RUHRPUMPEN

Specialist for Pumping Technology







Session 31 –

Comparison of API610 12th and 11th Editions (2)

Simon Smith March 2024

Presenter Profile – Simon Smith

Simon graduated with an honours degree in Chemical Engineering from the University of Surrey in 1978 and began a long career in the engineered pump industry spanning 43 years (so far!) with Peerless Pump, BW/IP International / Flowserve, SPP Pumps, Ruhrpumpen and Ebara Cryodynamics.

Over his long career he has filled various roles as Applications Engineer / Manager, Project Manager, Key Account Specialist, Vertical Pump Product Specialist, International Sales Engineer / Manager / Director and he has considerable experience in Training & Mentoring young engineers.

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Here is a listing of all the previous courses.

- No 1 – API610 12th v 11th editions
- No 2 - Curve Shape (1)
- No 3 – The Importance of System Curves (1)
- No 4 - Selecting the Right Pump for the Application
- No 5 - NPSH & Nss
- No 6 - Mechanical Seals & Systems (1)
- No 7 - Firepumps
- No 8 - BB5 Barrel Pumps
- No 9 - Pump Instrumentation
- No 10 – Non-Destructive Examination
- No 11 - Vertical Pumps (Part 1) Type VS1, VS2, VS3
- No 12 – Vertical Pumps (Part 2) Type VS4, VS5, VS6 & VS7
- No 13 – Performance Testing of Centrifugal Pumps; the What, the Why & the How
- No 14 – Testing & Inspection of API 610 Pumps
- No 15 – Start-Up, Commissioning & Troubleshooting Centrifugal Pumps
- No 16 – Introduction to Positive Displacement (Plunger) Pumps
- No 17 – Refresher Session
- No 18 – Overhung Process Pumps OH1 & OH2

Continued next slide

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- No 21 – BB4 Multistage Pumps for the Power Industry
- No 22 – Coking Process and Hydraulic Decoking Equipment
- No 23 – Pumps for the Desalination Market
- No 24 – Cryogenic Pumps
- No 25 – Magnetic Drive Pumps
- No 26 – Mechanical Seals & Systems (2)
- No 27 – The Importance of System Curves (2)
- No 28 – NPSH & Nss Made Simple (2)
- No 29 – Curve Shape, Head Rise & Allowable Tolerances (2)
- No 30 – Selecting the Right Pump for the Application (2)

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SHORT COURSE 12

Vertical Pumps (VS4/5, VS6, VS7)

Full session.

Downloads. (14.73 MB)

SHORT COURSE 13

Performance Testing and Inspection of API 610 Pumps

Full session.

Downloads. (4.58 MB)

SHORT COURSE 14

Performance Testing and Inspection of API 610 Pumps

Full session.

Downloads. (7.30 MB)

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Full session.

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SHORT COURSE 15

Start-Up, Commissioning & Troubleshooting Centrifugal Pumps

Full session.

Downloads. (6.14 MB)

SHORT COURSE 16

Introduction to Positive Displacement (Plunger) Pumps

Session part 1.

Session Part 2.

Downloads. (10.50 MB)

Session 30 –
“Comparison of API610 12th and 11th Editions”

API 610 12th Edition has been around for a couple of years now and is being referenced in more and more end user/client specifications
The session will look at the KEY FEATURES of, & MAJOR CHANGES between 12th & 11th Editions of API610.
Aimed at Process and Mechanical Engineers and Consultant Engineers specifying pumping equipment as well as Applications & Sales Engineers selecting and quoting them.

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Synopsis of API 610, 12th Edition (Major changes wrt 11th Edition)

API 610, the standard specifies requirements for Centrifugal Pumps, including pumps running in reverse as hydraulic power recovery turbines (HPRTs), for use in petroleum, petrochemical, and gas industry process services. Latest 12th Edition was released in January, 2021 (3 years ago).

Key features and major changes of 12th edition, are highlighted in this write up with the objective to support Pump professionals with quick overview who already know about the API 610, 11th edition, which is 10 years old. Deliberately, I have avoided to discuss on interpretation, implications and effect of these changes to the OEM or Purchaser. This is not a complete highlight of 12th edition. You may not find many fundamental and important recommendations in this article, if those are the same as 11th edition. Reference of API section is provided in parenthesis. Of course, this list is selective, not exhaustive.

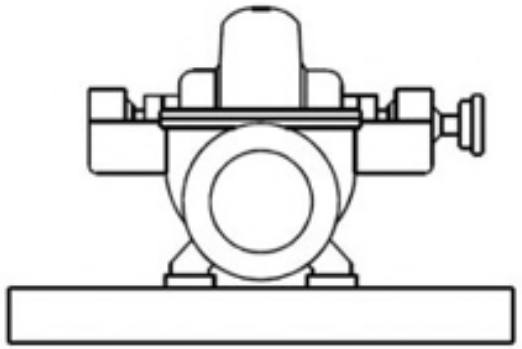
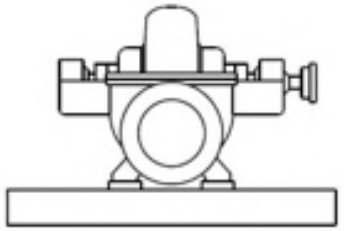
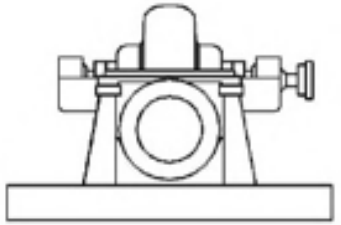
Acknowledgements
Thanks are due to the following who contributed to the content of this presentation.
Kirit Domadiya – Sundyne Pumps
Simon Bradshaw - Trillium

Basic Overview

Section	API 610 11th Edition	API 610 12th Edition
TOC	Total 10 Main sections + Annexures from A to O	Total 10 Main Sections + Annexures from A to O
Additional annexure	Annex O: API regional annexure	Figure N3: Data list, provide summary of all the field of APIdatasheet with page number reference
		Annex O: (informative) Special-purpose Centrifugal Pumps.
Released in	September 2010	January 2021
Total Pages	205	223

Acronyms and Abbreviations are provided with around 60 items (*Ref. 3.2*)

Pump Classification (Ref 4.2 Table 1)

API 610 11th Edition	API 610 12th Edition
One or Two stage, Axial split between bearing pump is called BB1  Figure 7 — Pump type BB1	BB1 is with two variants. Foot mounted → BB1-A Near centerline mounted → BB1-B  a) Pump Type BB1-A "Foot Mounted"  b) Pump Type BB1-B "Near-centerline Mounted"

Basic Design & Selection (Ref 6.1)

No major changes in the 12th edition as far as core design features of pump is concerned. Additional requirement focusing on improved equipment reliability are addressed below. Requirement of field proven record and API 691 is introduced

Section	API 610, 11th edition	API 610, 12th edition, different or additional requirement
Reliability concept	Shall be designed and constructed of 20 years and at least 3 years of uninterrupted operation.	Only equipment that is field proven, as defined by the Purchaser, is acceptable, API 691 can provide guidance on this. In the event no such equipment is available, the vendor shall submit an explanation of how their proposed equipment can be considered field proven.
		The vendor shall advise in the proposal any component designed for a finite life.
		The purchaser shall specify if equipment will be supplied in accordance with API 691.
Parallel Operation		Additional recommendations: the head values of the pumps at any given flow within the preferred operating range shall be within 3% of each other for pumps larger than 3 in. (80 mm) discharge.
Curve Shape		Pumps with a continuously rising head curve are preferred for all applications, but this is not possible with all pump types. Head curve shape is dependent on several factors specific to the pumps hydraulic design.
End of curve	Not mentioned	The “end of curve flow” is defined as 120% of the BEP flowrate.
Viscosity correction	performance corrected in accordance with ISO/TR 17766	performance corrected in accordance with HI 9.6.7. Both the standards are equivalent.
Site Performance	Not covered	Provision for vendor to witness site alignment

API 691 Extract

1.1 General

1.1.1 This recommended practice defines the minimum requirements for the management of health, safety, and environmental (HSE) risks across the machinery life cycle. It shall be applied to the subset of operating company and/or vendor defined high-risk machinery.

