



Equipment Health - Troubleshooting Pump and Systems - Reliability

How do you know you have a pump issue?

Mechanical Seal Leak

Low Flow

Low Pressure

Motor AMP's Excessive

Motor Trips on High AMP's

Excessive Vibration

Auxiliary Equipment not Operating Properly or Failing Prematurely

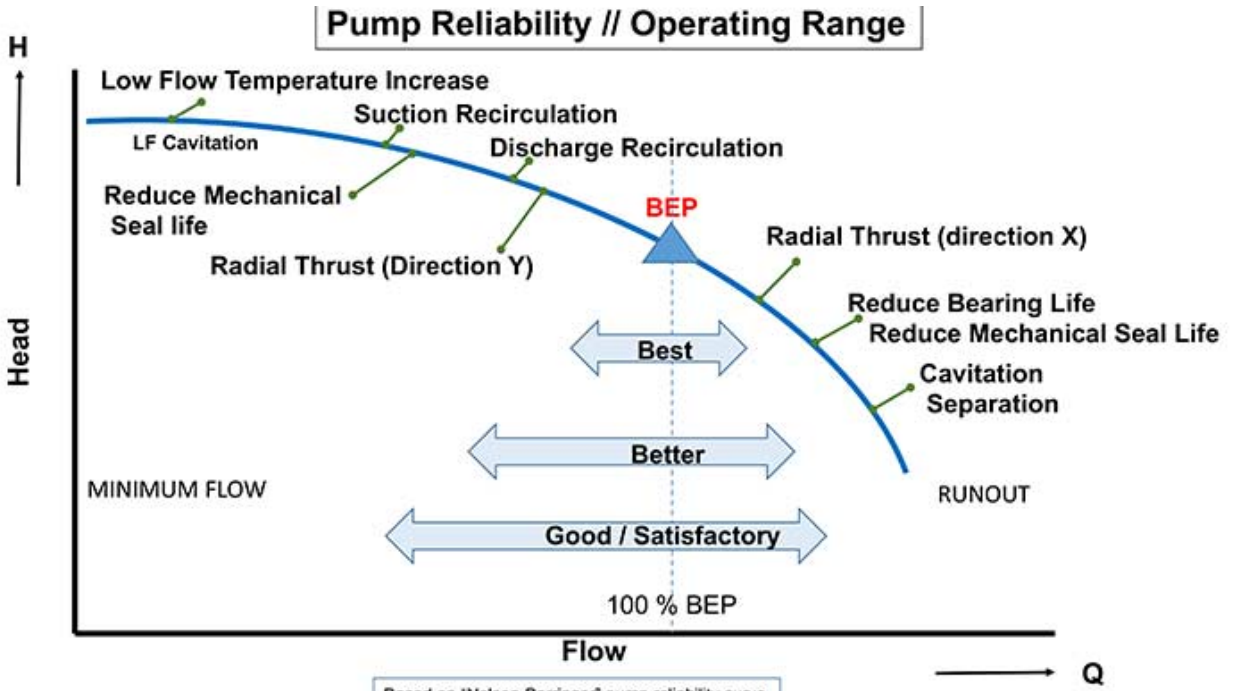
Trained Staff

Why did the Pump, Motor or Auxiliary Fail or not operating Properly?

System Requirements have Changed, More Production, Less Production, Recent Maintenance, Pump Repaired, Motor Repaired and or Changes to the Equipment, such as Impeller Size, Material Changes in the pump or Mechanical Seal, Motor HP / RPM, Different Valve Design

What is Required to Determine the Root Cause

- ✓ Pump Curve and Hydraulic Data Sheet
- ✓ Motor Curve
- ✓ Changes made to the System
- ✓ Bill of Material
- ✓ Auxiliary Equipment Specifications
- ✓ Vibration Analysis



