 1X. Amplitude vs speed: Large, sudden.
Waveform / orbit: Large looped orbit. Notes: Above ~2 x 1st critical.
Oil whirl that has locked onto the first rotor critical (natural) frequency, usually when running above about twice the first critical. The sub-synchronous frequency stays fixed as speed rises. Large, sudden and potentially destructive. Needs bearing redesign (tilting pad) or a change in rotor stiffness.
Key symptoms: Sub-synchronous at a fixed frequency (1st critical). Supporting: Orbit with internal loops (forward whirl); Sensitive to oil temperature or load.

Fault chart (continued)

13. Resonance

Frequency: Forcing freq at a natural freq. Direction: Highly directional.
Phase: 90 deg at peak; ~180 deg shift through it. Amplitude vs speed: Sharp peak at one speed.
Waveform / orbit: Sine at forcing freq. Notes: Bump test, Bode plot.
A natural frequency coincides with 1X, 2X or another forcing frequency. Amplitude peaks sharply at one speed and is highly directional; phase lags about 90 deg at the peak and shifts about 180 deg passing through it. Confirm with a bump test or a coast-down Bode / Nyquist plot. Fix by moving the natural frequency (stiffness, mass), changing speed or adding damping; balancing alone helps little.
Key symptoms: Sharp peak at one speed, phase shifts 180 deg; Highly directional (one radial direction). Supporting: High 1X radial (dominant peak).

14. Eccentric rotor

Frequency: 1X of eccentric part. Direction: Radial, along centre line.
Phase: H vs V ~0 or 180 deg. Amplitude vs speed: Load dependent.
Waveform / orbit: Straight-line motion. Notes: Balancing does not cure it.
Geometric centre offset from the rotation centre (sheave, gear, armature, impeller). Highest 1X along the line through the two shaft centres; H and V phase about 0 or 180 deg (straight-line motion), unlike unbalance (~90 deg). Balancing may reduce one direction but raise the other. An eccentric motor rotor also gives pole-pass sidebands; an eccentric gear gives GMF sidebands.
Key symptoms: High 1X radial (dominant peak); 1X phase H vs V about 0 or 180 deg. Supporting: Highly directional (one radial direction).

15. Rolling bearing - stage 1

Frequency: Ultrasonic only (~20-60 kHz). Direction: Radial (load zone).
Phase: n/a. Amplitude vs speed: n/a.
Waveform / orbit: Normal spectrum. Notes: Trend HFE / spike energy.
Earliest stage: only ultrasonic, spike energy, shock pulse or HFE readings rise; the velocity spectrum looks normal. Trend the readings. Remaining-life figures quoted for each stage are vendor estimates and vary widely.
Key symptoms: Only ultrasonic / spike energy / HFE raised.

16. Rolling bearing - stage 2

Frequency: Bearing natural freq (~0.5-2 kHz). Direction: Radial.
Phase: n/a (non-synchronous). Amplitude vs speed: n/a.
Waveform / orbit: Ringing; sidebands. Notes: Plan replacement.
Small defects ring the bearing component natural frequencies (about 500 to 2000 Hz). A haystack appears with sidebands at the defect frequency or 1X. HFE readings keep rising.
Key symptoms: Haystack at a natural frequency, with sidebands. Supporting: Only ultrasonic / spike energy / HFE raised.

17. Rolling bearing - stage 3

Frequency: BPFO, BPFI, BSF, FTF + harmonics. Direction: Radial (axial if thrust).
Phase: n/a (non-synchronous). Amplitude vs speed: Grows.
Waveform / orbit: Impacts at defect rate. Notes: Replace bearing.
Defect frequencies and their harmonics appear: BPFO (outer race, few sidebands), BPFI (inner race, 1X sidebands), BSF (rolling element, FTF sidebands), FTF (cage). They are non-integer multiples of 1X. Haystacks grow, more sidebands appear. Replace the bearing.
Key symptoms: Peaks at BPFO, BPFI, BSF or FTF; Haystack at a natural frequency, with sidebands. Supporting: Only ultrasonic / spike energy / HFE raised.

18. Rolling bearing - stage 4

Frequency: 1X rises; random broadband floor. Direction: Radial.
Phase: n/a. Amplitude vs speed: Overall high.
Waveform / orbit: Random, high crest factor. Notes: Near failure: replace now.
Discrete defect frequencies merge into a raised random broadband noise floor; 1X and its harmonics rise as clearance grows (can mimic looseness). HFE may fall and then rise just before failure. Replace immediately.
Key symptoms: Raised broadband noise floor. Supporting: Peaks at BPFO, BPFI, BSF or FTF; Haystack at a natural frequency, with sidebands; High 1X radial (dominant peak).