1.1.2 Unless otherwise specified, the following criteria shall be used for initial risk screening to identify potential high-risk machinery for which this recommended practice will be applied:

a) hazardous gas or liquid services as defined by jurisdiction, appropriate regulatory body, and/or operating company standards or specifications,

b) services operating at temperatures >350 °F (177 °C) and having design or specified off design operating pressures >80 % maximum allowable working pressure (MAWP),

c) services operating at temperatures >400 °F (204 °C),

d) components and subcomponents having technology readiness levels (TRLs) < 7 whose failure may lead to a loss of containment and/or a loss of functionality that could lead to a potential process safety event (see Table 1),

e) liquid services operating at pressures in excess of 600 psig (41.4 bar),

f) liquid services having specific gravities less than 0.5.

API 691 Extract

It is acknowledged that most operating companies and vendors may have existing risk management processes. This recommended practice is not written to replace or invalidate company practices but is meant to supplement them to provide safe working and living environments for facilities and surrounding communities. Operating companies (i.e. Sections 5, 6, 7, and 8 for design, installation, and operating purposes) or vendors [i.e. in Section 4 for research and development (R&D) and product development purposes] can use their own initial risk screening criteria where these have been found to be effective or the criteria recommended above.

NOTE 1 Typically only between 10 % and 20 % of machinery falling within any given initial risk screening will be considered API 691 Machinery. This can include a subset of "critical," "unspared," "special purpose," "prototype," and/or worst actor machinery. Risks can include loss of containment of hazardous fluids, loss of functionality, high energy releases, etc.

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Site Performance	Not covered	Provision for vendor to witness site alignment

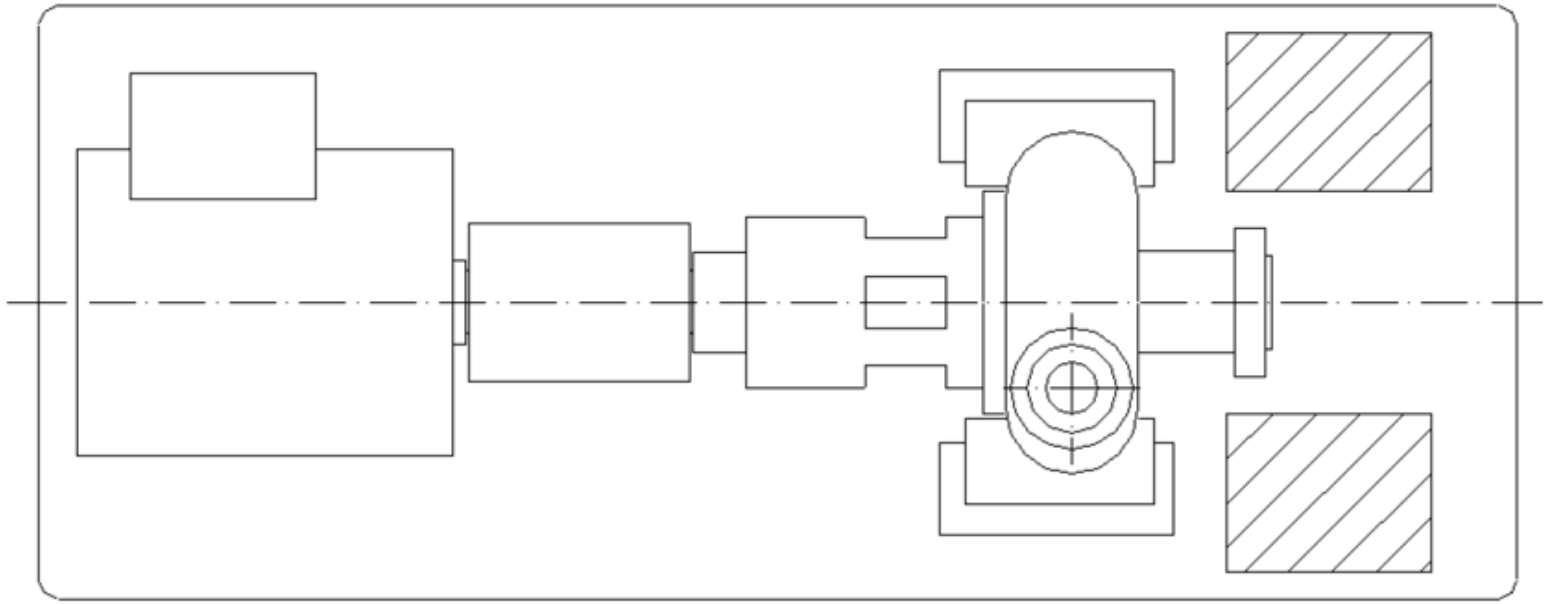
Accessories (Ref 7)

Accessories	Changes or additional points in 12th edition
Coupling	Flexible elements shall be non-lubricated metal type of corrosion-resistant material.
	If specified, major coupling components shall be balanced in accordance with ISO 21940-11, to the balance grade specified by the purchaser. According to 11th edition it is ISO 1940-11, grade G6.3
Guard	Separate sub-section is available on Guard.
Coupling Guard	Unless otherwise specified, guards between drivers and driven equipment and between the bearing housing and seal gland shall be supplied and mounted by the vendor with unit responsibility.
Shaft Guard (New concept)	Exposed shaft areas including the area between pump bearing housing(s) and mechanical seal(s) shall have a shaft guard. The guard shall meet the following requirements: a) prevent personnel from contacting moving parts during operation of the pump; allowable opening dimensions shall comply with specified standards, such as EN 953 or ISO 14120; b) sufficiently vented to prevent the accumulation of seal emissions, liquid, or vapor; c) allow visual inspection of the seal without removal of guard; d) constructed of steel, stainless steel, brass, or aluminum materials, as suitable; e) fabricated from sheet (solid or perforated), plate, expanded metal, or woven wire and securely fastened to the pump.

Baseplates

Accessories	Changes or additional points in 12th edition
Base Plate	Single-piece baseplates designed for grouting shall be furnished for horizontal pumps. The purchaser shall specify the type and options as follows: a) Flat deck plate with a sloped gutter drain, b) Sloped full deck plate c) Sloped partial deck plate, d) Open deck version of the above with no deck/top plate e) Non-grouted baseplate of one of the versions above where the baseplate and pedestal support assembly shall be sufficiently rigid to be mounted without a grout fill, f) Non-grouted baseplate as in Item e) with a gimbal mount, three-point mount, anti-vibration mount (AVM) spring mount, or other type of mount.
	Baseplates for OH2 pumps shall have nothing (auxiliaries or seal flush plan) mounted beside or above the coupling or bearing housing. If the seal flush plan and/or auxiliaries are specified to be mounted on the baseplate, the increased length standard baseplate shall be used and the auxiliaries and/or seal flush plan shall be mounted adjacent to the suction nozzle (see Figure 40).

