WEST YOST

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What's the Big Deal with Big Pumps?

May 4, 2023

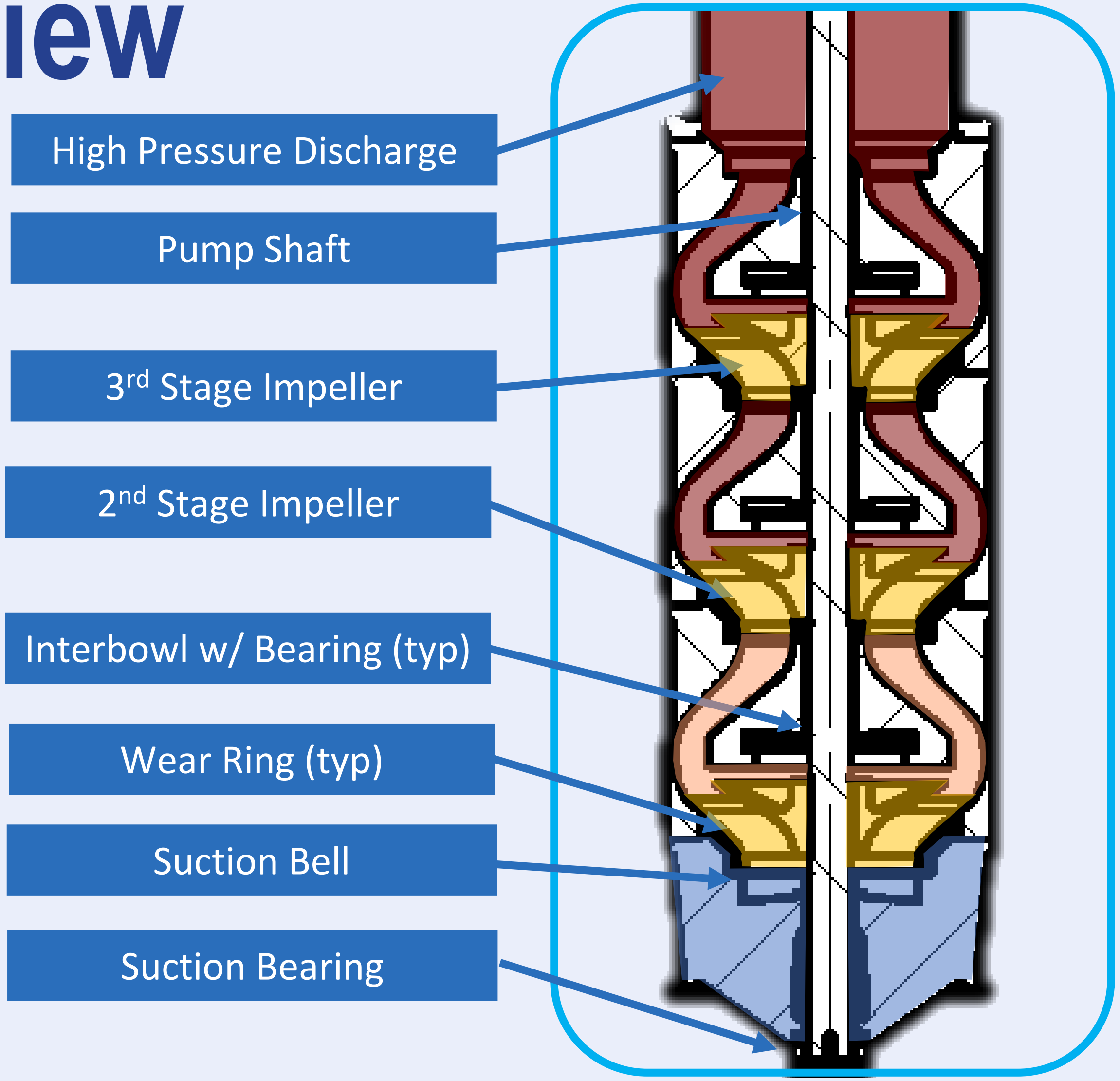
Presentation Overview

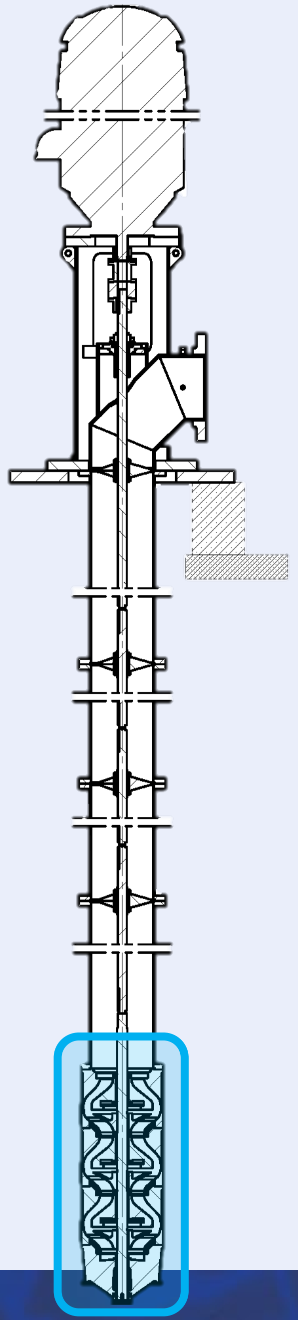
- **Goals**
  - Understand key design elements
  - Small items that make a BIG difference
- **Vertical Turbine (VT) Pump Overview**
- **Specifying Large Vertical Turbine Pumps**
  - Hydraulic Considerations
  - Vibration / Structural
  - Electrical and Controls
- **Case Study**

VT Pump Overview

Pump Components

- Multi-stage impeller and volute assembly





VT Pump Overview

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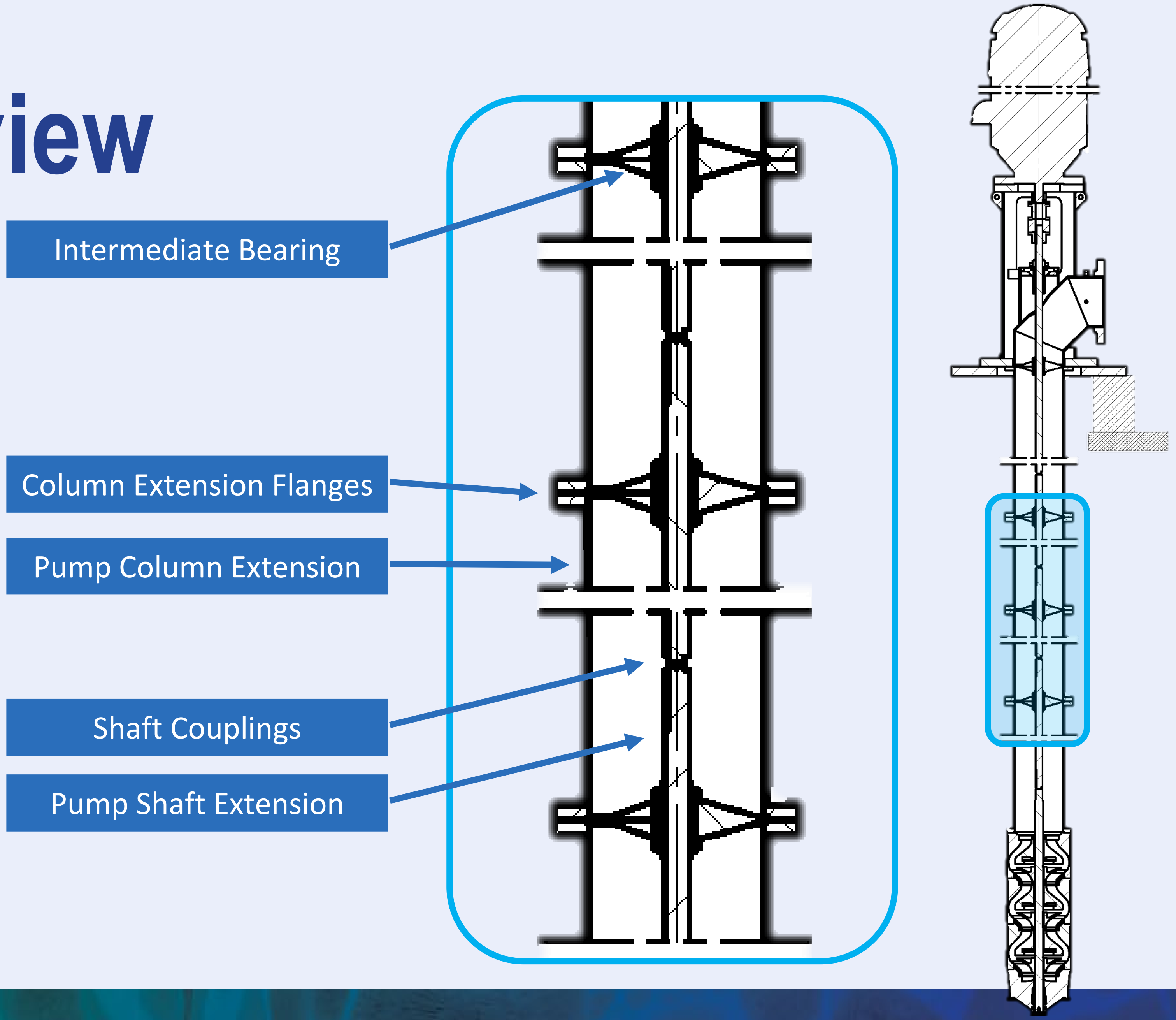
- Multi-stage impeller and volute assembly
- Column and shaft extensions