Based on "Nelson-Barringer" pump reliability curve

Potential Issues for Flowrates Q...as depart from BEP

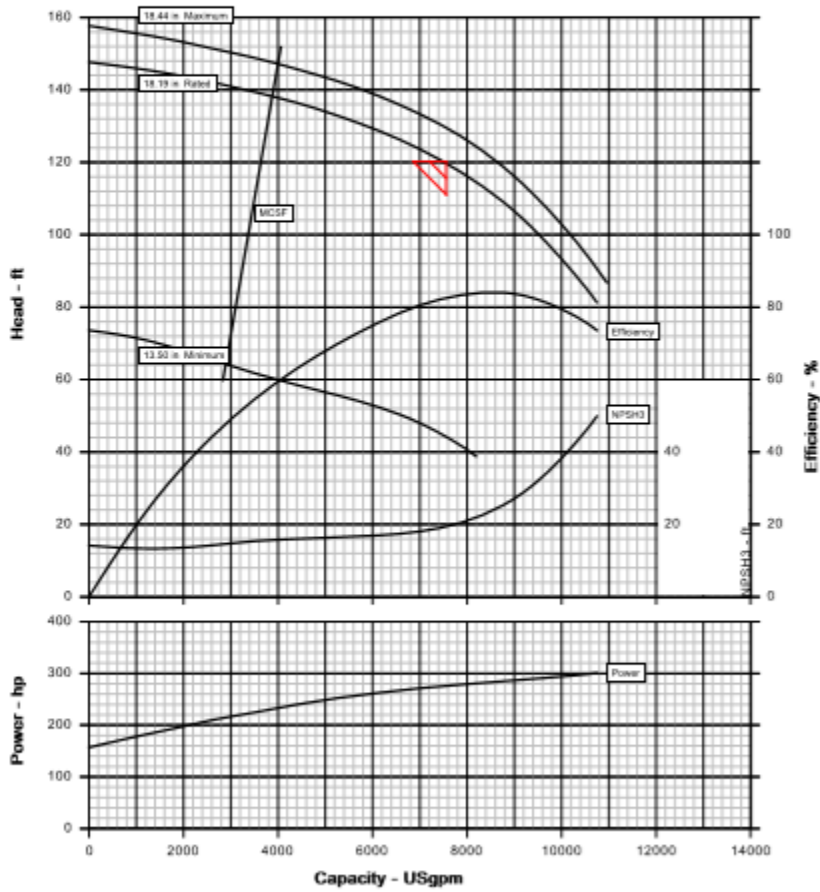


Pump size & type / Stages : 4K14X14-18CP / 1
Based on curve no. : ER4598
Impeller diameter : 18.19 in

Customer : PCS Phosphates
Item number : APPLICATION ONE NEW CONDITION
Service : -
Flowserve reference : 2263877665
Date : May 12, 2020

Capacity : 7560.0 USgpm
Head : 120.00 ft
Density / Specific gravity : - / 1.000
Pump speed : 1180 rpm
Ns / Nss : 3077 / 5890 (US units)
Test tolerance : ANSI/HI 14.6 Grade 1B

CURVES ARE APPROXIMATE. PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS: CAPACITY, HEAD, AND EFFICIENCY.



The customer must provide a minimum NPSHs of 19.2 ft.
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Hydraulic Datasheet