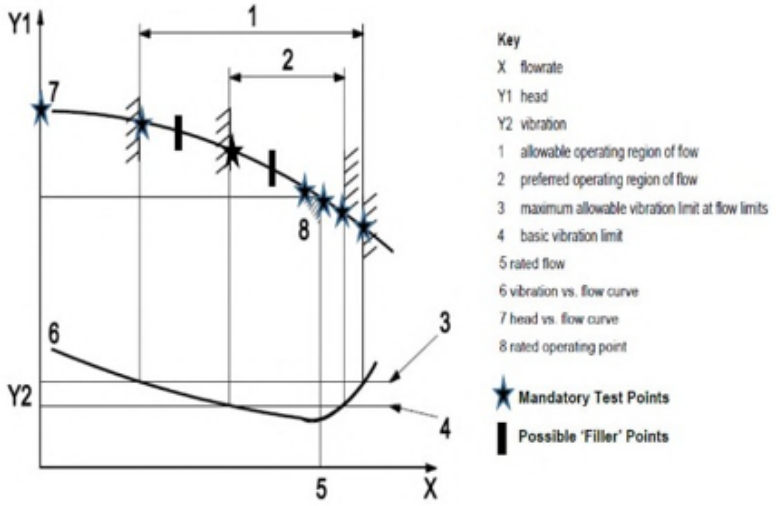
Baseplates (contd)

Accessories	Changes or additional points in 12th edition
Base Plate	
	Annexure D : Base plate numbers are 2.5 to 12 whereas 11th edition have 0.5 to 12 (the 3 smallest sizes deleted)

Accessories (contd)

Accessories	Changes or additional points in 12th edition
Vertical Pump Driver	12th edition: Shaft-to-driver mating face perpendicularity and surface flatness. 0.002 in./ft (0.17mm/m) 11th edition: Shaft-to-driver mating face perpendicularity and surface flatness. 25 µm TIR
Piping and Appurtenances	12th edition: Piping shall be in accordance with API 614, API 682 and this standard. API 682 and this standard take precedence in case of conflicts with API 614. 11th edition: Piping shall be in accordance with ISO 10438.
Instrumentation	12th edition: Accordance with API 614 11th edition: Accordance with ISO 10438

Pump Performance (Ref 8.3)

Section	API 610, 11th edition	API 610, 12th edition, difference or additions
Performance and NPSH test standard	ISO 9906, Grade 1. ANSI/HI 1.6 - Centrifugal pump, ANSI/HI 2.6 for vertical pump	HI 14.6 (ISO 9906), Grade 1
Performance test points	1. Shutoff (No vibration data) 2. Minimum continuous stable flow 3. Midway between minimum and rated flow 4. Between 95% and 99% of rated flow 5. Between rated flow and 105% of rated flow 6. Maximum allowable flow (end of allowable operating region)	1. Shutoff (no vibration data required) 2. Minimum continuous stable flow 3. Approx halfway between continuous stable flow and minimum preferred operating flow 4. Minimum preferred operating flow 5. Approx. halfway b/w minimum preferred operating flow and rated flow 6. B/w 95 % and 99 % of rated flow 7. B/w rated flow and 105 % of rated flow 8. End of preferred operating region 9. End of allowable operating region if different from the end of the preferred operating region.  For units with BEP less than 11 m3/h, Point 3) and Point 5) are not required.

Section	API 610, 11th edition	API 610, 12th edition, difference or additions
Site performance recommendations *(Ref 6.1.34)*		Many factors can adversely affect site performance. These factors include such items as piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site. If specified, the vendor's representative shall witness: a) a check of the piping alignment performed by unfastening the major flanged connections of the equipment; b) the initial shaft alignment check at ambient conditions; c) shaft alignment at operating temperature, i.e. hot alignment check
Vertical suspended pumps *(Ref 9.3.2)*		Detail added on suction barrel design (flat, elliptical), fabrication and NDE (RXE) as well as definition of what constitutes pressure casing.

Annexes

- **Material of Construction (*Annexure G and H*)**

  - ✓ Material class I-1, I-2, S-1, and S-3 are completely removed from the selection in annexure H. Minimum material class is now S4. Few minor changes in the material class S.
  - ✓ List of services and operating temperature are also changed in annexure G.
  - ✓ Material class selection for few services is changed as per the annexure G.

- **API Data sheet (*Annexure. N*)**

  - ✓ API data sheet in the 12th edition is almost the same as 11th edition, except minor lay out and cosmetic changes.
  - ✓ Data list is provided after the datasheet annexure, covers all the terms used in the datasheet with its reference page number on this API standard to get additional clarification.
  - ✓ Format of project data sheet is provided to record and communicate on site design data and utility condition.

- **Contract documents and Engineering data (*Annexure. I)***

  - ✓ Vendors data requirement such as contract data, proposal, Drawings and technical data, recommended spares data, manuals etc. is part of the section 10 of API 610, 11th edition. whereas in 12th edition it is covered under the annexure L, Contract documents and Engineering design data.

RP Full Engineering Review

The above has been, as I said at the outset of this presentation, ***not*** an exhaustive review of the differences between 11th & 12th editions.

Key features and major changes to 12th edition, have been highlighted in this write up with the objective to support pump professionals who already know about the API 610, 11th edition, with quick overview.

RP Engineering Dept has carried out an in-depth review to ensure that our pumps will be fully compliant with the revised and new requirements.

This is an extensive very detailed document and is, of course, confidential so regrettably I cannot share it with you.

On the next slide is an extract – 1 page – to give you an indication of the depth to which all pump manufacturers will be going to ensure compliance

RP Full Engineering Review (Extract)