VT Pump Overview

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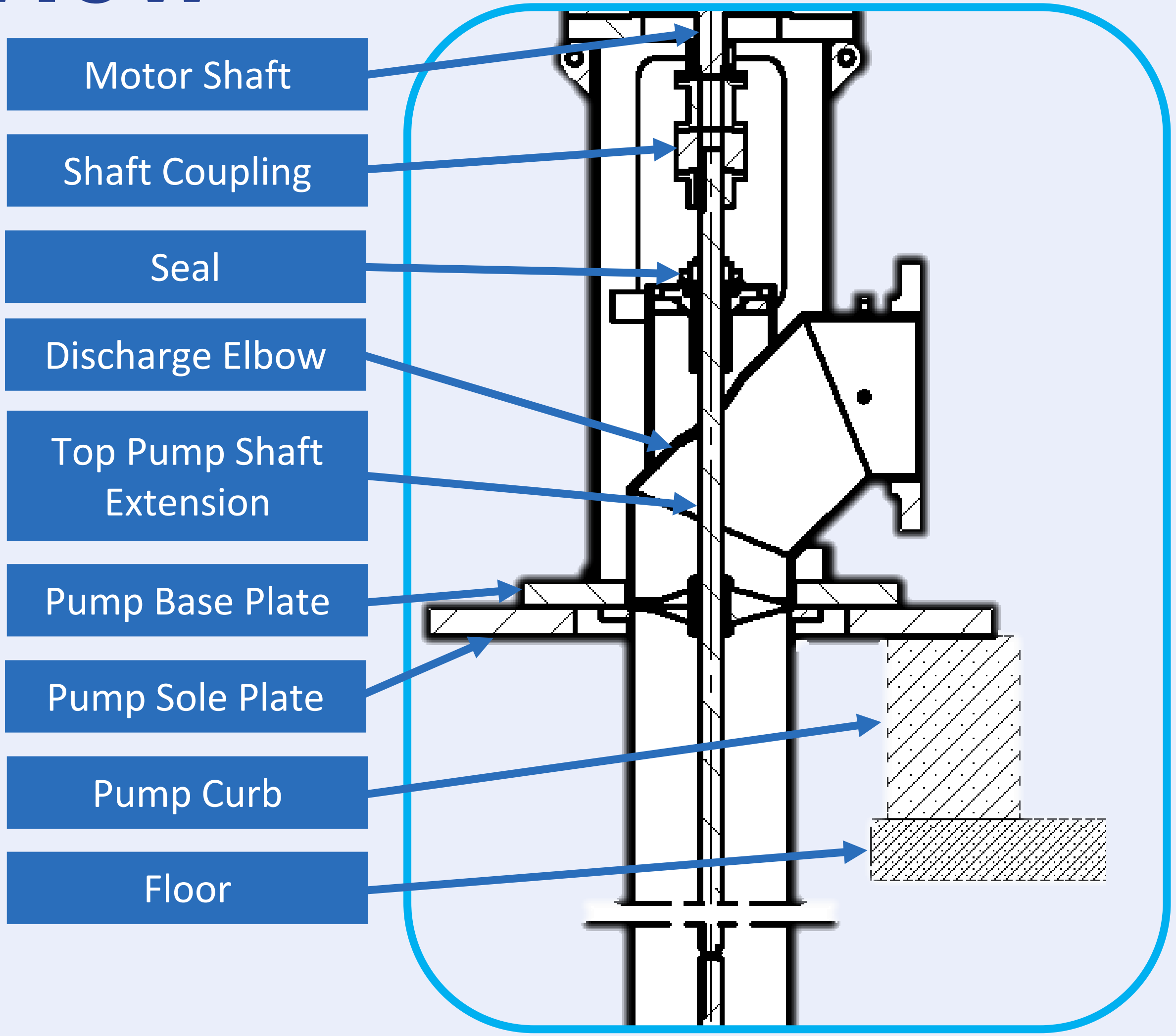
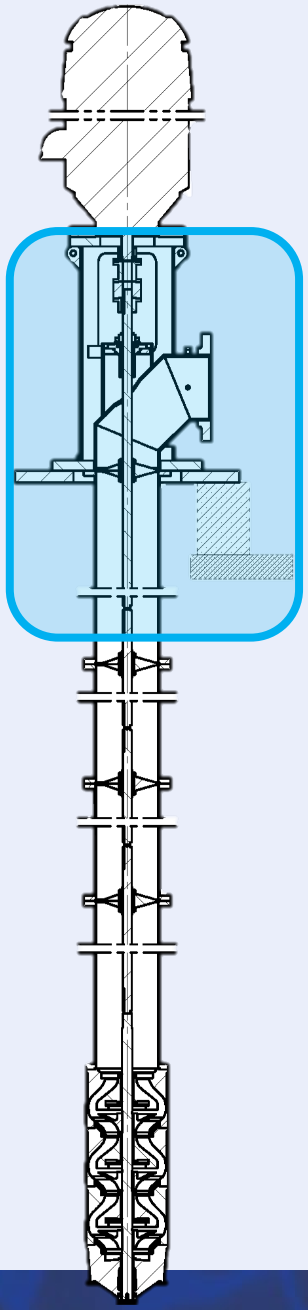
- Pump base

