

Engine Reliability and Maintenance

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Dataset Overview

- **Operating Hours (OPH)** – Total engine run-time.
- **Max RPM** – Peak rotational speed reached.
- **Resting analysis results** – Engine behaviour in an ideal situation.
- **Issue Type** – Classification of detected faults.
- **Past Damage & Full-Load Issues** – History of damage and issues under full load.
- **High Breakdown Risk** – Target variable indicating the likelihood of failure. Supports proactive maintenance to reduce downtime and costs.

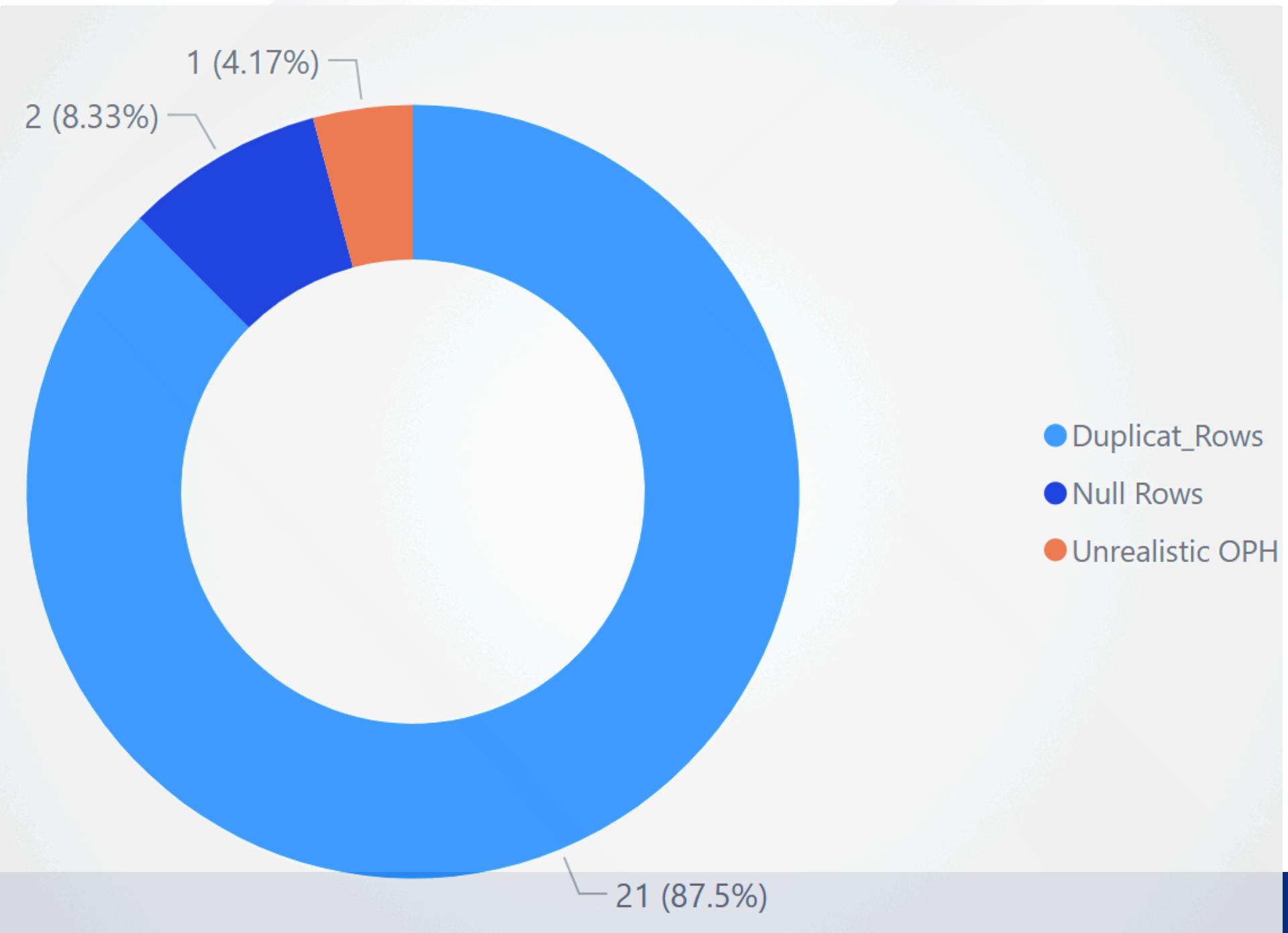
316
Total Rows

302
cleaned rows

| Resting_Analysis_Results | | |
|--------------------------|----------|--------|
| Abnormal | Critical | Normal |

| combustion issue type | | | |
|-----------------------|-------------|---------------|---------|
| atypical | non-related | non-sympto... | typical |