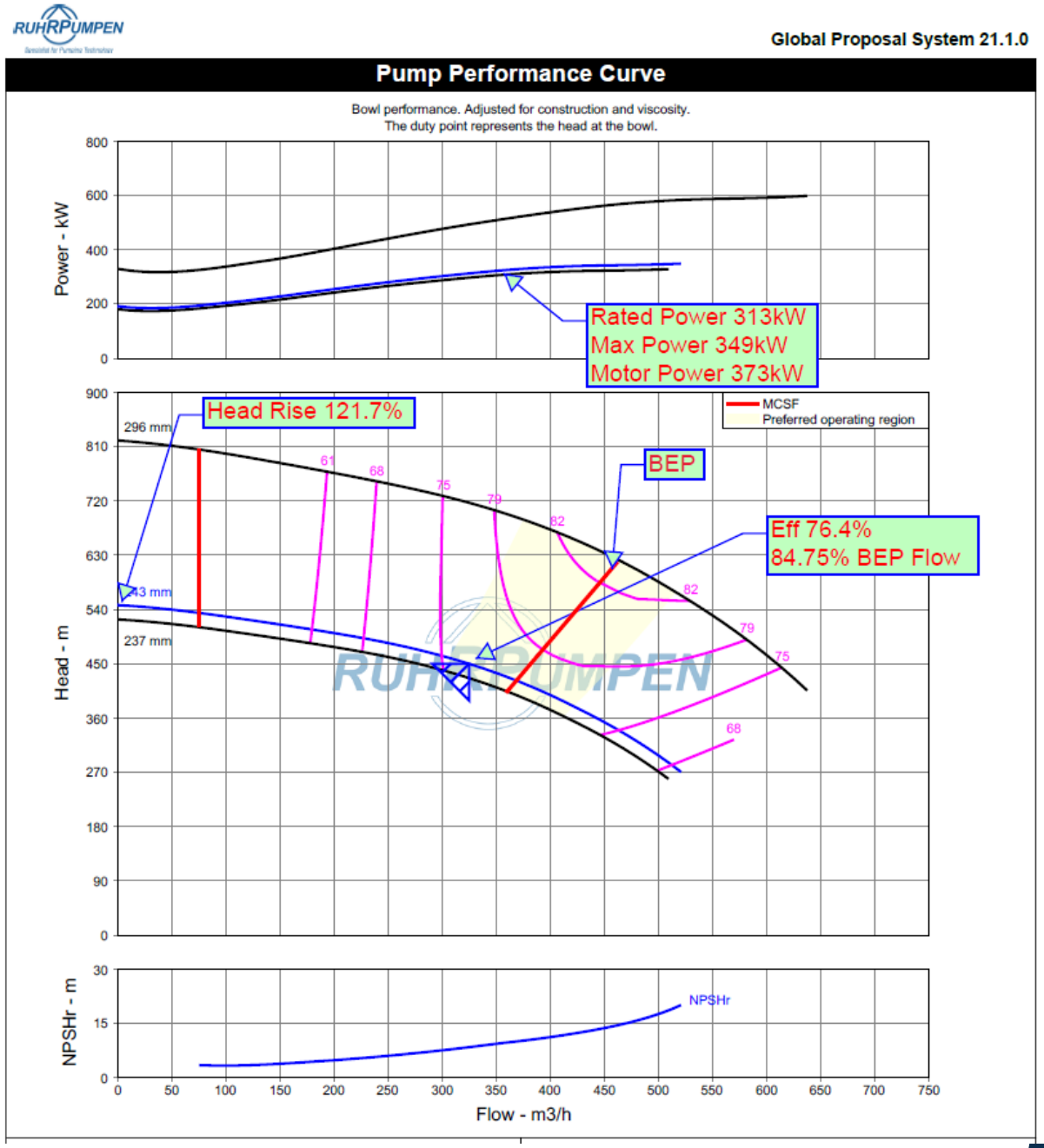
API 610 11th vs API 12th Comparison						
Topic	Section Number	Paragraph	New Value/ Consideration	API 610 11th	Reference Standards	Comments
Basic Design	6	6.1.1	20-year service life has been excluded. Field proven requirement added.	20 years		
Basic Design	6	6.1.2	Components designed for finite life.	NA		
Basic Design	6	6.1.3.1	Purchaser shall specify if equipment is to be supplied in accordance with API 691 - Risk Based Machinery Management	NA	RP 691	
Basic Design	6	6.1.3.2	Requirement for API RP 691. When 6.1.3.1 is specified, Vendors to advise which components are not "Field Qualified"	NA	RP 691	
Basic Design	6	6.1.9	More explanation added about NPSH at 3% head loss (NPSH3) requirement.	NA		
Basic Design	6	6.1.10	More explanation added about NPSHA requirement.	NA		
Basic Design	6	6.1.11	Provision for limit on pump suction-specific speed to be specified	NA		
Basic Design	6	6.1.12	ISO/TR 17766 discarded. ANSI/HI 9.6.7 added.	ISO/TR 17766	ANSI/HI 9.6.7	
Basic Design	6	6.1.13 c)	c) has been added regarding head values in parallel operation.	NA		within 3% of each other
Basic Design	6	6.1.14	Advise if orifice used to ensure continuous rising curve	NA		
Basic Design	6	6.1.20	Formula to calculate clearance has been clearly defined, brackets added.	Without brackets		
Basic Design	6	6.1.27	Minimum temperature criteria added.	NA		
Basic Design	6	6.1.29	More clarity added on electrical classification.	NA		
Basic Design	6	6.1.34	Provision for Witnessing by vendor of factors that can affect site performance.	NA		
Basic Design	6	6.1.37.1	Details of threading shall conform to ASME B1.1, ASME B1.13M, or ISO 261.	ISO 262, ISO 724 and ISO 965		
Basic Design	6	6.1.37.2	Threads shall be UNC for sizes up to 1 in. and 8 UN for sizes greater than 1 in.	NA		
MAWP	6	6.3.9	MAWP of pressure casing for HPRT shall be at least equal to the minimum inlet pressure or the minimum MAWP, whichever is greater.	NA		
Radially Split	6	6.3.12.d	Radially split casing shall be used for services with liquid temperature transients greater than 100 °F (55 °C)	NA		Additional
Radially Split	6	6.3.12.e	Radially split casing shall be used for services with liquid temperature transients which cause metal temperature change rates greater than 5 °F (3 °C) per minute.	NA		Additional
Radially Split	6	6.3.21	If specified, the main casing joint studs and nuts shall be designed for the use of hydraulic bolt tensioning.	NA		
Flanges	6	6.4.2.2.1	Tolerances for flanges OD is specified.	NA	EN 1092-1, Table 22	
Drain	6	6.4.3.7	IOM Must indicate all sections of the casing that can not be drained through the drain connection	N/A		
Auxiliary Connect	6	6.4.3.9	Requirements for socket-welded construction added.	NA		1.5mm gap
Forces and mome	6	6.5	No changes.			
Rotors	6	6.6.9	Shaft shall be single-piece construction.	NA		
Wear Rings	6	6.7.4	Requirements for nonmetallic wear rings added.	NA		
Torsional Analysi	6	6.9.2.1	Figure 29 (Torsional Analysis Decision making Flow Chart) has been updated.	Fig 29		

What API610 Got Wrong!

- *6.1.12 Pumps shall have a preferred operating region of 70 % to 120 % of best efficiency flowrate of the pump as furnished. Rated flow shall be within the region of 80 % to 110 % of the best efficiency flowrate of the pump as furnished.*
- The purpose of it is to get the pump operation close to BEP, where reliability of the pump has been demonstrated to be significantly better and I have no problem with that.
- Here is the central problem. BEP isn't a **single** flowrate but rather a **range** of flowrates that varies depending on how much the pump impeller is trimmed. The example below illustrates the point on a real pump.