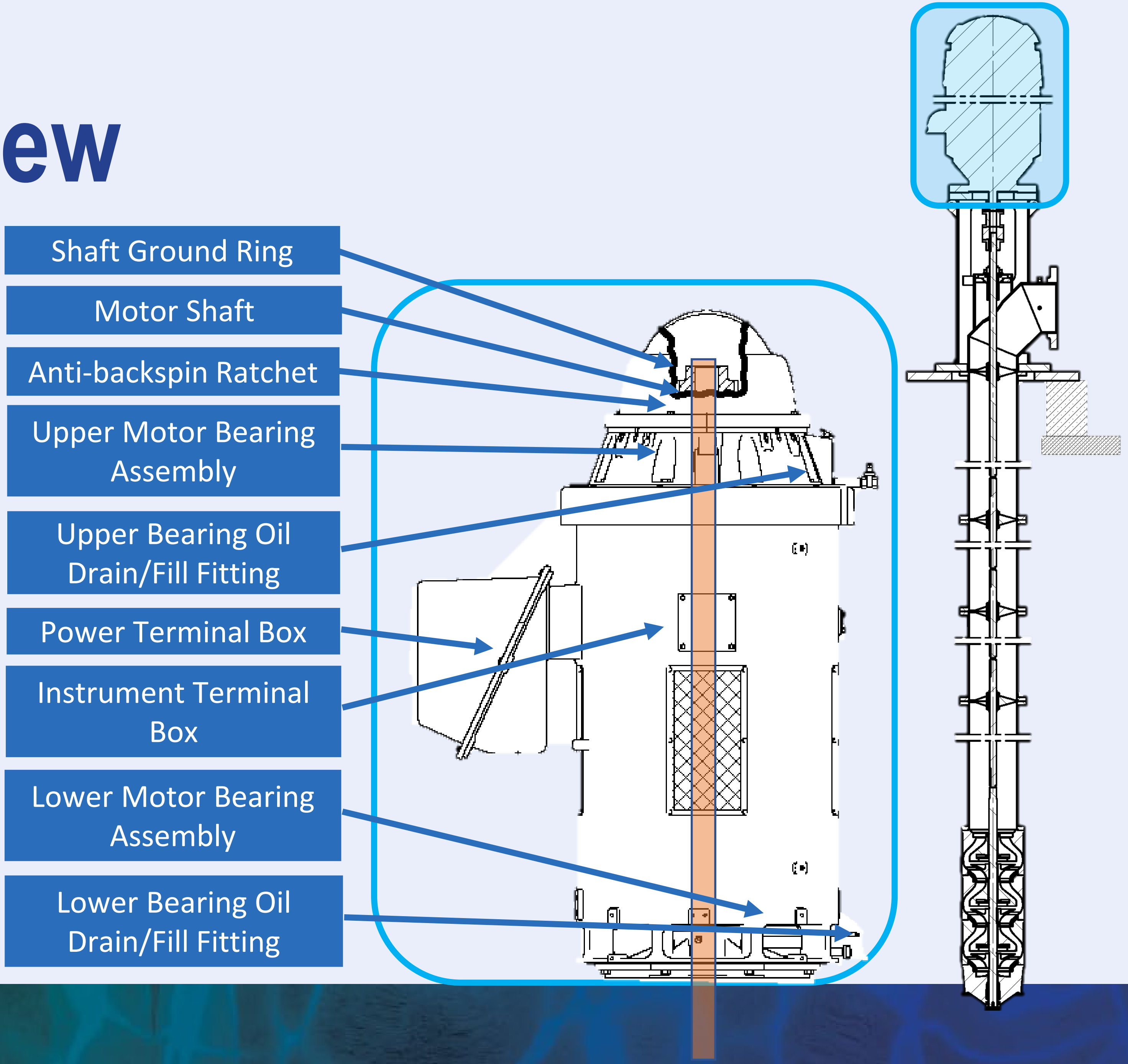




VT Pump Overview

Pump Components

- Multi-stage impeller and volute assembly
- Column and shaft extensions
- Pump base
- Motor



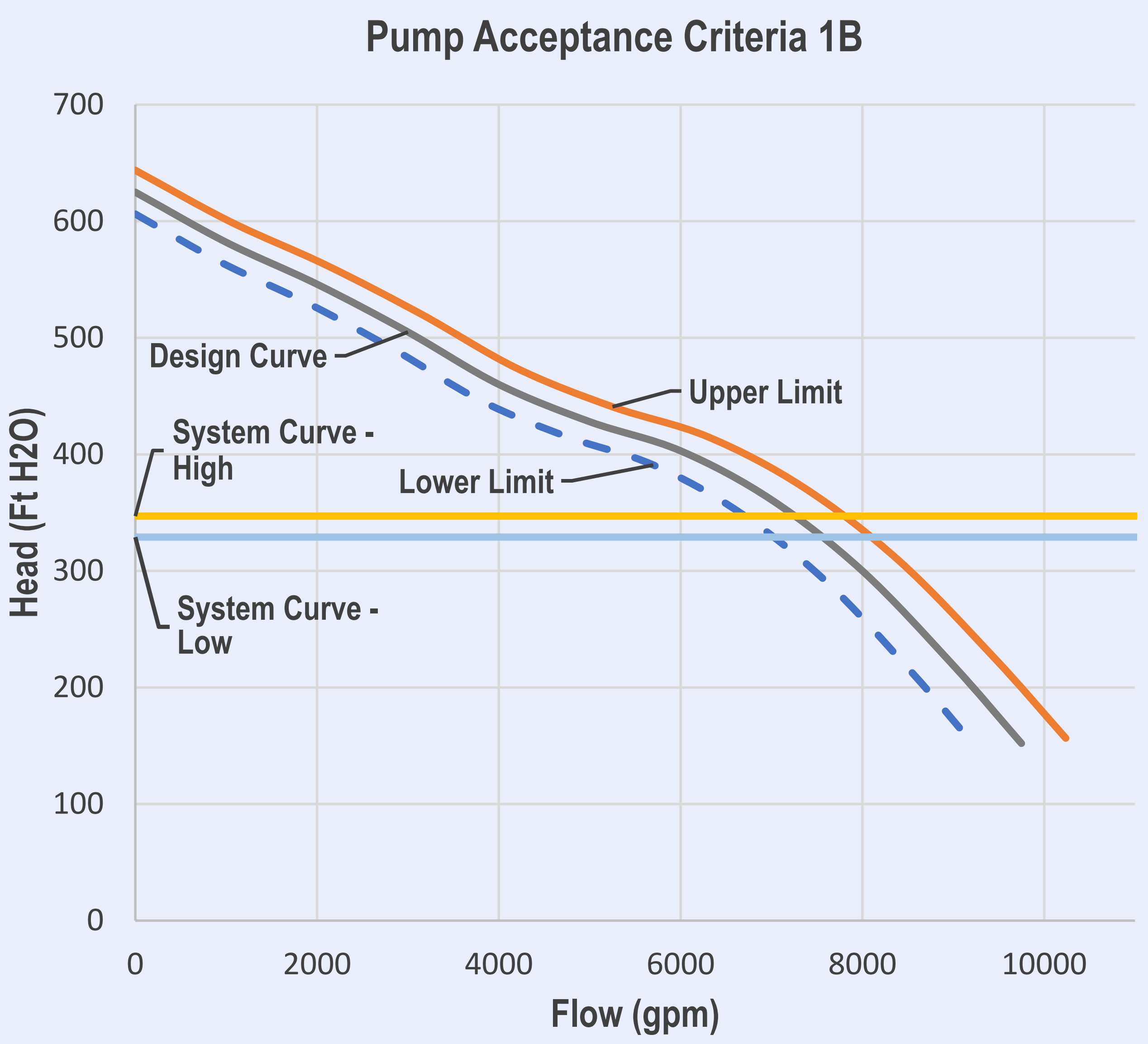
Specifying Large Vertical Turbine Pumps

ANSI/HI 14.6-2022

Pump Acceptance Tests

Table 14.6.3.4 — Pump test acceptance grades and corresponding tolerance band

		Grade	Grade 1			Grade 2		Grade 3
		Δt_Q	10%			16%		18%
		Δt_H	6%			10%		14%
			Acceptance grade					
Test parameter	Guarantee requirement	Symbol	1B	1E	1U	2B	2U	3B
Rate of flow	Mandatory	t_Q (%)	± 5%	± 5%	0% to + 10%	± 8%	0% to +16%	± 9%
Total head	Mandatory	t_H (%)	± 3%	± 3%	0% to + 6%	± 5%	0% to +10%	± 7%
Power	Optional[a] (either/or)	t_P (%)	+ 4%	+ 4%	+ 10%	+ 8%	+ 16%	+ 9%
Efficiency[b]		t_η (%)	− 3%	− 0%	− 0%	− 5%	− 5%	− 7%