Data Quality & Anomalies



A

Duplicate Records → Removed 21 duplicates to avoid skewing breakdown risk

B

Unrealistic OPH → Removed record with 1B hours runtime

C

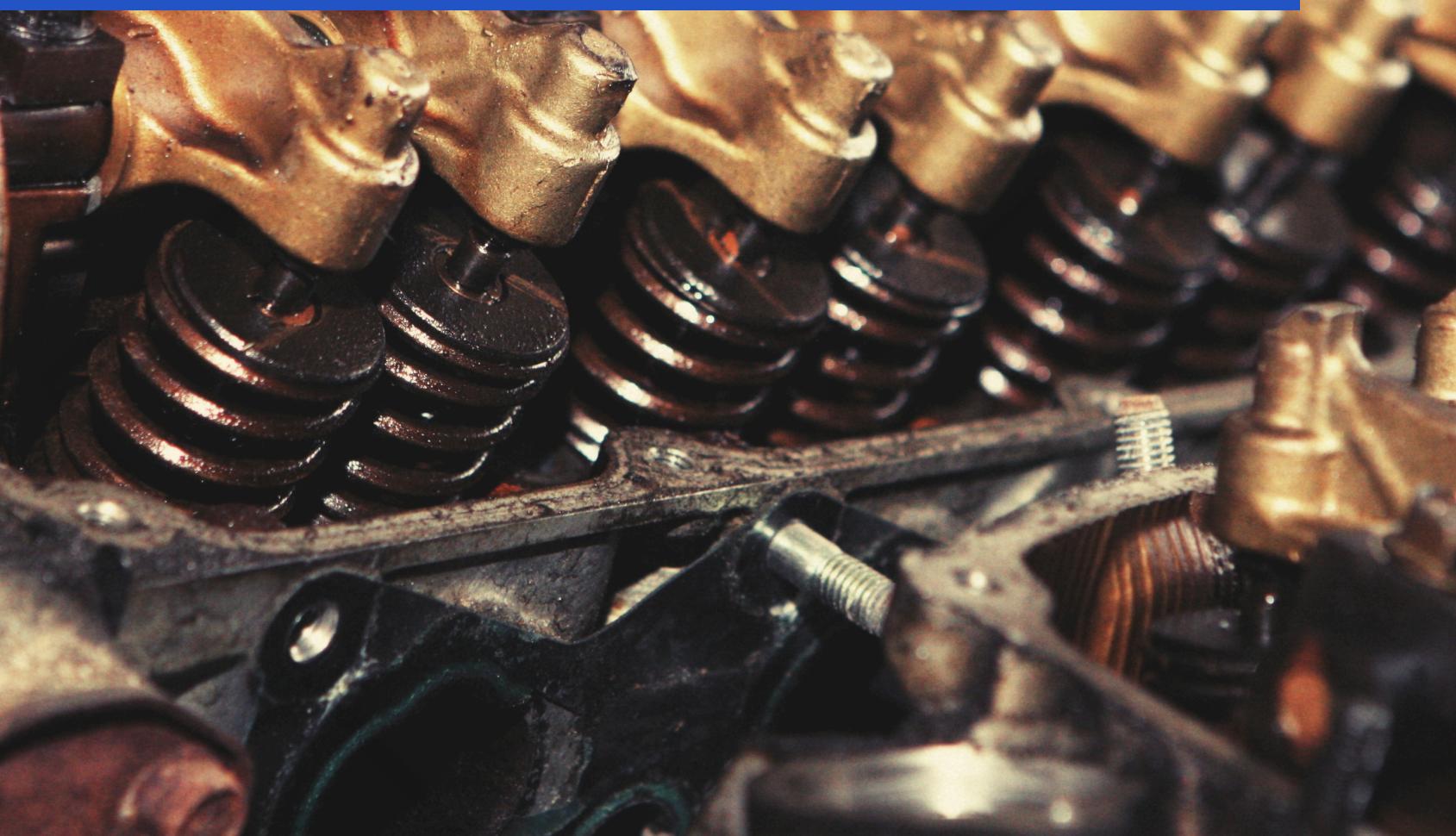
Missing Values → Removed Op_set_2 field as entirely blank.
Removed 2 blank records having OPH, but all other KPI's are blank.