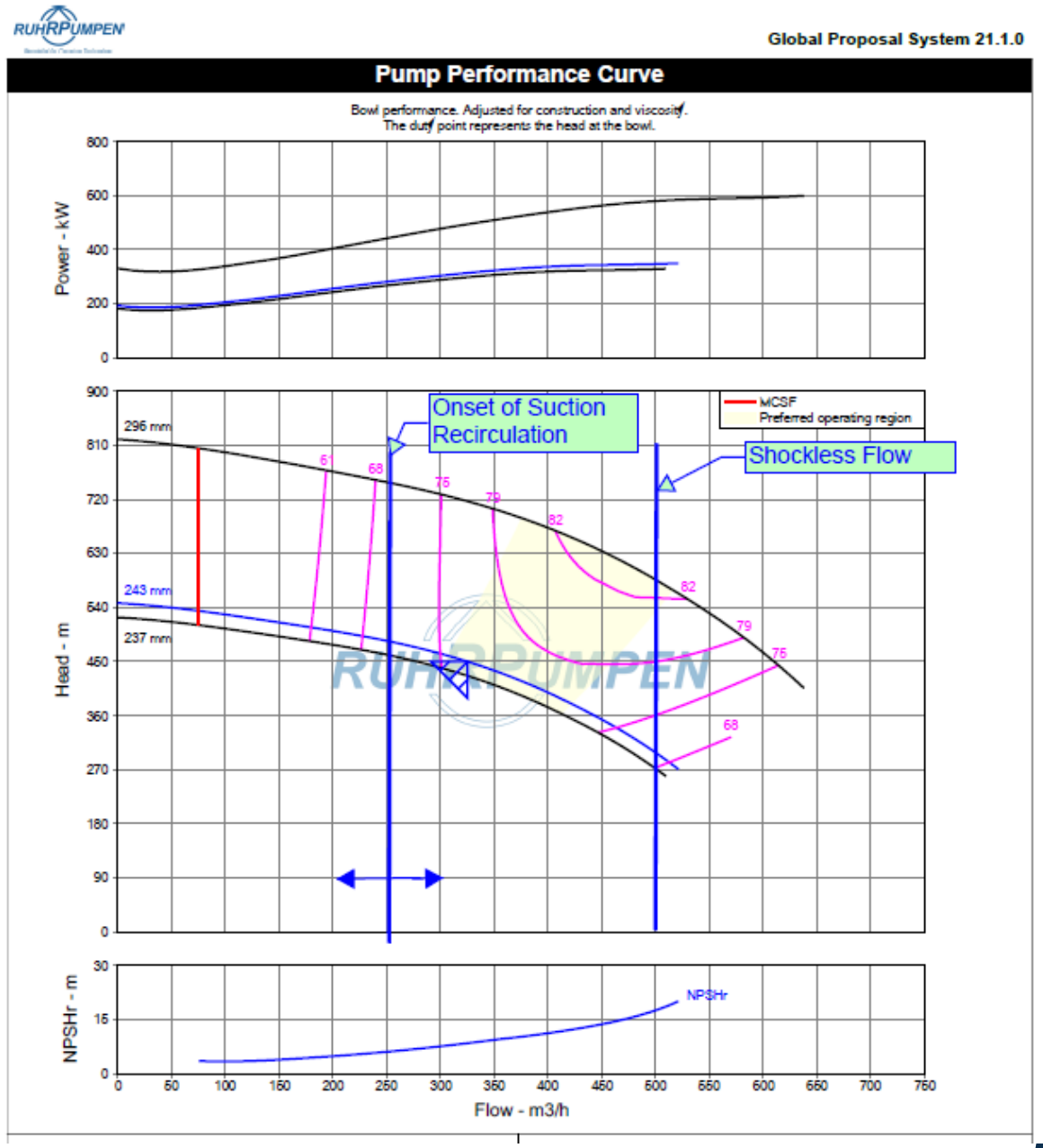
Case Study

- An inexperienced engineer would be tempted to say “That’s an acceptable compliant selection”
  - Head rise 122%
  - 85% of BEP Flow
  - Reasonable efficiency 76.5%
- **BUT HE/SHE WOULD BE WRONG**



Case Study

- Shockless Flow
  - This is the flow rate at which the flow into the impeller impinges on the inlet vanes at the optimum angle. It is normally close to the BEP Flow of the **full diameter** impeller.
  - Trimming the impeller has no impact on the shockless flow rate.
  - Onset of Suction Recirculation is generally around 40-60% of the Shockless Flow rate
  - So the Rated Duty Point might be 85% of BEP Flow for the trimmed impeller but it is at 65% of the Shockless Flow
- This selection is a train wreck waiting to happen



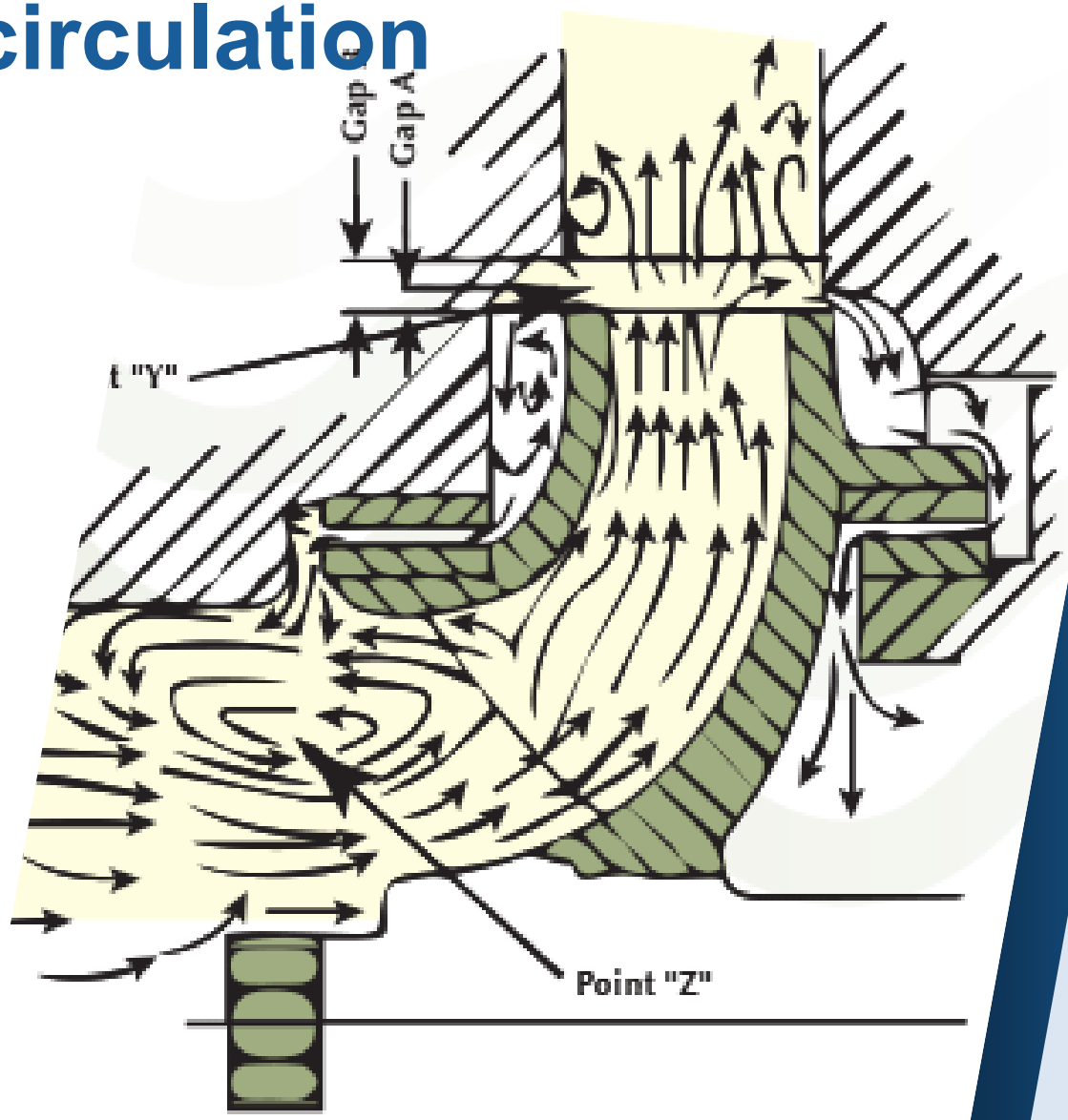
Suction & Discharge Recirculation

A Different kind of Cavitation

Occurs when pumps operate back on the curve from BEP

When two flow paths within a fluid are moving in opposing directions and in close proximity to each other, vortices form.

These vortices result in low pressure areas (where bubbles form) and high pressure areas (where they collapse).



Recirculation vortices at impeller suction eye and at vane tips (sourc
Handbook, Igor J. Karassik and Joseph P. Messina; ISBN-10 007033

What API 610 Got Right!!