Specifying Large Vertical Turbine Pumps

ANSI/HI 14.6-2022

Pump Acceptance Tests

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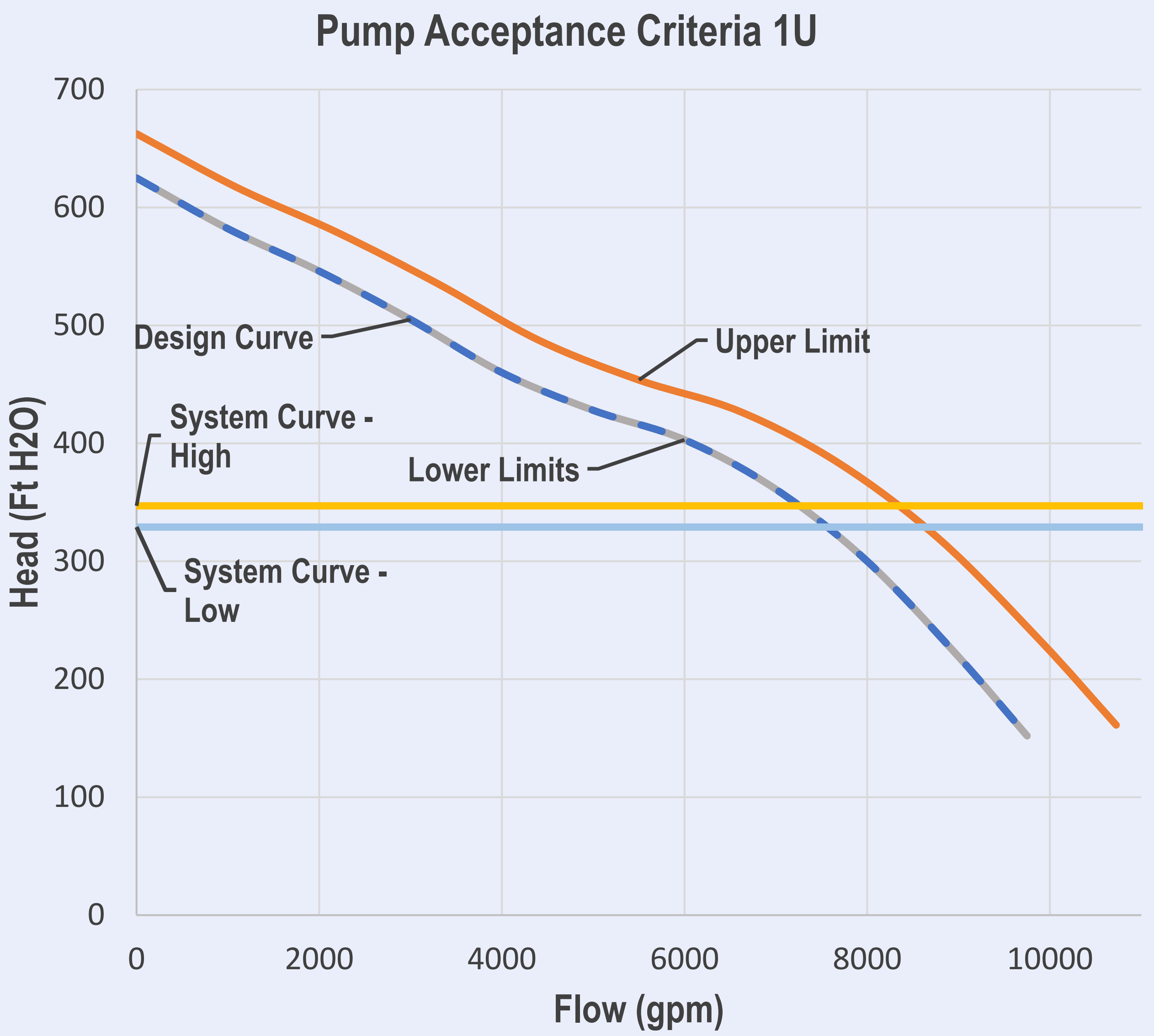

Specifying Large Vertical Turbine Pumps

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Efficiency[b]		t_η (%)	− 3%	− 0%	− 0%	− 5%	− 5%	− 7%

Testing and Inspection

Qty	Description
1	**Testing and Inspection**
	Performance Testing Details
	Test Acceptance Criteria: ANSI/HI 14.6 Grade 1U
	Test Tolerance: Flow = -0/+10%, Head = -0/+6%, Power = -0/+10%, Efficiency -0/+0%
	Performance Test Options
	Complete Unit Test With Job Driver - 1 units

Capacity	: 7150.0 USgpm
Head	: 350.00 ft
Density / Specific gravity	: - / 1.000
Pump speed	: 1780 rpm
Ns / Nss	: - / 11810 (US units)
Test tolerance	: ANSI/HI 14.6 Grade 1B

Take Away: Incorrect tolerances can cause underperformance, incorrect pump submission, or system damage

NSF 61 Compliance vs. Certification

NSF 61: *Drinking Water System Components*

Primarily focused on materials in contact with water

NSF 61 COMPLIANCE

- (OAR) 333-061-0050
- Designed for potable water
- All components meet NSF 61

NSF 61 CERTIFICATION

- Applies to pump assembly
- 3rd party certification
- Limits available pumps and features
- Must use spare parts matching original certification

NSF 61 Compliance vs. Certification

NSF 61: *Drinking Water System Components*

Primarily focused on materials in contact with water

NSF 61 COMPLIANCE

	OEM	OEM Alt Parts	3RD PARTY
Pump Internals	✓	✓	✓
Motor, shaft coupling, etc.	✓	✓	✓