Fault chart (continued)

19. Gear - tooth wear / load

Frequency: GMF + harmonics; gear natural freq. Direction: Radial (axial if helical).
Phase: n/a. Amplitude vs speed: GMF load sensitive.
Waveform / orbit: Modulated. Notes: Trend 1, 2, 3 x GMF.
GMF = teeth x gear speed. Tooth wear excites the gear natural frequency with sidebands at the speed of the worn gear; sideband growth is a better wear indicator than GMF itself. Always measure gear boxes at a fixed load.
Key symptoms: Gear mesh frequency (GMF) and harmonics; Haystack at a natural frequency, with sidebands. Supporting: Sidebands at a gear speed around GMF.

20. Gear - eccentricity / backlash

Frequency: GMF with high gear-speed sidebands. Direction: Radial (axial if helical).
Phase: n/a. Amplitude vs speed: Load dependent.
Waveform / orbit: Modulated once per gear rev. Notes: Misalignment raises 2 x GMF.
An eccentric gear, bent gear shaft or excessive backlash modulates the mesh: large sidebands around GMF spaced at the speed of the bad gear, and raised 1X of that gear. Gear misalignment raises 2 x GMF and higher mesh harmonics.
Key symptoms: Sidebands at a gear speed around GMF. Supporting: Gear mesh frequency (GMF) and harmonics; High 1X radial (dominant peak).

21. Gear - cracked / broken tooth

Frequency: Gear natural freq + sidebands. Direction: Radial.
Phase: n/a. Amplitude vs speed: Load dependent.
Waveform / orbit: Impact once per gear rev. Notes: Use time waveform.
A cracked or broken tooth produces a large impact once per revolution of that gear, best seen in the time waveform; the spectrum shows the gear natural frequency with sidebands at the gear speed and can look like wear.
Key symptoms: One impact per revolution of one gear. Supporting: Haystack at a natural frequency, with sidebands; Gear mesh frequency (GMF) and harmonics; Sidebands at a gear speed around GMF.

22. Belt - worn, loose or mismatched

Frequency: Belt freq + harmonics, below 1X. Direction: Radial, in belt line.
Phase: Unsteady. Amplitude vs speed: Erratic, beating.
Waveform / orbit: Unsteady. Notes: 2 x belt freq often highest.
Belt frequency fb = pi D N / (60 L) and harmonics, below 1X of both sheaves; 2 x fb is often dominant. Highest in the line of the belt spans. A strobe light helps. Span resonance can amplify (see belt_drive_frequencies_a).
Key symptoms: Belt frequency and harmonics below 1X. Supporting: Phase unsteady from reading to reading.

23. Belt - sheave misalignment / eccentric sheave

Frequency: 1X of driver or driven sheave. Direction: Axial (misalign); radial (eccentric).
Phase: Axial differs across sheaves. Amplitude vs speed: Load dependent.
Waveform / orbit: 1X. Notes: Straightedge or laser check.
Misaligned sheaves give high 1X axial at the driver or driven shaft. An eccentric sheave gives high 1X radial in the belt line (see eccentric rotor).
Key symptoms: High axial 1X at a sheave (belt drive). Supporting: High 1X axial.

24. Electrical - stator / air gap

Frequency: 2 x line freq (2FL). Direction: Radial.
Phase: n/a. Amplitude vs speed: Load dependent.
Waveform / orbit: 2FL. Notes: Stops at power off.
Stator problems (loose laminations, shorted turns), soft foot or an eccentric (static) air gap give a peak at 2 x line frequency, 100 Hz or 120 Hz. It disappears the instant power is cut. Use enough resolution to separate 2FL from 2X of a 2-pole motor.
Key symptoms: Peak at 2 x line frequency (100 / 120 Hz); Drops instantly when power is cut.