- *6.1.13 If parallel operation is specified and the pumps are not individually flow controlled, the following is required:*

  a) the pump head curves shall be continuously rising to shutoff;

  b) the head rise from rated point to shutoff shall be at least 10 %;

  c) the head values of the pumps at any given flow within the preferred operating range shall be within 3 % of each other for pumps larger than 3 in. (80 mm) discharge.

Here is why this is so important.

API Table 16 allows Performance Tolerances +/-3% of TDH at rated flow +/- 5%, 8% or 10% (depending on head) at shutoff.

So without this change two “identical” pumps could easily have a “stronger pump” operating in parallel with a “weaker pump” as illustrated below.

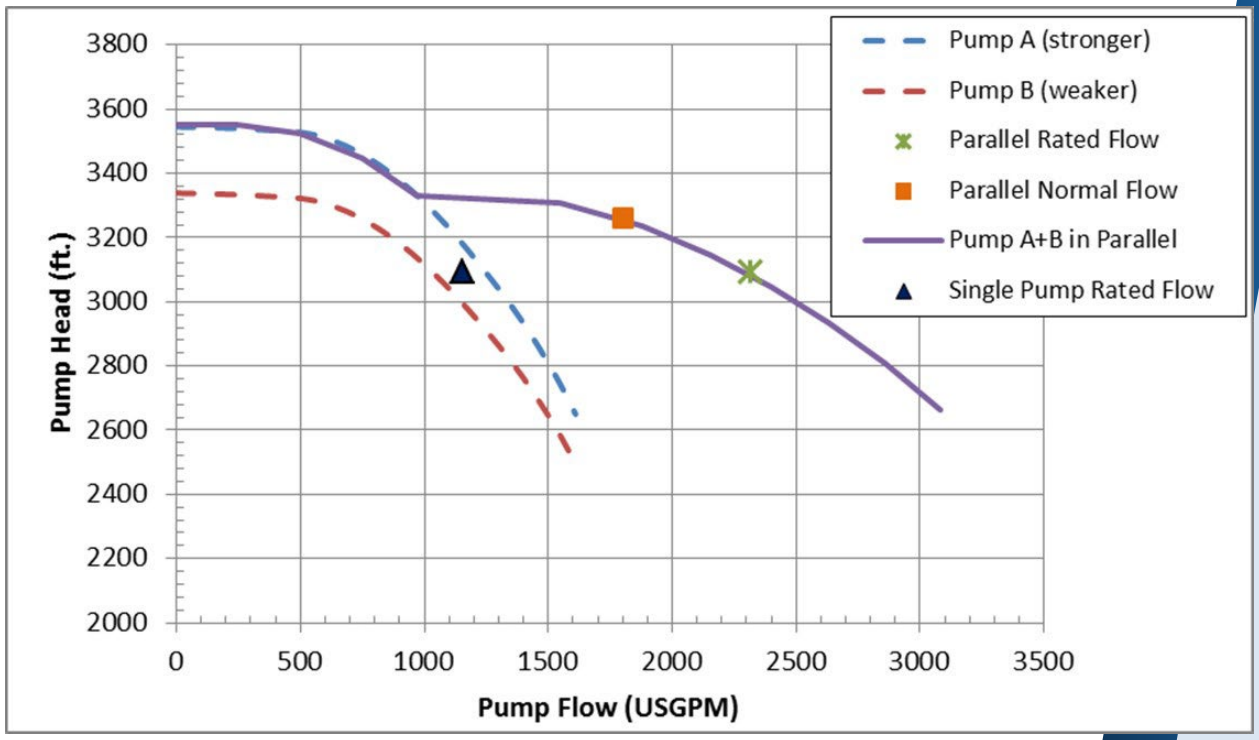
What API 610 Got Right!!

The resulting combined Pump A+B parallel curve is discontinuous due to the mismatching of the two pumps. This exhibits itself as a step at around 1000 USGPM. (Below that point Pump B would operate at zero flow resulting in rapid failure).

In this scenario Pump A being stronger will force Pump B to operate back on its curve. If the system is operated at its Parallel Normal Flow, **Pump B will be running at around only 50% of BEP**. This is well outside the preferred operating range and will result in Pump B seeing higher wear and ultimately needing repair *much* sooner.

Whether the pump has a HRSO of 9%, 10% or 11% doesn't matter so much. A 10% minimum HRSO helps to reduce the necessary matching accuracy a little but the end result is still much the same.

(Source – Simon Bradshaw, Director Engineering, Trillium)



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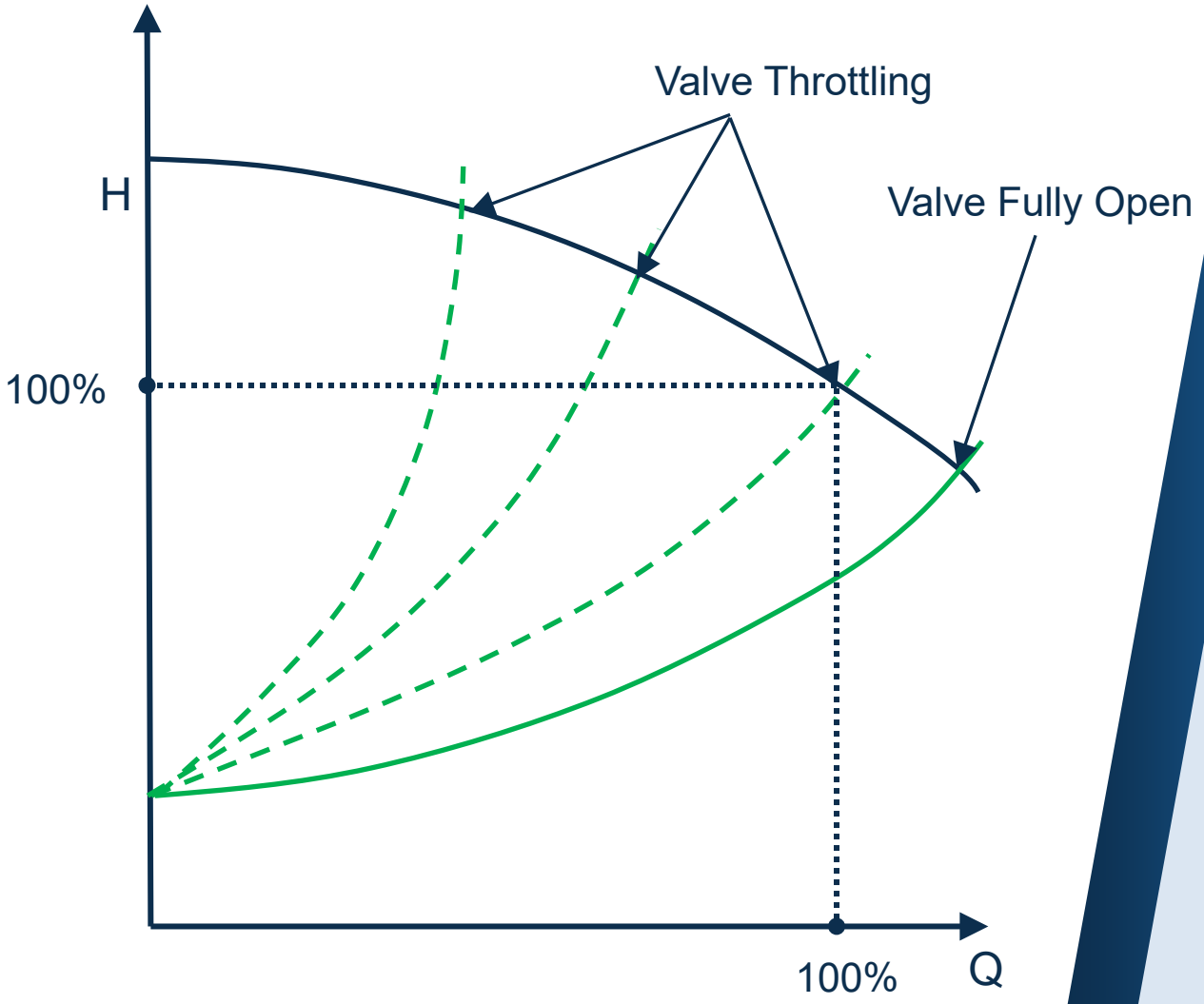
Curve Shape – Continuously Rising Curve