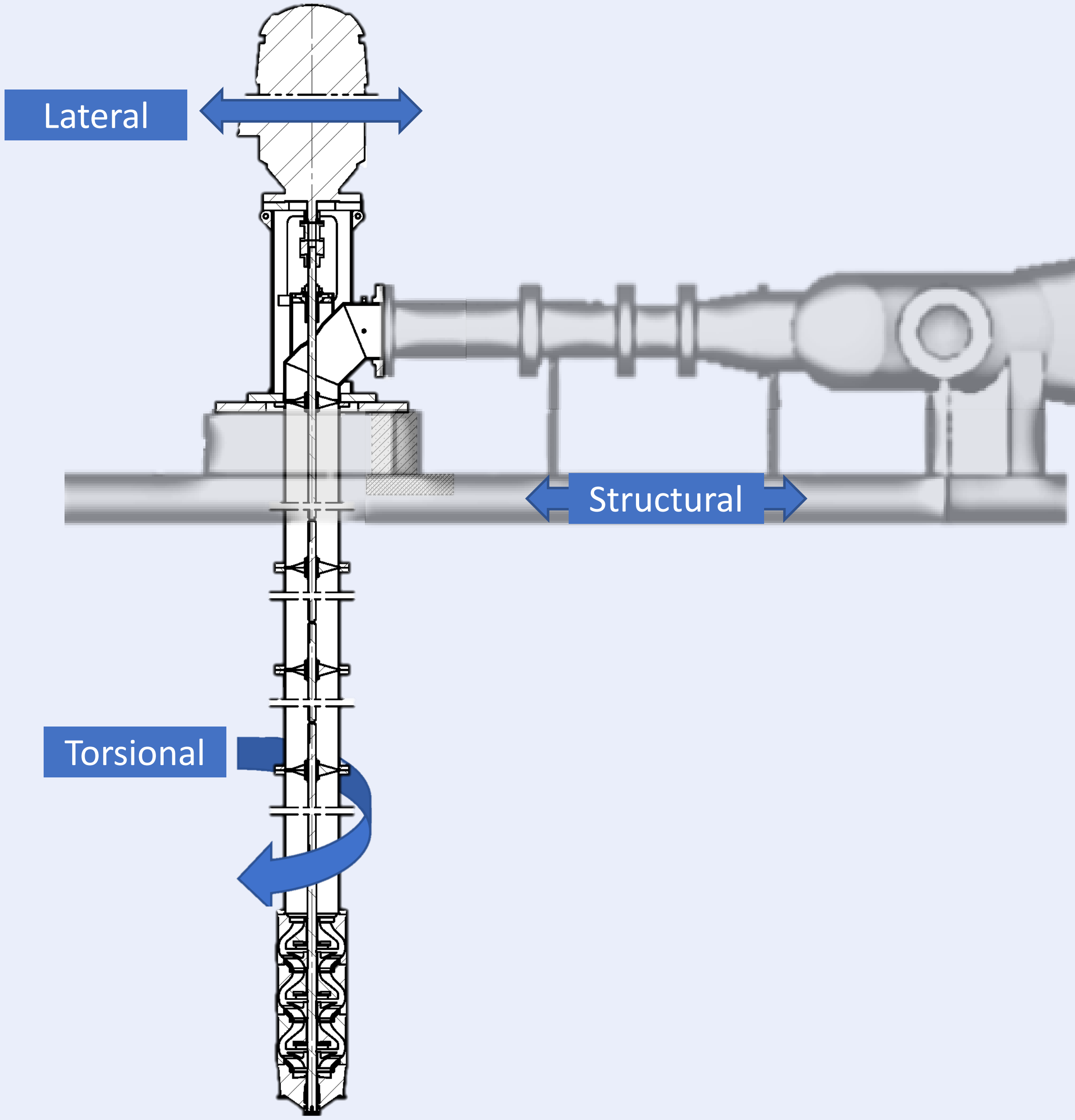
NSF 61 CERTIFICATION

	OEM	OEM Alt Parts	3RD PARTY
Pump Internals	✓	☐	☐
Motor, shaft coupling, etc.	✓	✓	✓

Vibration Analysis

ANSI/HI 9.6.8: Lateral Rotodynamic, Torsional Rotordynamic and Structural Analyses

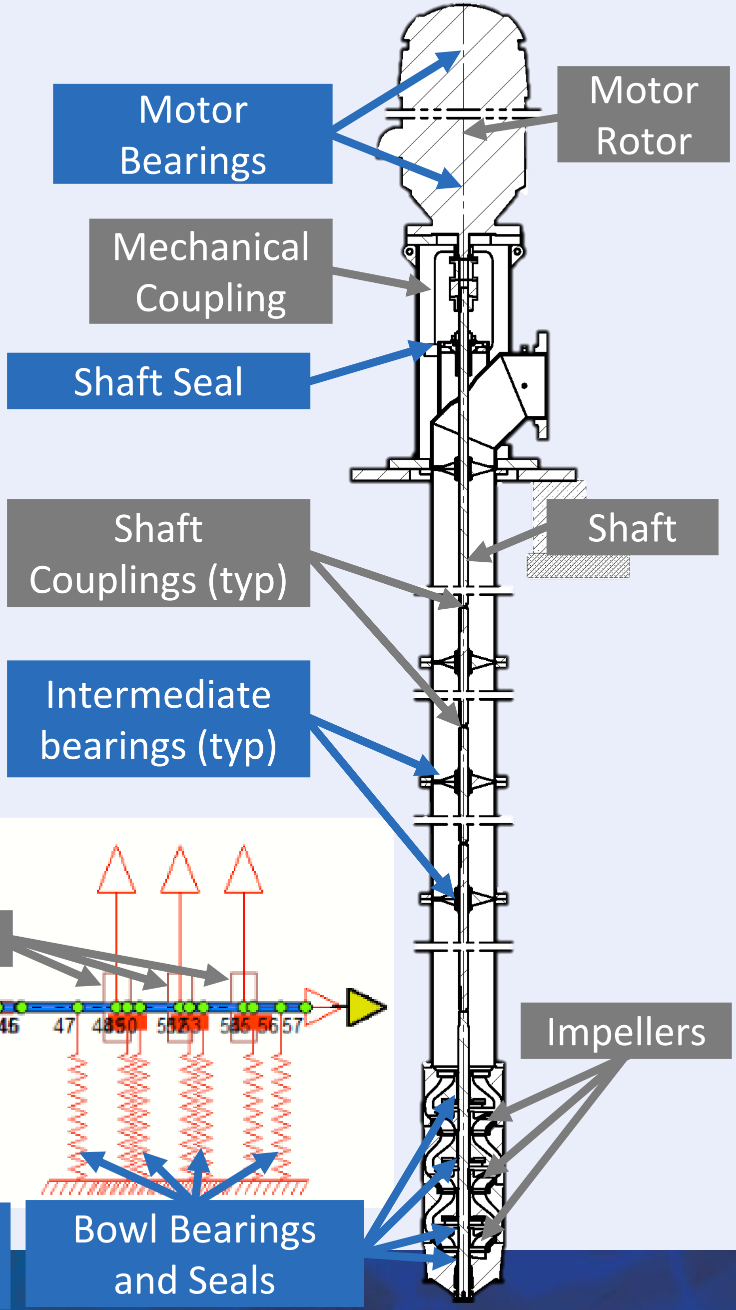
- Performing these analyses reduce the risk of vibration and reliability problems

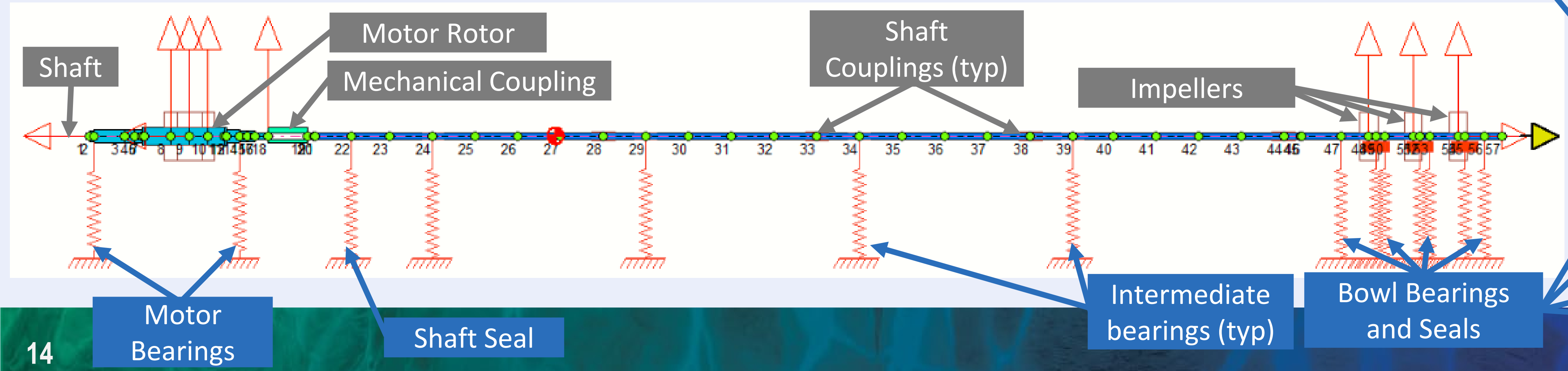


Lateral Rotodynamic Analysis

Lateral Vibration related issues:

- Accelerated wear at wear rings
- Rubs at internal clearance locations
- Accelerated bearing wear
- Excitation of critical frequencies