Customer	: PCS Phosphates	Pump / Stages	: 4K14X14-18OP / 1
Customer reference	: NUTRIEN	Based on curve no.	: ER4598
Item number	: APPLICATION ONE NEW CONDITI...	Flowserve reference	: 2263877665
Service	: -	Date	: May 12, 2020
Operating Conditions		Materials / Specification	
Capacity (rated/normal)	: 7560.0 USgpm / -	Material column code	: CD4
Water capacity (CQ=1.00)	: -	Pump specification	: -
Total developed head	: 120.00 ft	Other Requirements	
Water head (CH=1.00)	: -	Hydraulic selection : No specification	
NPSHa/NPSHa less margin	: Ample / -	Construction : No specification	
Maximum suction pressure	: 0.0 psig	Test tolerance : ANSI/HI 14.6 Grade 1B	
Liquid		Driver Sizing : Rated Power	
Liquid type	: Other	Seal configuration : Single Mechanical Seal	
Liquid description	: -		
Temperature	: 60 °F		
Density / Specific gravity	: - / 1.000		
Solid Size - Actual / Limit	: - / 1.60 in		
Viscosity / Vapor pressure	: 1.00 cP / -		
Performance			
Hydraulic power	: 229 hp	Impeller diameter	
Pump speed	: 1180 rpm	Rated	: 18.19 in
Pump overall efficiency (CE=1.00)	: 83.0 %	Maximum	: 18.44 in
NPSH required (NPSH3)	: 19.2 ft	Minimum	: 13.50 in
Rated brake power	: 276 hp	Ns / Nss	: 3077 / 9890 (US units)
Maximum brake power	: 301 hp	Minimum continuous flow	: 3909.6 USgpm
Driver power rating	: 300 hp / 224 kW	Maximum head at rated diameter	: 147.78 ft
Casing working pressure	: 64.0 psig	Flow at BEP	: 8590.3 USgpm
(based on shut off @ cut dia/rated SG)		Flow as % of BEP	: 88.0 %
Maximum allowable	: 200.0 psig	Efficiency at normal flow	: -
Hydrostatic test pressure	: 300.0 psig	Impeller diameter ratio (rated/max)	: 98.7 %
Estimated rated seal chamber pressure	: -	Head rise to shut off	: 23.2 %
		Total head ratio (rated / max) / (max / rated)	: 92.5 % / 108.1 %



REV 3

PUMP DESIGN AND PROCESS FLUID DATA

Pump ID	PRM Filtration - Chill Water	Design GPM	7560	Design FTHD	120
Pump Design PSI	52	GPM @ PUMP BEP	8590	Flow at % of BEP	88.0%
Process Fluid	Chill Water				
Fluid Temperature	60	SG	0.999	Water Specific Volume	0.1199
Vapor PSI	-14.44			Pump Efficiency	83.0%
Required FTHD - NPSHr					
FTHD	120	PSI	52	NPSHr	19.20
				PSI	8

CALCULATE API MIN / MAX GPM FOR HYDRAULIC OPERATING RANGE

Design GPM		Flow at % of BEP				Design FTHD	SG	Design Disch PSI	Pump Effic
7560		88.0%				120	0.999	52	83.0%
GPM @ Pump BEP		Flow 30 % BEP		Design GPM < 30% of BEP		FTHD	SG	< 30% PSI	Pump Effic
8590		70%		6013		129	0.999	56	74.0%
GPM @ Pump BEP		20% Above BEP		Design GPM > 20% of BEP		FTHD	SG	> 20% PSI	Pump Effic
8590		1.2		10308		90	0.999	39	77.0%
NPSHr	19.20		NPSHa	23					
	8	PSI		10	PSI			Differential PSI	2



REV 21



Electrical Calculation

HP				kW
300	746	223800		223.8
Volts	Motor Eff %	PF		
460	95.8%	84.5%		
	Motor Tag AMP's - RLA	Service Factor	FLA	
	644.95	347.0	1.15	434.0

Design GPM - FTSD - HP - AMP's

Design GPM
7560

Design HDFT
120

SG
1.000

Design Pump Efficiency
83.0%

276.0 Brake HP (Rated HP @ Pump Design)

Brake HP @ GPM
276.0

Volts
460

Motor Eff %
95.8%

PF
84.5%

Design AMP's
318.8

Actual AMP's Reading
0.0

Motor Tag AMP's
347.0

Design BHP
276.0

HP
300

% HP Used
92.0%

kW
205.9

SYSTEM EVALUATION

Once the pump and motor minimum and maximum performance is established we can determine if there is a system or equipment issue.

If there is a System issue we need to know the required flows and pressures and operating conditions. We can then size the equipment to meet the system demands.

We strongly suggest a System Analysis to trend the system demands and the equipment's performance during demand changes.

EQUIPMENT INSPECTION

All parts during disassembly need to be inspected for wear, damage, erosion, corrosion. Each parts should be matched marked to evaluate any wear or damage. This will assist to determine if the pump was operating to the right or left of the Best Efficiency Point.