System Control by Throttling

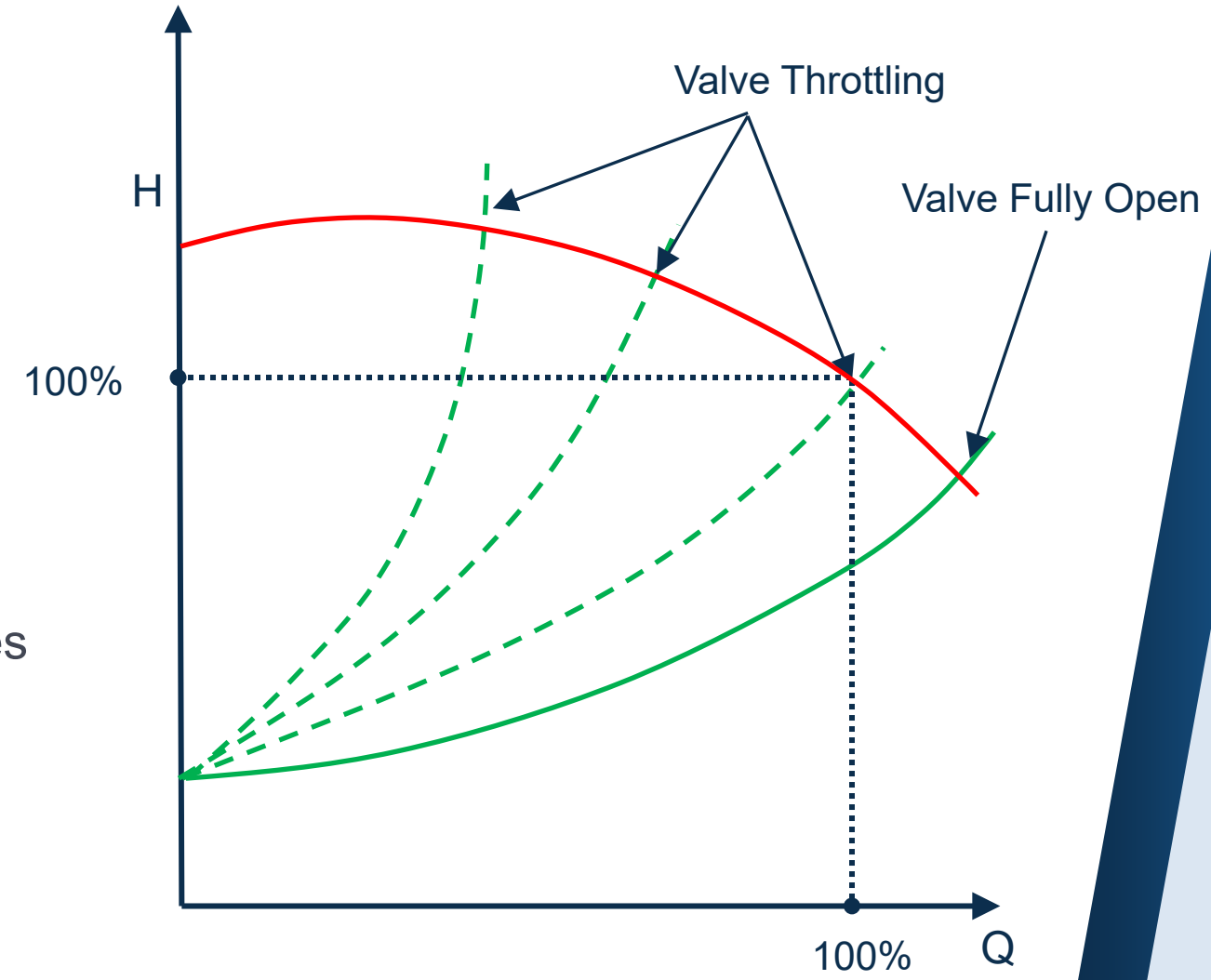
Probably the most common system control.

By opening or closing a control valve on the pump discharge, a “family” of system curves are created reflecting the ever-increasing frictional component of the system head.



Curve Shape – Continuously Rising “Hooked” Curve

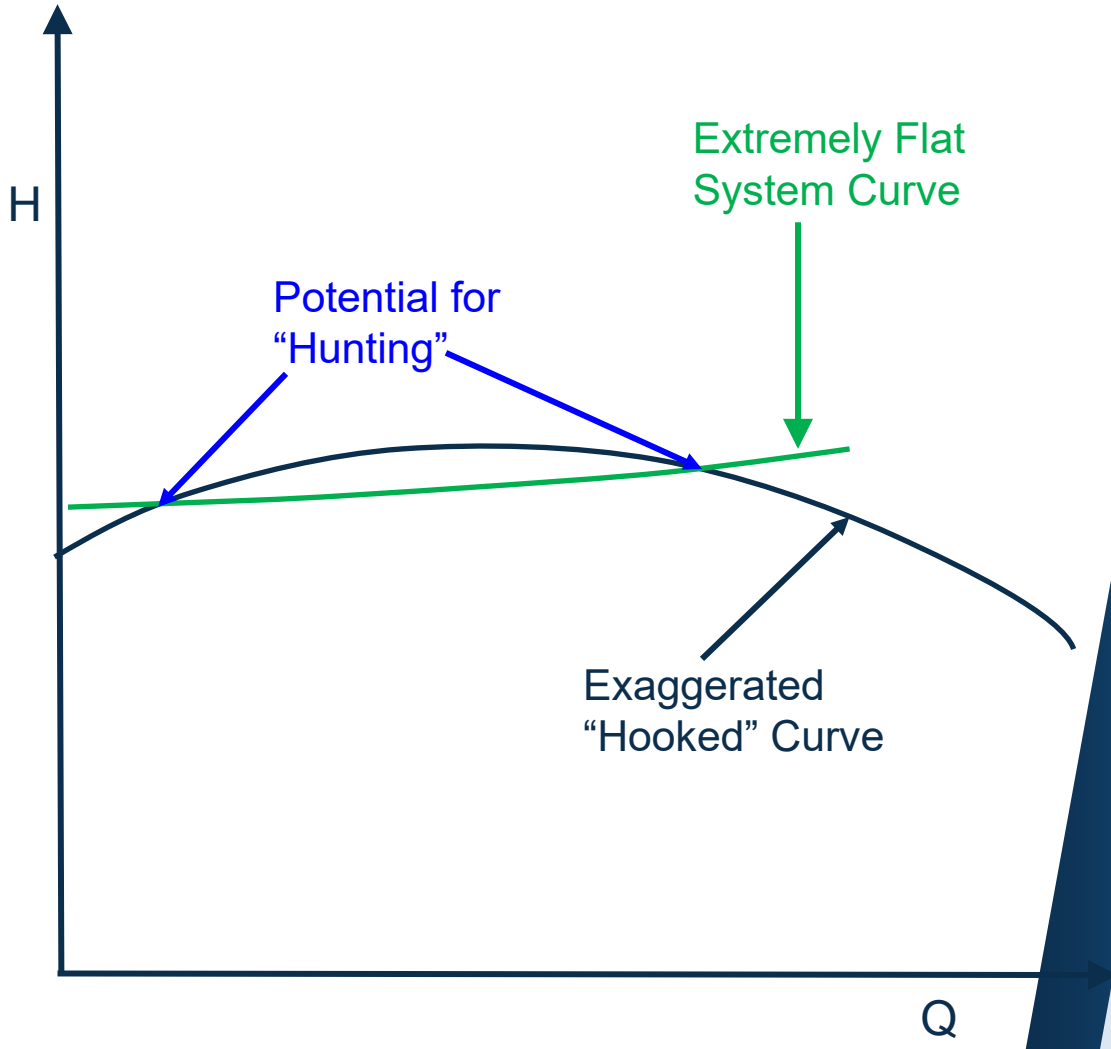
- Many specifiers run a mile from a hooked curve believing they are unstable.
- **A pump will only operate where the system permits – where the system curve crosses the pump curve.**
- **“The pump is slave to the system” ***
- Even as the control valve is gradually closed, each system curve only crosses the pump curve once.
- So no “hunting” is possible