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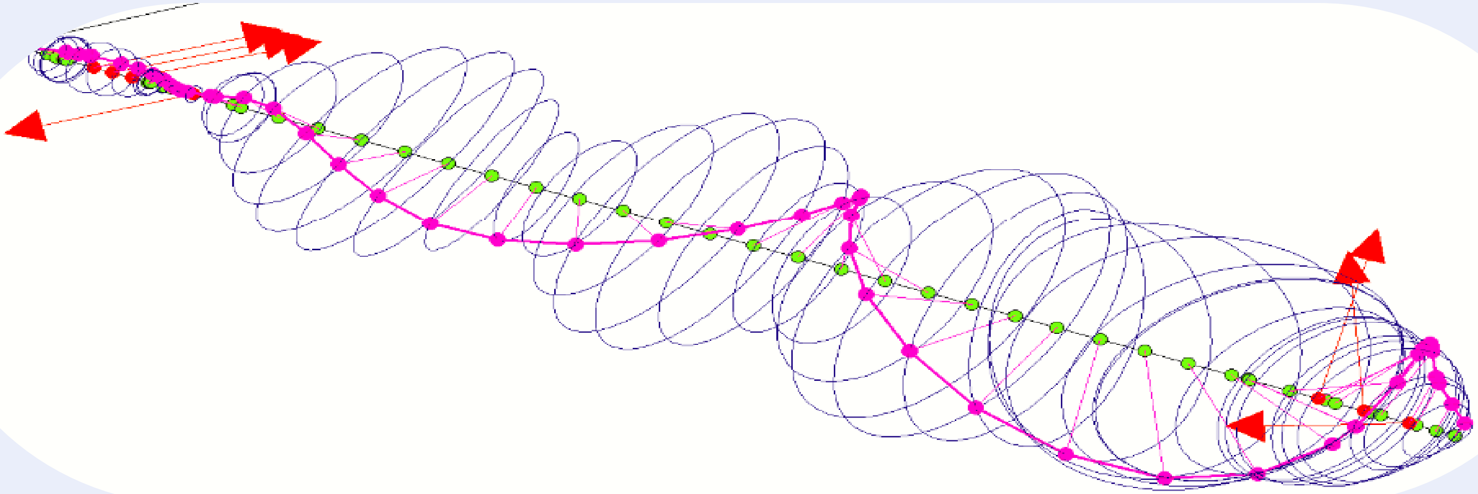


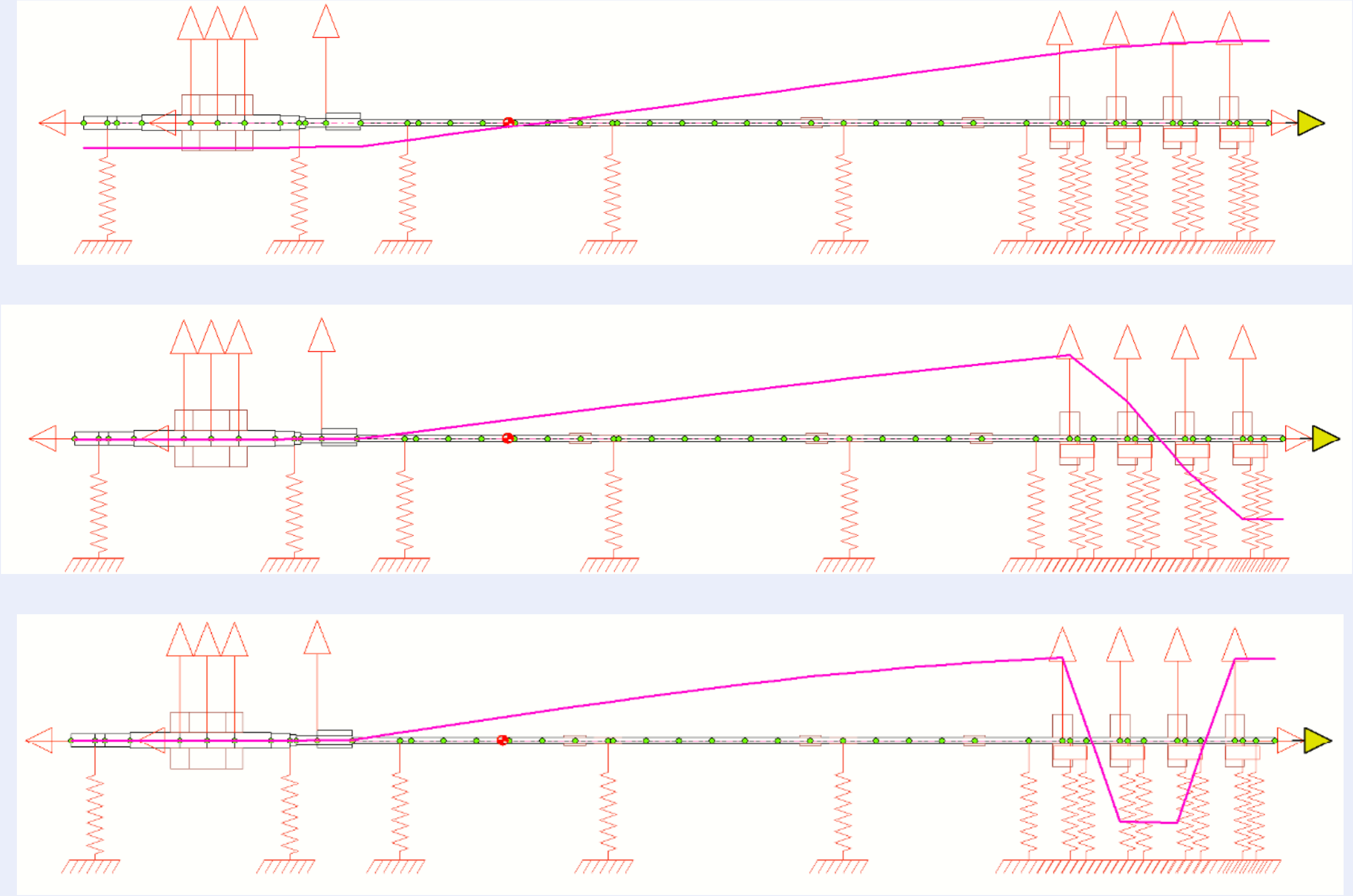
Torsional Rotordynamic Analysis

Torsional Vibration related issues:

- Damaged couplings
- Gear wear, noise
- Shaft fatigue or failure

Torsional Analysis

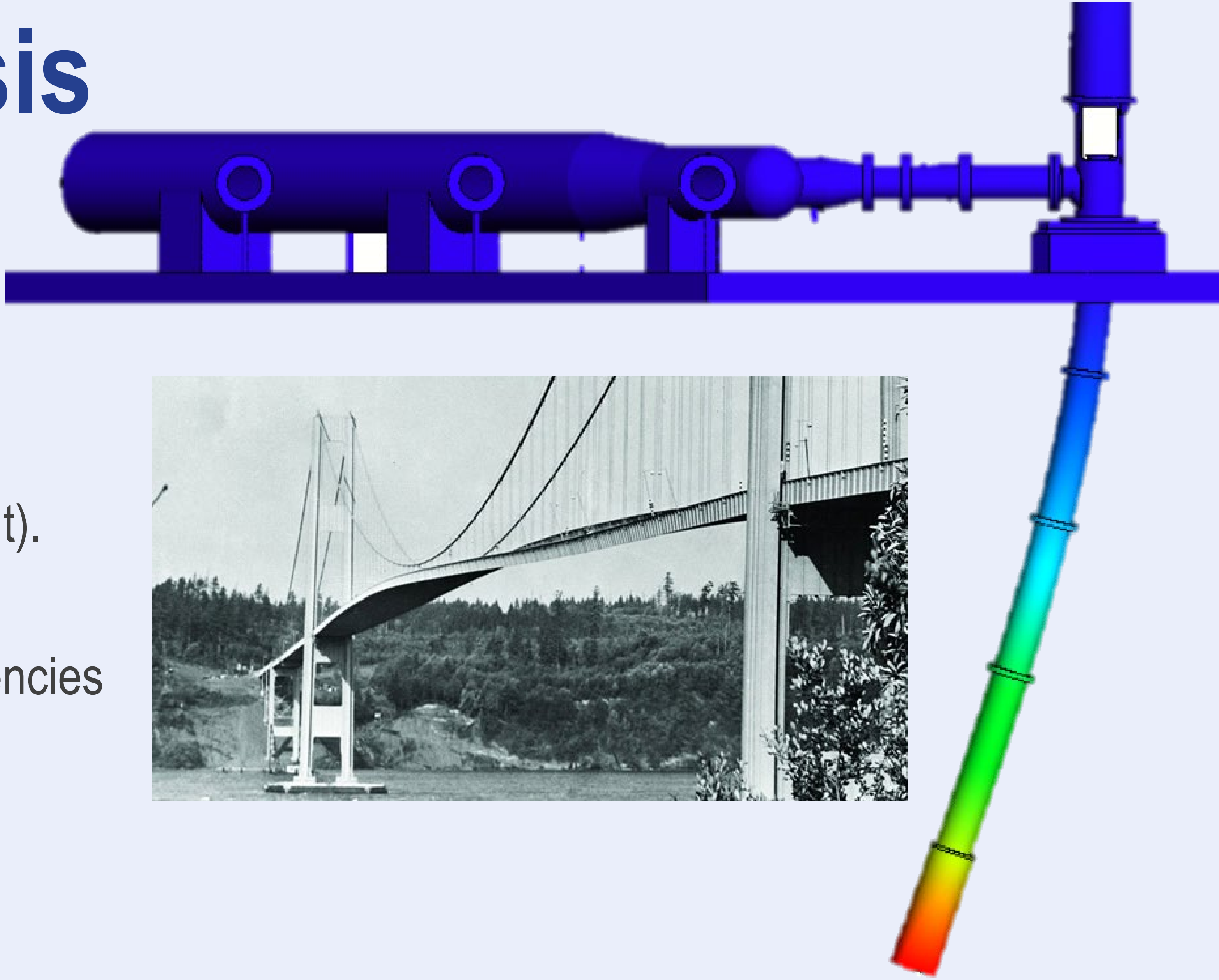
- Performed on the *complete train* (pump, driver, couplings, and gears)



