BASICS OF MACHINE OPERATION

Laboratory · Exercise 5

Condition monitoring – vibration and oil

Trends · spectra · oil analysis · RUL



Akademia Techniczno-Artystyczna
Nauk Stosowanych w Warszawie

Prepared by: dr inż. Radosław Gościniak

Akademia Techniczno-Artystyczna Nauk Stosowanych w Warszawie

Academic year 2026/2027

1. Goal and organisation

Goal. Evaluate monitoring data from three machines: classify vibration severity, find trends, identify faults from spectra, interpret an oil analysis report, estimate the remaining time to the alarm limit and decide on maintenance actions.

Organisation. Teams of 3–4 students. In class (about 80 min): trend chart, classification and spectrum diagnosis. At home: oil analysis, decisions, monitoring programme and the report (max. 6 pages). File name: BMO_Ex5_<team number>.pdf.

2. Plant and machines

Machine	Description	Speed	Notes
M1	exhaust fan, 22 kW, rigid foundation	1 480 rpm	rolling bearings 6310
M2	process pump, 30 kW, rigid foundation	2 960 rpm	coupling to motor
M3	motor + helical gearbox of a conveyor, 15 kW	input 1 450 rpm	pinion z = 19, oil bath ISO VG 220

Vibration velocity RMS [mm/s], measured weekly on the drive-end bearing housing (horizontal). Example zone limits: A ≤ 1.4, B ≤ 2.8, C ≤ 4.5, D > 4.5 mm/s; warning 2.8 mm/s, alarm 4.5 mm/s.

Week	M1 fan	M2 pump	M3 gearbox
1	1.8	1.6	2.4
2	1.7	1.7	2.5
3	1.9	1.6	2.4
4	1.8	1.7	2.6
5	1.8	1.8	2.5
6	1.9	1.7	2.5
7	1.8	1.9	2.6
8	1.7	2.0	2.5
9	1.9	2.2	2.6
10	1.8	2.4	2.5
11	1.9	2.6	3.3
12	1.8	2.7	3.4
13	1.8	2.9	3.3
14	1.9	3.2	3.4
15	1.8	3.4	3.5
16	1.9	3.7	3.4

Spectrum findings (week 16)

Machine	Velocity spectrum	Envelope spectrum	Axial / radial
M1	dominant 24.7 Hz (1×), small 49 Hz	no peaks	axial low
M2	49 Hz (1×) and 98 Hz (2×) both high	no peaks	axial as high as radial
M3	24 Hz (1×) stable; 459 Hz with sidebands ±24 Hz, growing since week 11	24 Hz and harmonics	axial low

Oil analysis report – gearbox M3

Parameter	New oil	Week 4	Week 16	Typical limit
Viscosity at 40 °C [mm²/s]	220	218	205	± 10% of nominal
Iron Fe [ppm]	0	18	96	trend; > 100 alarm
Copper Cu [ppm]	0	2	4	trend
Silicon Si [ppm]	1	6	22	> 15 – dirt entry
Water [ppm]	80	150	900	> 500
ISO 4406	16/14/11	18/16/13	21/19/16	target 18/16/13
PQ index	0	12	85	trend

$$f_{\text{mesh}} = z \cdot \frac{n}{60} \qquad \text{RUL} \approx \frac{v_{\text{alarm}} - v_{\text{now}}}{\text{trend slope}}$$

3. Tasks

1. **Trends.** Draw the vibration trends of the three machines on one chart with the zone limits; classify each machine in week 16 (zone A–D).
2. **Remaining time.** For M2 fit a straight line to weeks 8–16 and estimate the weeks left until 4.5 mm/s. Why may linear extrapolation be optimistic?
3. **Spectrum diagnosis.** Calculate the gear mesh frequency of M3 and identify the most likely fault of each machine. What does the step change of M3 in week 11 show?
4. **Oil analysis.** Interpret the M3 report: oil condition, contamination (how many times dirtier than the target?), wear. Which findings confirm the vibration diagnosis? Likely source of silicon and water?
5. **Decisions.** For each machine propose an action with a deadline (continue, measure more often, repair at the next shutdown, stop now) and justify it with the P-F curve.
6. **Monitoring programme.** Methods, measurement points and intervals for all three machines; which should have online sensors?

Deliverable: report with trend chart, diagnosis table and action plan.

4. Assessment

Criterion	Weight
Trend analysis and classification	25%
Spectrum diagnosis	25%
Oil analysis	20%
Decisions and monitoring programme	30%