Vibration Alarm Limits & Trending

vibration_alarm_trending_a ver 1.0 by Tom Irvine

Notation

v_i overall velocity at time t_i (days), $i = 1 \dots n$; baseline period points $i_1 \dots i_2$ ($m = i_2 - i_1 + 1$);
the trend fit uses the last N points.

v_{AB}, v_{BC}, v_{CD} zone boundaries for the chosen machine group (same defaults as vibration_severity_iso_a).

Baseline

1. Mean $\mu = \dfrac{1}{m} \sum_{i=i_1}^{i_2} v_i$

2. Sample standard deviation $\sigma = \sqrt{\dfrac{1}{m-1} \sum_{i=i_1}^{i_2} (v_i - \mu)^2}$

Alarm methods (lower level, upper level)

3. ISO zones (defaults $f = 0.25$, $F = 1.25$) $\text{ALARM} = \min(\mu + f\, v_{BC},\ 1.25\, v_{BC})$ $\text{TRIP} = F\, v_{CD}$

4. Statistical (defaults $k_1 = 2$, $k_2 = 3$) $\text{alert} = \mu + k_1 \sigma$ $\text{alarm} = \mu + k_2 \sigma$

5. Ratio to baseline (defaults $r_1 = 2$, $r_2 = 4$) $\text{alert} = r_1\, \mu$ $\text{alarm} = r_2\, \mu$

ISO guidance as given in public secondary summaries of ISO 10816-3 / 20816-3 (operational limits):
set ALARM above the machine's own baseline by 25% of the upper limit of zone B (v_{BC}), normally not above $1.25\, v_{BC}$;
TRIP normally not above 1.25 times the upper limit of zone C (v_{CD}).
Not confirmed against the ISO text (ISO 20816-1 Annex wording not seen). Check before use.

Trend fit and projected crossing (least squares over the last N points)

6. Linear trend $v = a_0 + a_1 t, \quad a_1 = \dfrac{\sum (t_i - \bar{t})(v_i - \bar{v})}{\sum (t_i - \bar{t})^2}, \quad a_0 = \bar{v} - a_1 \bar{t}$

7. Linear crossing of level L $t_L = \dfrac{L - a_0}{a_1}$ $(a_1 > 0)$

8. Exponential trend $v = A\, e^{bt}$ $\ln v = c_0 + c_1 t, \quad A = e^{c_0}, \quad b = c_1, \quad \text{growth} = 100\, c_1$ %/day

9. Exponential crossing $t_L = \dfrac{\ln L - c_0}{c_1}$ $(c_1 > 0,\ v_i > 0)$

10. Goodness of fit $R^2 = 1 - \dfrac{\sum (v_i - \hat{v}_i)^2}{\sum (v_i - \bar{v})^2}$

If the latest reading is at or above L the level is reported as exceeded since the first point of the final run above L.
If the slope is zero or negative there is no crossing. Times are fitted about t_n for numerical conditioning.

Units and amplitude

English: velocity in/sec. **metric**: velocity mm/sec. 1 in/sec = 25.4 mm/sec. Time in days (dates are calendar days).
Zone boundaries are RMS. For peak or peak-to-peak readings they are scaled (sinusoid): $v_{pk} = \sqrt{2}\, v_{rms}$, $v_{pp} = 2\sqrt{2}\, v_{rms}$.
Statistical and ratio limits are in the unit and amplitude type of the readings. Crossing dates do not depend on the unit system.

Default zone boundaries (mm/sec RMS, A/B / B/C / C/D; secondary sources)

ISO 20816-3: Group 1 rigid 2.3/4.5/7.1, Group 1 flexible 3.5/7.1/11.0, Group 2 rigid 1.4/2.8/4.5, Group 2 flexible 2.3/4.5/7.1
ISO 10816-1: Class I 0.71/1.8/4.5, Class II 1.12/2.8/7.1, Class III 1.8/4.5/11.2, Class IV 2.8/7.1/18.0

Assumptions

Readings at the same point, direction, speed and load. The last N points represent the current trend. Projections are extrapolations, not failure predictions. The baseline period should be a stable period after commissioning or repair.

References: ISO 20816-1:2016, ISO 20816-3:2022 (replaces ISO 10816-3:2009), ISO 10816-1:1995 (not seen; values and ALARM/TRIP guidance from public summaries, e.g. fabrico.io "ISO 10816-3 vibration severity" and Tractian "Vibration alarm thresholds").
Mean $+k\sigma$ and ratio-to-baseline alarms are common condition-monitoring practice, not ISO requirements.