Structural Analysis

Structural Analysis

- Performed to *non-rotating portions of the pump and system* to provide reasonable assurance that structural natural frequencies will not be close enough to typical excitations (resonant).
  - Determine reed frequency
  - Identify and ideally shift any frequencies within the pump operating range
  - Keep structure stiffness in mind

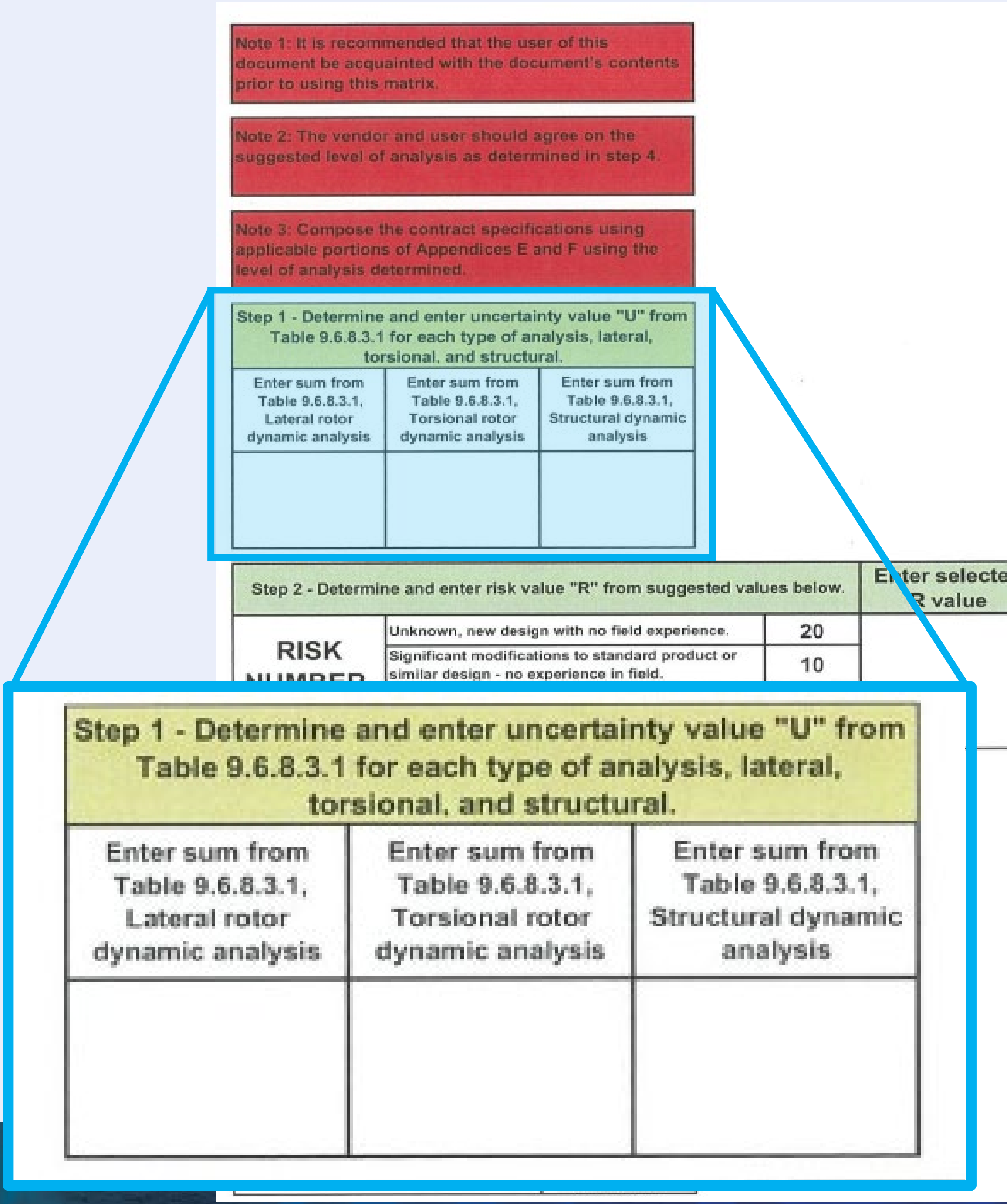


Requirements for Vibration Analysis

ANSI/HI 9.6.8: Lateral Rotodynamic, torsional rotordynamic and structural analysis

Rotodynamic Pumps – Guideline for Dynamics of Pumping Machinery:

- Damaged couplings
- Gear wear, noise
- Shaft fatigue or failure



Note 1: It is recommended that the user of this document be acquainted with the document's contents prior to using this matrix.

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Note 3: Compose the contract specifications using applicable portions of Appendices E and F using the level of analysis determined.

Step 1 - Determine and enter uncertainty value "U" from Table 9.6.8.3.1 for each type of analysis, lateral, torsional, and structural.		
Enter sum from Table 9.6.8.3.1, Lateral rotor dynamic analysis	Enter sum from Table 9.6.8.3.1, Torsional rotor dynamic analysis	Enter sum from Table 9.6.8.3.1, Structural dynamic analysis

Step 2 - Determine and enter risk value "R" from suggested values below.			Enter selected R value
RISK NUMBER	Unknown, new design with no field experience.	20	
	Significant modifications to standard product or similar design - no experience in field.	10	

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Requirements for Vibration Analysis

Type VS Pumps	Maximum speed > 3800 rpm, U = 2 Specific gravity < 0.7, U = 2 Fly wheel driven, U = 2 Drive shaft driven, U = 2 Variable speed driven, U = 2 Power > 30 kW (40 bhp) and < 375 kW (500 bhp), U = 1 Power > 375 kW (500 bhp) and < 750 kW (1000 bhp), U = 2 Power > 750 kW (1000 bhp), U = 3 No. of vanes = 3 or fewer, U = 3
	System Configuration Total U ______ (Sum)

NOTE: In the case of VFDs, the uncertainty can be reduced substan monic frequencies to distortion is low, e.g., less than 1.0%.

