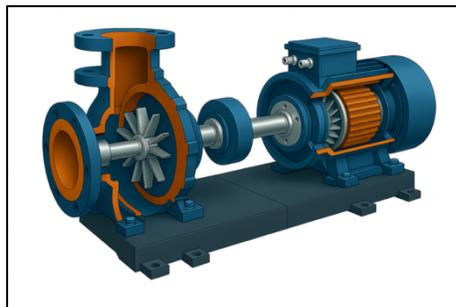


Integrated Diagnostic Model: Pump

This datasheet outlines the Pump Integrated Diagnostic Model (IDM), defining the pump's core components and sub-components. It details the associated failure modes, signal features, and symptoms that are most effective for detecting and diagnosing pump failures. Please note that Cutsforth proprietary information has been omitted in certain tables to protect our intellectual property. This sheet is intended to give you a clear understanding and appreciation of the model's depth and complexity.



Pump Types

This datasheet is a generalization based on different models developed for the following motors types:

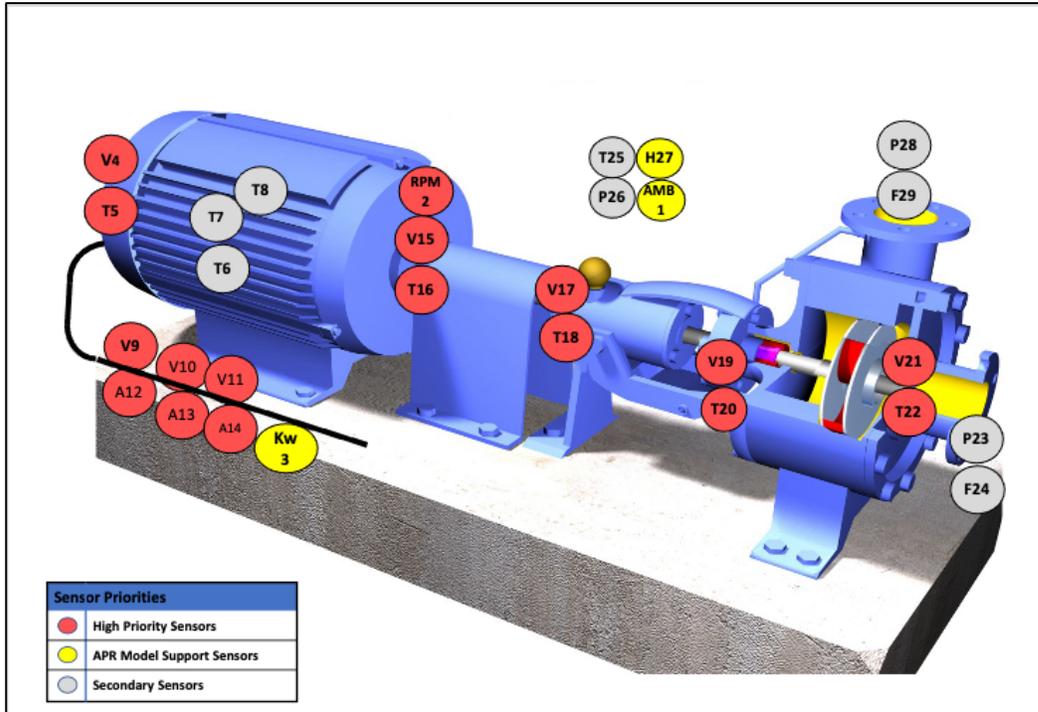
- Condensate Pump – Roller Bearing
- Condensate Pump – Sleeve Bearing
- Boiler Feed Pump – Constant Speed
- Boiler Feed Pump – Variable Speed
- Boiler Feed Pump – Steam Driven
- Boiler Feed Pump w/ Gearbox
- Circulating Water Pump
- Standard Pump
- Standard Pump – Roller Bearings

Pump Components and Failure Modes

Component	Sub-Component (Failure Locations)	Failure Modes
Pump	Bearings	Pump Upper/Lower Bearing Wear
	Shaft	Pump Shaft Cracked
		Pump Shaft Bent
	Impeller	Worn Impeller
Cracked/Chipped Impeller		
Loose Impeller		
Coupling	Coupling Loose	
	Misalignment	
Motor	Stator	Stator Winding Temperature High
		Stator Winding Shorted
		Stator Windings Loose
		And 4 more...
	Rotor	Rotor Bars Damaged
		Rotor Lamination Loosened
Air Gap Static Eccentricity		
Shaft Bent		
And 2 more...	And 3 more...	
Lube System	Lube Oil Pump	Lube Oil Pump Failure
	Lube Oil Cooler	Loss of Cooling Water
	And 3 more...	And 32 more...

Sensor Locations

Each model defines a list of appropriate sensors and/or inspections that are optimal for capturing measurements needed to track potential symptoms of identified failure modes.