D

Constant Columns → Removed Op_set_1 & Op_set_3 (no value add)

Result: Cleaned dataset with ~302 records ready for analysis

Engine Health KPI's



Breakdown Rate %

~54% of the Engines are flagged high risk, highlighting significant downtime exposure.



Peak Avg RPM

Engine operates at avg RPM~ 1500 highlighting engine wear.



High - Risk Units

Out of 302 cleaned records, 164 units are in red zone → requiring priority maintenance.



Full Load Issue Rate

~33% of engines have full load stress issues, correlating strongly with failure probability.

54.3%

Breakdown Rate (%)

1.50K

Average Max RPM

164

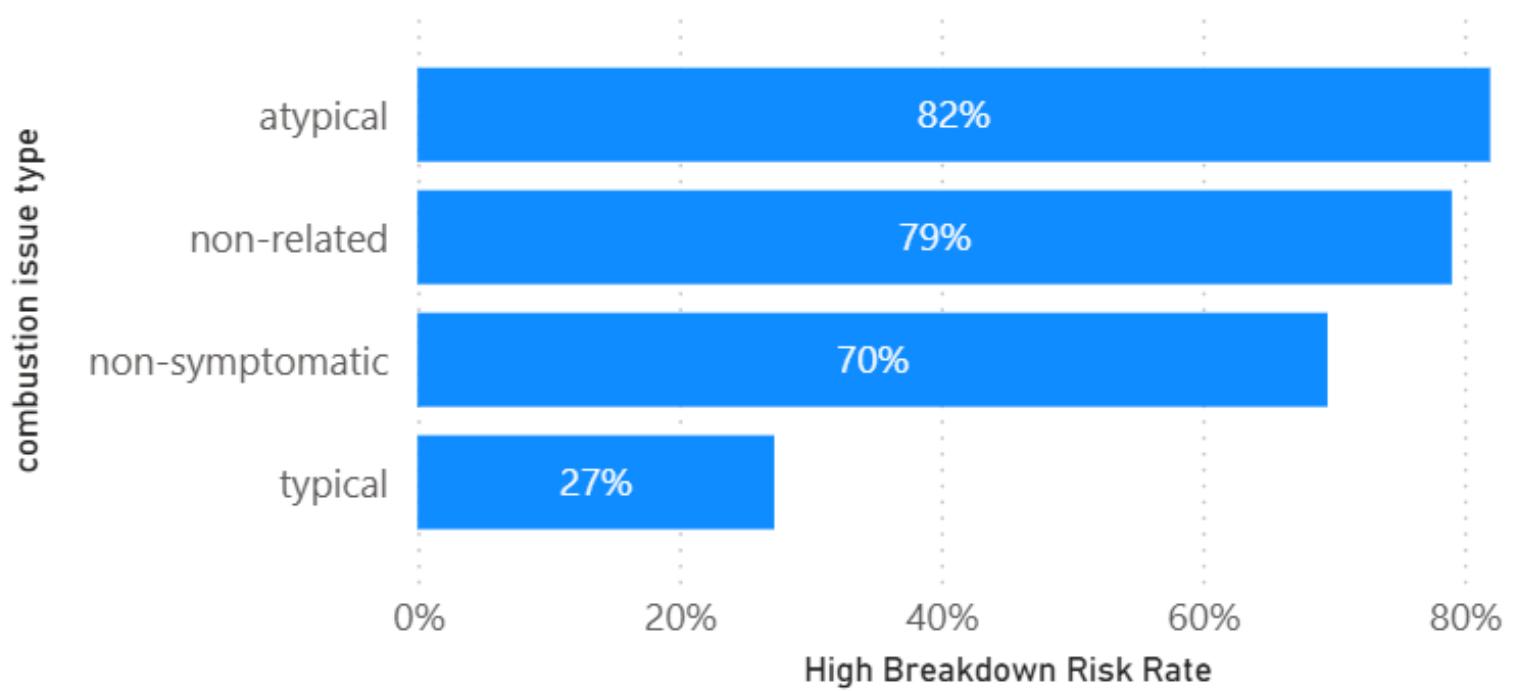
Count of High Risk Units

32.8%

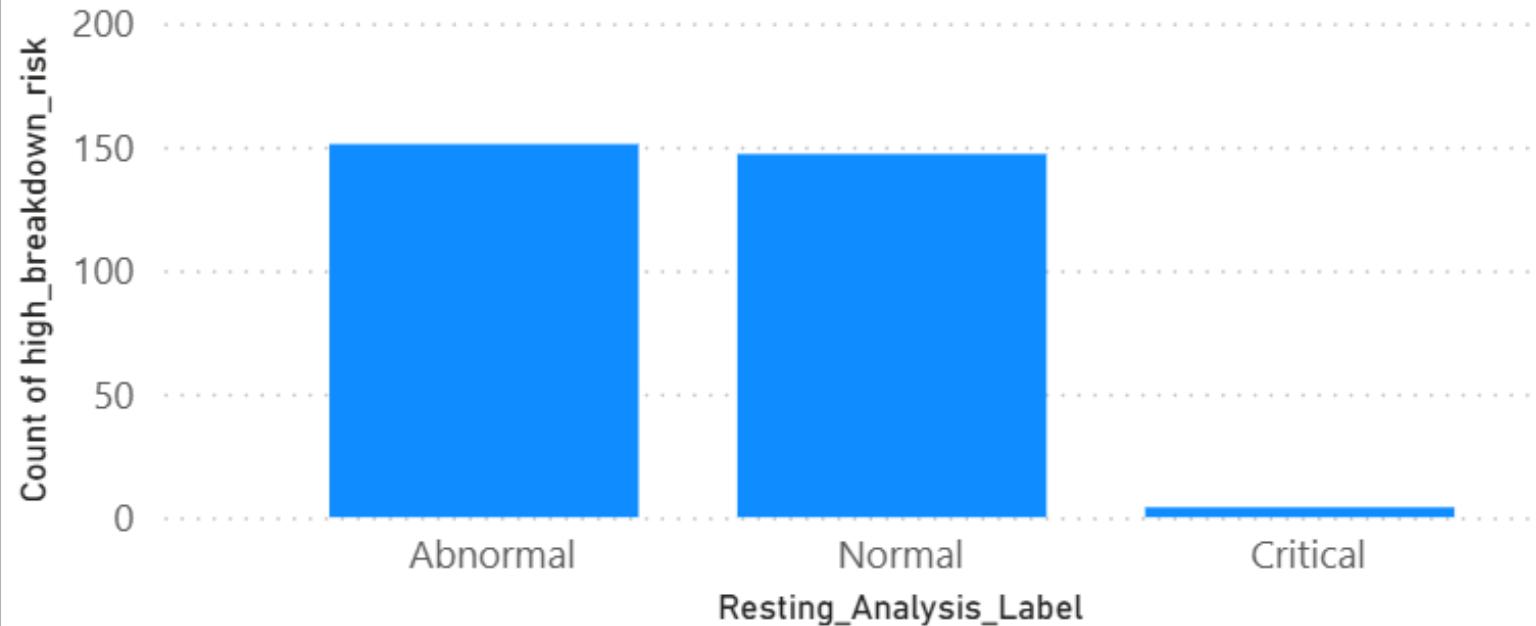
Full Load Issue Rate

Breakdown Risk Drivers

High Breakdown Risk Rate by combustion issue type



Count of high_breakdown_risk by Resting_Analysis_Label



Key Analysis

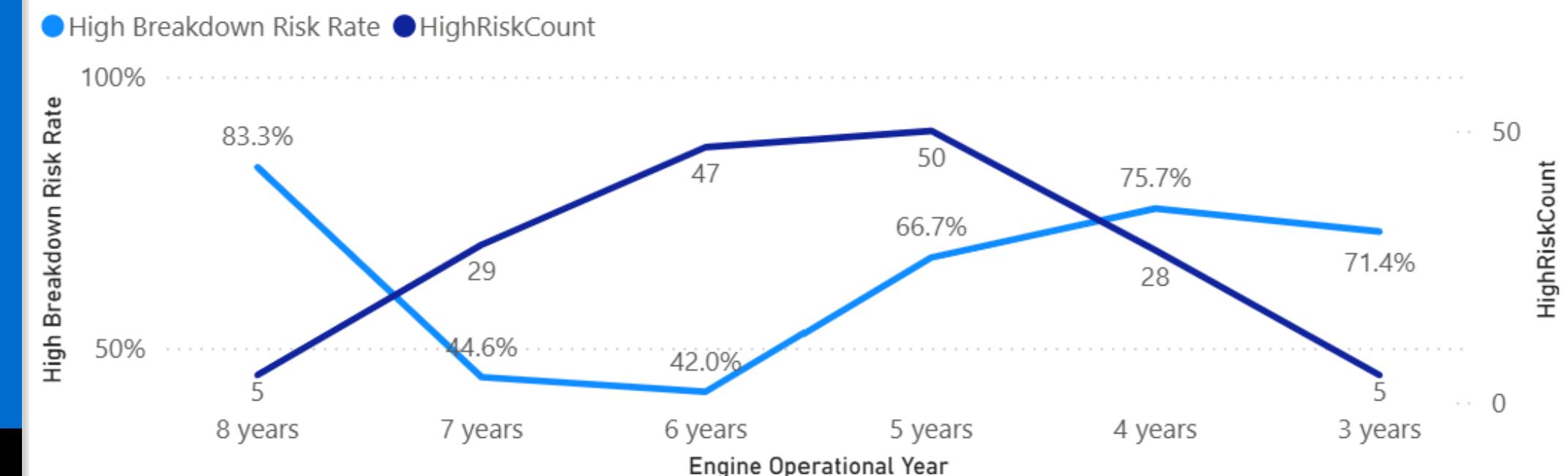
- **Atypical combustion issues** → 82% breakdown risk, compared to only 27% of typical issues.
- **Non-related and non-symptomatic** issues also show disproportionately high risk(70-79(%))
- **Resting Analysis:** Engines labeled “Abnormal” or “Critical” show higher breakdown clustering than Normal.