25. Electrical - rotor bars / rotor

Frequency: 1X + harmonics with pole-pass sidebands. Direction: Radial.
Phase: n/a. Amplitude vs speed: Load dependent; beats.
Waveform / orbit: Beating at pole-pass freq. Notes: Confirm by current analysis.
Broken or cracked rotor bars, shorted rings or a dynamic air-gap eccentricity: pole-pass sidebands (slip frequency x poles) around 1X and its harmonics, beating amplitude, and rotor-bar pass frequency with 2FL sidebands. Drops when power is cut. Confirm with motor current signature analysis.
Key symptoms: Pole-pass sidebands around 1X (beating); Drops instantly when power is cut. Supporting: High 1X radial (dominant peak).

Fault chart (continued)

26. Cavitation / flow turbulence

Frequency: Random HF broadband (+ low-freq turbulence). Direction: Radial and axial.
Phase: n/a. Amplitude vs speed: Varies with flow / NPSH.
Waveform / orbit: Random, crackling. Notes: Check NPSH and duty point.
Cavitation gives random high-frequency broadband energy and a gravel-like noise; flow turbulence gives low-frequency random energy. Both change with flow and suction pressure. Check NPSH available against NPSH required and the operating point.
Key symptoms: Random HF broadband, varies with flow / NPSH. Supporting: Raised broadband noise floor.

27. Vane / blade pass (hydraulic, aero)

Frequency: Vanes x rpm + harmonics. Direction: Radial.
Phase: n/a. Amplitude vs speed: Rises off design point.
Waveform / orbit: Periodic at BPF. Notes: Check cutwater gap.
Vane or blade pass frequency = number of vanes x speed. Rises when the machine runs away from its design point or when the gap between impeller and cutwater / diffuser is small. Piping or casing resonance can amplify it.
Key symptoms: Vane / blade pass frequency dominant. Supporting: Random HF broadband, varies with flow / NPSH.

28. Cocked bearing

Frequency: 1X axial with 2X and 3X. Direction: Axial.
Phase: Axial ~180 deg top/bottom (twist). Amplitude vs speed: Not speed^2.
Waveform / orbit: Repeatable. Notes: Looks like misalignment.
A bearing cocked on the shaft produces axial 1X, 2X and 3X like angular misalignment. The difference is phase: about 180 deg top to bottom or side to side on the same bearing housing (a twisting motion). Reinstall the bearing; realignment or balancing will not fix it.
Key symptoms: High 1X axial; Axial phase 180 deg top/bottom of one bearing. Supporting: High 2X (comparable to or above 1X); 3X and a few low harmonics (to about 4X).

References and sources

[1] J. S. Mitchell, Introduction to Machinery Analysis and Monitoring, 2nd ed., PennWell, 1993.

[2] J. I. Taylor, The Vibration Analysis Handbook, Vibration Consultants Inc., 2nd ed., 2003.

[3] R. L. Eshleman, Basic Machinery Vibrations, VIPress, 1999.

[4] D. E. Bently and C. T. Hatch, Fundamentals of Rotating Machinery Diagnostics, Bently Pressurized Bearing Press, 2002 (orbits, whirl, whip, rub).

[5] J. E. Berry, Illustrated Vibration Diagnostic Chart, Technical Associates of Charlotte (as described in public summaries; looseness types A, B, C; bearing stages).

[6] ISO 13373-3:2015, Condition monitoring and diagnostics of machines - Vibration condition monitoring - Part 3: Guidelines for vibration diagnosis.

[7] SKF, Vibration Diagnostic Guide, CM5003.

[8] Acoem, "3 Types of Mechanical Looseness" (web article, acoem.com) - looseness types A, B, C.

[9] Machinery Lubrication, "Oil Whirl and Whip Instabilities - Within Journal Bearings" (web article) - 0.40 to 0.48X whirl, whip locked to a critical.

[10] Reliabilityweb, "Detecting Bearing Faults - Part 3" (web article) - cocked bearing phase test.

Notes on the content

- The chart text is written for this app; it summarises symptoms that are widely published in the references above. It is not a copy of any one chart.

- The web articles were used to cross-check the misalignment phase rule, looseness types A/B/C, oil whirl / whip ratios, the bearing stages and the cocked-bearing phase test.

- The Technical Associates chart and ISO 13373-3 were not read in full; their content is used as described in public summaries. Check details against the originals.

- The remaining-life figures sometimes quoted for bearing stages are vendor estimates and are omitted here. Bearing stage frequency ranges are approximate.

- The scoring weights are engineering judgement. A high score means the ticked symptoms are consistent with that fault, not that the fault is present.

- Several faults can coexist (e.g. misalignment with looseness, unbalance with resonance). Look at the second and third ranked faults as well.