The equipment Bill of Material documents the material of all the parts. If there is a corrosion issue then the material has been replaced and is incorrect. If excessive then we any chemical reaction to the process fluid if the process fluid temperature increases or decreases.

Erosion issue will lead to evaluate the erosion as normal or excessive. If excessive then we evaluate the velocity of the process fluid and temperature increases or decreases.

IMPELLER SIZE AND MATERIAL

Review the Pump Curve and BOM for impeller OD and construction of material. If the impeller was changed during a repair the impeller OD must be the same as the Pump Curve. Impeller OD smaller or larger than the Pump curve specification is likely to cause a hydraulic imbalance in the pump volute, casing, or suction bowl. This imbalance will create additional vibration and may be excessive.

The impeller material but be compared to the BOM to ensure the impeller is compatible with the process fluid. If the impeller material is not as described in the BOM than a chemical reaction may occur causing impeller corrosion.

Valve Design

Ensure any valves replaced are the same design. Do not replace a Gate Valve with a Globe Valve, these effects the “K” Factor, and changes the system flow and equipment original design.

Motor HP & RPM

Ensure the pump motor HP and RPM are the same as the original design. Decreased HP may cause the motor to trip on excessive AMP's. Decrease in RPM will reduce discharge pressure and can cause internal recirculation. Increase in Motor HP will cause excessive power consumption. Increase in RPM may cause excessive pressure.

Vibration Analysis and Trending

Install a Equipment Health Monitoring System to Trend the Equipment's Vibration, Pressures, AMP's and RPM's.

Vibration Engineer involved when a Trend is documented. If there is no Equipment Health Monitoring System to Trend the Data then Set-up Equipment Health based Critical Equipment

Good Practices

- ✓ Install a Suction and Discharge Pressure Gauges
- ✓ Review the Pump Curve and Hydraulic Data Sheet and know the Pump and Motor Design Minimum and Maximum Parameters
- ✓ Require a Written Repair Document with details and pictures of failed parts
- ✓ Consider the OEM to be on Site for Equipment Start-Up and Require Start-Up Document of all Data to ensure the Equipment and System are operating as designed
- ✓ If a Change is made to the Equipment and/ or System consider a System Analysis to ensure the Changes do not affect the equipment
- ✓ Train Plant Millwrights/Mechanics OEM Disassemble, Inspection and Reassembly and Root Cause Evaluation
- ✓ Train Engineers and Operations when changes are made to Pumps, Motors, Auxiliary Equipment how that will the System and Equipment
- ✓ Train Operations how to Properly Start-up and Shut-down Equipment
- ✓ Critical Equipment with a Equipment Continuous Health Monitoring System with Alarms and Alerts

Items That Should be Available to Troubleshoot the Pump, Motor and System

Pump Curve – This is the document that shows the Design of the Pump and Motor.

- ✓ Design Capacity (GPM)
- ✓ Total Head Pressure (FTHD)
- ✓ Net Positive Suction Head Available
- ✓ Flow (GPM) at Best Efficiency Point (BEP)
- ✓ Flow (GPM) as % of Best Efficiency Point (BEP)
- ✓ Minimum Continuous Flow (Not to be confused with Minimum Hydraulic Flow)
- ✓ Impeller OD with the Minimum and Maximum Impeller OD
- ✓ Suction Specific Speed (Nss)
- ✓ RPM
- ✓ Efficiency
- ✓ Horsepower
- ✓ Rated Horsepower
- ✓ Hydraulic Horsepower

Pressure Gauges – Install a pressure gauge on the pump suction, discharge, discharge bypass line and the system header. This will give you indications of equipment and system performance

AMP Read Out or Meter – Determine actual motor AMP draw to ensure the motor and pump are operating within the allowable design

Key to Success – Trained Staff operating the equipment, repairing the equipment and root cause, knowledge of the system, knowledge of the equipment, pressure gauges. And AMP Meter. Management ability to Listen and Act.