Breakdown is clustered around specific issue types and diagnostic flags. These drivers provide early-warning indicators before failure.

Service Life Analysis

- Past Damage** rises with age, but breakdown risk dips at 7 yrs → likely due to refurbishment/survivor effect.
- Max RPM** stays high (~1900+), engines above 1600 RPM consistently show higher failures.
- NGI** peaks at 7 yrs, but doesn't directly trigger breakdowns — interacts with load and age.
- Unplanned events** increase sharply with service years, correlating with breakdown risk (except refurbished year 7).
- Risk curve peaks at 3–5 yrs (66–76%), dips at 7 yrs, then spikes again at 8 yrs (83%).
- Failures are driven by combined effect of age + RPM stress + damages + unplanned events, not age alone.

Engine Failure Probability by Years in Service



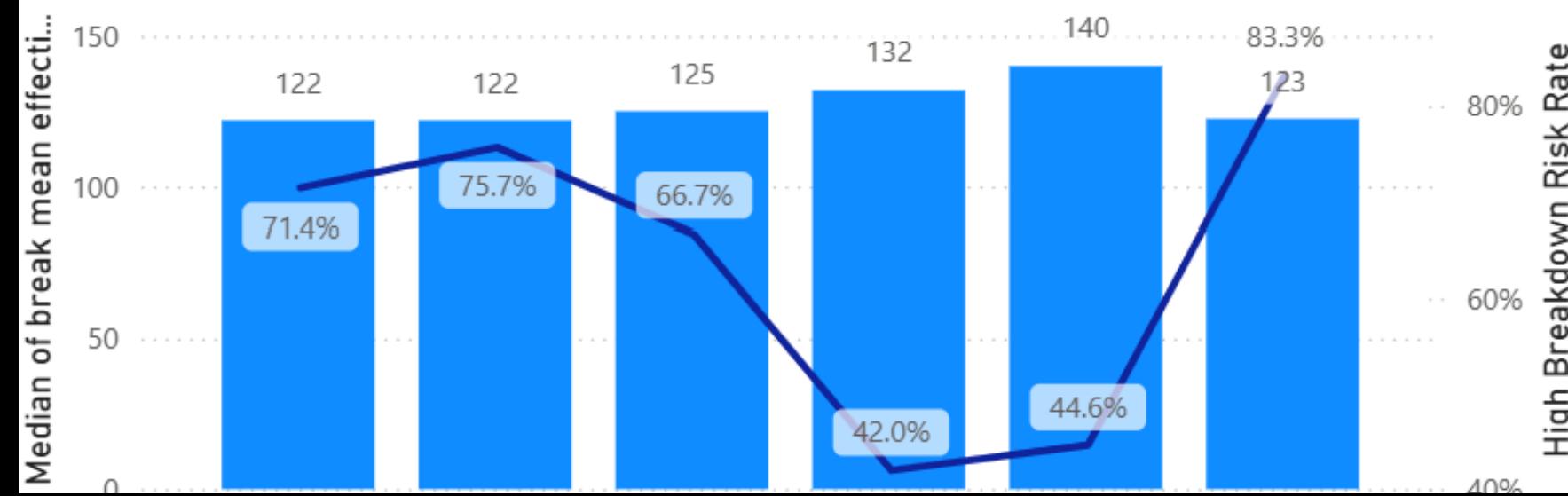
| OPH_Year_Flag | Max of natural gas impurities (nmol) | Count of past damages | No. of Unplanned Events | Max RPM | Breakdown Risk | High Breakdown Risk Rate |
|---------------|--------------------------------------|-----------------------|-------------------------|-------------|----------------|--------------------------|
| 3 years | 564 | 7 | 37 | 2020 | 5 | 71.4% |
| 4 years | 682 | 37 | 297 | 1940 | 28 | 75.7% |
| 5 years | 650 | 75 | 500 | 1900 | 50 | 66.7% |
| 6 years | 818 | 112 | 1385 | 1950 | 47 | 42.0% |
| 7 years | 1128 | 65 | 898 | 1790 | 29 | 44.6% |
| 8 years | 608 | 6 | 33 | 1620 | 5 | 83.3% |
| Total | 1128 | 302 | 3150 | 2020 | 164 | 54.3% |