Legend					
1	Ambient Temperature	12	A Phase Amps	23	Pump Inlet Pressure
2	Speed	13	B Phase Amps	24	Pump Inlet Flow
3	Power (Calculated)	14	C Phase Amps	25	Lube Oil Supply
4	Triaxial Vibration (Mtr.	15	Triaxial Vibration (Mtr.	26	Lube Oil Supply Pressure
5	Mtr. Bearing Temp.	16	Mtr. Bearing Temp.	27	Relative Humidity
6	Stator Winding A	17	Triaxial Vibration (Pump	28	Pump Outlet Pressure
7	Stator Winding B	18	Pump Bearing Temp.	29	Pump Outlet Flow
8	Stator Winding C	19	Triaxial Vibration (Pump		
9	A Phase Voltage	20	Pump Bearing Temp.		
10	B Phase Voltage	21	Triaxial Vibration (Pump		
11	C Phase Voltage	22	Pump Bearing Temp.		

Pump Integrated Diagnostic Model Table

This image displays a subset of the Pump Integrated Diagnostic Model Table. It details how each failure mode is evaluated based on its significance, likelihood, and diagnostic strength, along with the most effective sensors and detection signals. The complete pump model is robust, identifying more than 270 symptoms necessary for accurately diagnosing 56 different failure modes.

Major Component	Sub-Component	Failure Mode	Significance	Sensor	Diagnostic Strength	Likelihood	Notes
Pump	Impeller	Cracked/Chipped Impeller	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	4	
			2	Overall Pump/Motor Vibration	40	4	
			2	Motor Upper/Lower Bearing Thermocouple	20	4	
		loose Impeller	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	4	
			2	Overall Pump/Motor Vibration	40	4	
			2	Motor Upper/Lower Bearing Thermocouple	20	4	
	Shaft	Pump shaft cracked	3	Mtr inb/ob brg vib (dyn x,y, axial)	60	3	
			3	Pump Shaft Prox Probe X,Y	60	3	
			3	Overall Pump/Motor Vibration	40	3	
		Pump shaft bent	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	4	
			2	Pump Shaft Prox Probe X,Y	70	4	
			2	Overall Pump/Motor Vibration	40	4	
	Pump Bearings	Pump Upper/Lower bearing wear	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	7	
			2	Pump Shaft Prox Probe X,Y	60	7	
			2	Overall Pump/Motor Vibration	40	7	
			2	Motor Upper/Lower Bearing Thermocouple	20	7	
			2	Water Lubricating Flow	50	7	
			2	Lubricating Water Supply Strainer Diff Press	90	7	
	Coupling	Coupling Loose, misaligned	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	6	
			2	Overall Pump/Motor Vibration	40	6	
			2	Motor Upper/Lower Bearing Thermocouple	20	6	
	Performance	cavitation	2	Mtr inb/ob brg vib (dyn x,y, axial)	60	8	
			2	Overall Pump/Motor Vibration	40	8	
			2	Motor Upper/Lower Bearing Thermocouple	20	8	
			2	Motor Amps	20	8	
		Operating outside AOR (allowable operating range)	2	Motor Amps	20	4	
			2	Suction Basin Level	40	4	
			2	Discharge Pressure	50	4	
			2	Discharge Flow	50	4	
		Suction Bell worn/separated	2	Discharge Temperature	50	4	
2			Suction Temperature	40	4		
2			Mtr inb/ob brg vib (dyn x,y, axial)	60	2		
2			Overall Pump/Motor Vibration	40	2		
		2	Motor Upper/Lower Bearing Thermocouple	20	2		
		2	Motor Amps	20	2		

Applying the Model

IDMs capture and document subject-matter experts (SME) knowledge of failure modes, effects, and causes along with condition indicators, or symptoms, that most likely indicate a potential failure (high vibration, erratic current, high temperature, etc). Failure modes are assigned likelihood values based on MTBF statistical data and SME experience. Sensors and symptoms are rated for failure coverage and early detection effectiveness.

In consulting engagements, our experts integrate the client's current situation (assets, current sensors and data available, etc.) with each asset model and run automated algorithms to calculate:

- **Failure mode coverage exposure** rankings
- **Sensor gap analysis** and prioritized incremental coverage plan
- **Advanced Pattern Recognition (APR)** alignment to ensure appropriate inputs are available for accurate detection. Models can be deployed in industry available third-party APR tools with diagnostic engines (contact Cutsforth for more information).

Next Steps

The Cutsforth IDM Library includes more than 65 asset models across 12 categories, capturing the key technical characteristics, sensors, symptoms, and SME insights for each asset type. This information is available through several options:

- Purchase an asset-model license to use within your own tools or processes.
- Contract with Cutsforth to develop a new model for assets not yet included in the IDM library.
- Purchase Cutsforth software tools that include these models for detection and diagnosis.
- Engage Cutsforth to assess your equipment reliability program and build a roadmap for improving technology, processes, and training.