Table 9.6.8.3.1 — Uncertainty values

Pump Type	Lateral Rotordynamic Analysis	Torsional Rotordynamic Analysis	Structural Dynamic Analysis
Types OH & BB Pumps with Rigid Rotor Designs	Maximum speed > 3800 rpm, U = 2 Fly wheel driven, U = 2 Drive shaft driven, U = 2 Variable speed driven, U = 2 Power > 30 kW (40 bhp) and < 375 kW (500 bhp), U = 1 Power > 375 kW (500 bhp) and < 750 kW (1000 bhp), U = 2 Power > 750 kW (1000 bhp), U = 3 No. of vanes = 3 or fewer, U = 3	Trains with three or more elements, U = 1 Synchronous motor driven, U = 2 Fly wheel driven, U = 2 Drive shaft driven, U = 2 Internal combustion engine driven, U = 2 Variable speed driven, U = 3 Power > 30 kW (40 bhp) and < 375 kW (500 bhp), U = 1 Power > 375 kW (500 bhp) and < 750 kW (1000 bhp), U = 2 Power > 1000 bhp, U = 3	Flexible foundations, U = 1 Variable speed driven, U = 3 Power > 30 kW (40 bhp) and < 375 kW (500 bhp), U = 1 Power > 375 kW (500 bhp) and < 750 kW (1000 bhp), U = 2 Power > 750 kW (1000 bhp), U = 3 No. of vanes = 3 or fewer, U = 3 NOTE: For vertically oriented OH & BB pump types, use type VS pump values.
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	...eed > 3800 rpm, U = 2	Trains with three or more elements, U = 1	Drivers supported separately, U = 1

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Requirements for Vibration Analysis

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RISK NUMBER, R	Unknown, new design with no field experience.	20	
	Significant modifications to standard product or similar design - no experience in field.	10	
	Minor modifications to standard product or similar design proven in field.	4	
	Identical or standard product, proven field history.	2	

Step 3 - Multiply the "R" values from step 2 times the risk value "U" selected in step 1 for each type of analysis. These are the "RUN" values.		
Lateral	Torsional	Structural
Products of R x U, or RUN numbers		

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	Minor modifications to standard product or similar design proven in field.	4	
	Identical or standard product, proven field history.	2	

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Lateral	Torsional	Structural
Products of R x U, or RUN numbers		

Step 4 - Using the calculated "RUN" value from step 3 for each analysis type (lateral, torsional, or structural), determine the suggested level of analysis for each type of analysis from the guidelines below.	
RUN value from step 3	Suggested level of analysis
≤ 15	None Required
> 15, ≤ 20	Level 1
> 20, ≤ 50	Level 2
> 50, ≤ 160	Level 3
> 160	Level 3 +Validation*

Requirements for Vibration Analysis

Step 4 - Using the calculated "RUN" value from step 3 for each analysis type (lateral, torsional, or structural), determine the suggested level of analysis for each type of analysis from the guidelines below.	
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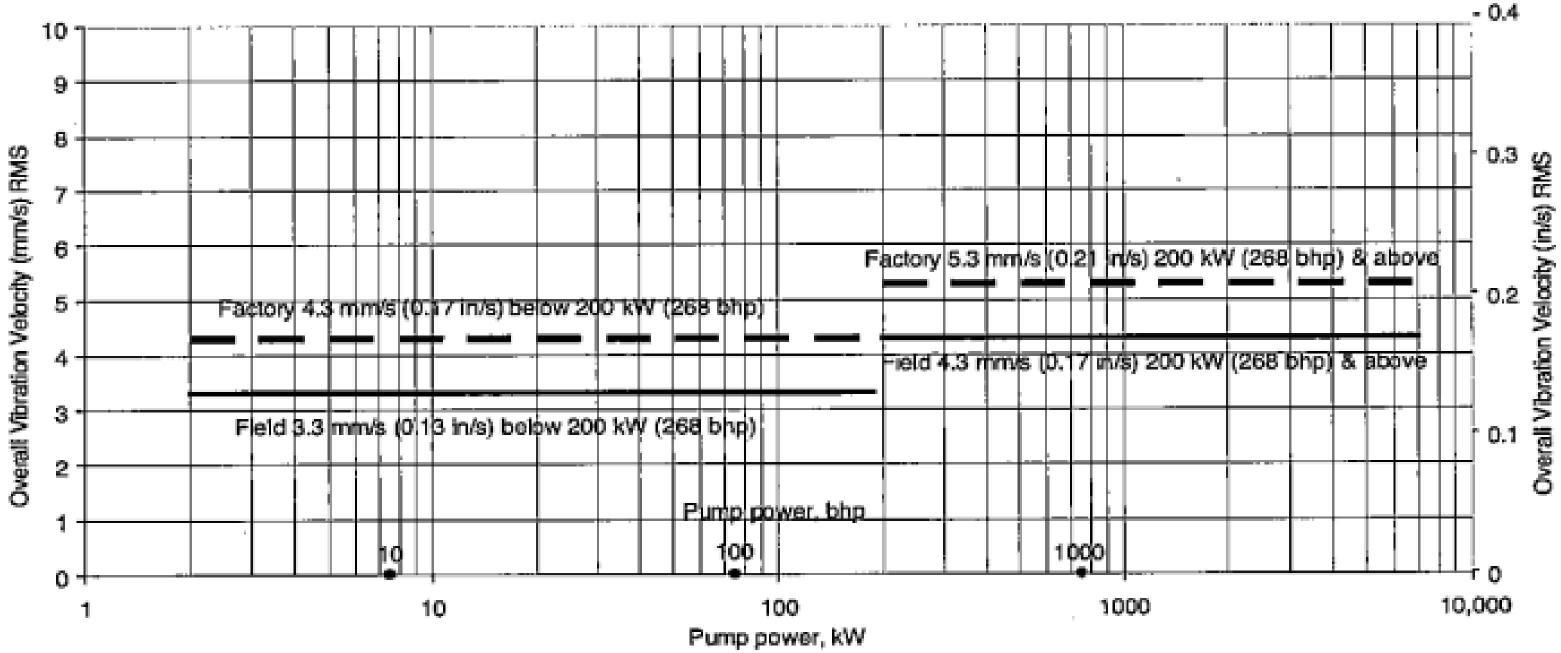
Vibration Testing and Measurement

ANSI/HI 9.6.4



Application notes:

1) The factory criteria are applicable for new pumps with either a factory or new motor. The field criteria are intended for use when both the pump and motor are in new condition.
2) For operation outside the POR but within the allowable operating region (AOR), increase the values shown by 30%.
3) For solids-handling versions of VS pump types, increase the values for AOR and POR, respectively, by 50% (tested free of clogging conditions).
4) Pump types refer to Figure 9.6.4.2.3.1.
5) Allowable pump values are based on historic data and, as more test data become available, limits will be subject to change.

Figure 9.6.4.2.5.1b — Allowable pump vibration, pump types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8 (For a more complete description of pump types, refer to ANSI/HI 1.1-1.2 and ANSI/HI 2.1-2.2.)

Electrical and I&C Requirements

NEMA MG-1 vs VFD Rated

Safety factors, starting conditions, and limitations

Shaft Grounding Rings

Bearing damage due to induced current

Motor lubrication

Grease vs oil

Instrumentation and Controls

Temperature, load, and vibration monitoring

Case Study | JWC Water Treatment Plant

Current Pump Stations			
FWPS NAME	**FIRM CAPACITY (MGD)**	**TOTAL CAPACITY (MGD)**	**NOTES**
FWPS #1	36	46	Firm Capacity assumes largest pump is out of service
FWPS #2	25.9	38.9	Firm Capacity assumes largest pump is out of service
Total FWPS #1 and #2	61.9	84.9	Current Capacities


US MOTORS

Closing Remarks

- Large Pumps (200+ HP) have unique considerations
- Standards such as NSF 61, HI 9.6.8, and NEMA MG-1 provide lot of specific guidance
- Still require detailed conversations with both manufacturers and clients
- Leverage those

THANK YOU

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