Component & Operational Stress

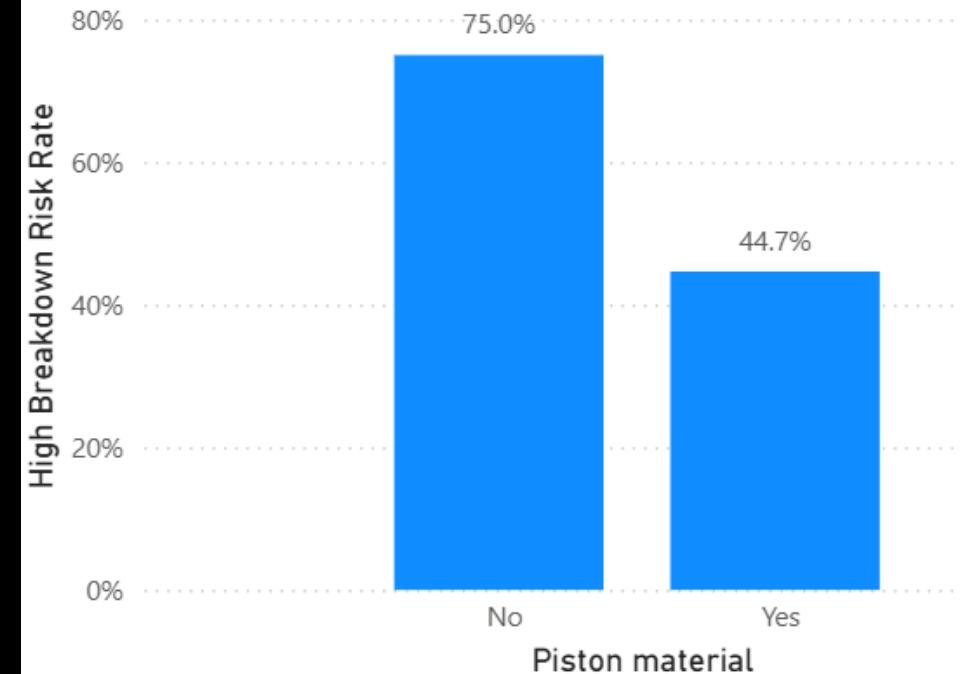
- Certain piston materials sustain higher BMEP longer → lower failure rate within the same age bands.
- BMEP↓ within a service year = early signal of degradation → pre-emptive overhaul window.
- High RPM × High BMEP = mechanical stress hotspot; risk intensifies when NGI is higher.
- Business value: Inform procurement on materials with better service life; reduce warranty & downtime.
- Action: Upgrade high-risk units to proven material; cap RPM in high-stress conditions; monitor BMEP trend by year.

Median of BMEP vs Breakdown Risk Rate

● Median of break mean effective pressure ● High Breakdown Risk Rate



High Breakdown Risk Rate by Piston material



1496

Average Max RPM

422

installed turbo chargers

Conclusion

- Breakdown rate ~54%; highest-risk cohort at 8 years in service.
- Combustion issue type and Max RPM are the strongest drivers.
- Lower BMEP within the same year band signals higher failure risk.
- Hotspot: Higher RPM and Higher NGI nmol (stress amplifies risk).
- Full-load testing/logging appears protective (earlier detection).

Next steps

- Set alerts: for NGI , RPM, BMEP drop based on the standard threshold value vs baseline.
- Triage 164 high-risk units by issue type, RPM, NGI, past damage.
- Operational: RPM caps in high-NGI scenarios; expand full-load tests.
- Data: fix null op settings; add parts-replaced & cost to track ROI.



**Thank
You.**