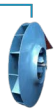
# Centrifugal Pump

## Failure Modeling Guide

$$\mathbb{P}(M \cap P) = \mathbb{P}(M) \times \mathbb{P}(P)$$

| Scenario | Motor Failure | No Motor Failure |
|---|---|---|
| Bearing_0, Rotor_0 | 0.05 | 0.95 |
| Bearing_1, Rotor_0 | 0.2 | 0.8 |
| Bearing_0, Rotor_1 | 0.6 | 0.4 |
| Bearing_1, Rotor_1 | 0.8 | 0.2 |

| Scenario | Pump Failure | No Pump Failure |
|---|---|---|
| Coupling_0, Bearing_0, Impeller_0 | 0.05 | 0.95 |
| Coupling_1, Bearing_0, Impeller_0 | 0.1 | 0.9 |
| Coupling_0, Bearing_1, Impeller_0 | 0.2 | 0.8 |
| Coupling_1, Bearing_1, Impeller_0 | 0.3 | 0.7 |
| Coupling_0, Bearing_0, Impeller_1 | 0.6 | 0.4 |
| Coupling_1, Bearing_0, Impeller_1 | 0.7 | 0.3 |
| Coupling_0, Bearing_1, Impeller_1 | 0.8 | 0.2 |
| Coupling_1, Bearing_1, Impeller_1 | 0.9 | 0.1 |



A
MISALIGNMENT

B
LUBRICATION

C
HIGH TEMP

D
CAVITATION

E
RESISTANCE

F
CONTAMINATION

G
CURRENT

H
FLOW

Misalignment can damage the shaft seal, causing the pump to leak. Cavitation erodes the pump impeller, reducing pump efficiency and flow.

### Pump Impellers

| MODE | MEASUREMENT | TIME-TO-FAILURE |
|---|---|---|
| A | VIBRATION | |
| D | VIBRATION | |
| H | FLOW | |

### AC MOTORS

| MODE | MEASUREMENT | TIME-TO-FAILURE |
|---|---|---|
| E | RESISTANCE | |
| C | TEMPERATURE | |
| A | VIBRATION | |
| G | CURRENT | |

Resistance causes localized overheating and imbalance, which is also caused by misalignment, and leads to reduced motor efficiency.

High temperatures cause flexible elements to soften, reducing stiffness, amplifying misalignment, and reducing component life.

### Flexible Couplings

| MODE | MEASUREMENT | TIME-TO-FAILURE |
|---|---|---|
| C | TEMPERATURE | |
| A | VIBRATION | |

### Rolling Element Bearings

| MODE | MEASUREMENT | TIME-TO-FAILURE |
|---|---|---|
| A | VIBRATION | |
| B | ULTRASOUND | |
| C | TEMPERATURE | |
| F | VIBRATION | |

Misalignment, improper lubrication, excessive temperatures, and contamination reduce bearing life and affect the rotation and alignment of other components.