* Simon Bradshaw

Curve Shape – Hooked Curve (Gasp!) Extreme Case

Only in the extremely rare case of an almost totally flat system curve (nearly all static head, very low frictional head) and a ***severely*** hooked curve might the system curve cross the pump curve more than once.



Coming Attractions ☺

"Pump Instrumentation"

Thur 11th April – 08.00 (UK GMT+1) (Eastern Hemisphere) & 17.00 (UK GMT+1) (Western Hemisphere)

Aimed at Process and Mechanical Engineers, Consultant Engineers and possibly even Instrumentation Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
This course will look at commonly supplied pump instrumentation (especially vibration monitoring) and understanding what the readings obtained tell you about your pump installation.

Future subjects in preparation include:

- Pump Testing & Inspection
- Double Case Pumps (Barrel Pumps – BB5)
- Fire Pump Systems & Packages
- Sump Pumps
- Wastewater Pumps

RUHRPUMPEN

Specialist for Pumping Technology

Q & A

ssmith@ruhrpumpen.com

marketing@ruhrpumpen.com

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+70 YEARS OF EXPERIENCE

+2,000 EMPLOYEES

15 **SERVICE CENTERS**

+70,000 PUMPING SOLUTIONS INSTALLED WORLDWIDE

A GLOBAL COMPANY

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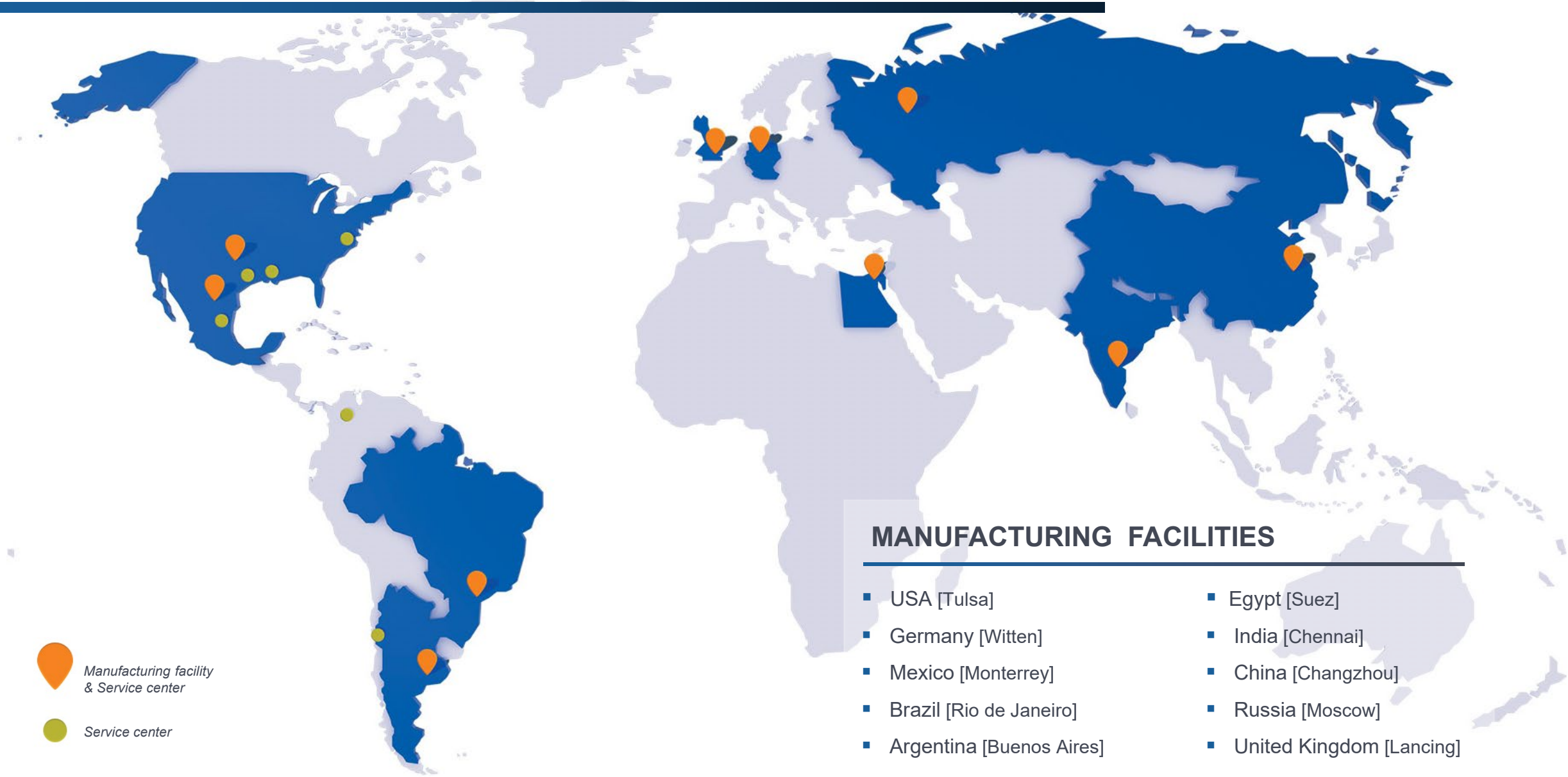


MANUFACTURING FACILITIES

- USA [Tulsa]
- Germany [Witten]
- Mexico [Monterrey]
- Brazil [Rio de Janeiro]
- Argentina [Buenos Aires]
- Egypt [Suez]
- India [Chennai]
- China [Changzhou]
- Russia [Moscow]
- United Kingdom [Lancing]

MARKETS WE SERVE

Our commitment to create innovations that offer reliable solutions to our customers allow us to provide a complete range of pump systems to support **core markets** as:

RUHRPUMPEN

OUR PUMP LINES

Ruhrpumpen offers a broad range of highly engineered and standard pumping products that meet and exceed the requirements of the most demanding quality specifications and industry standards.

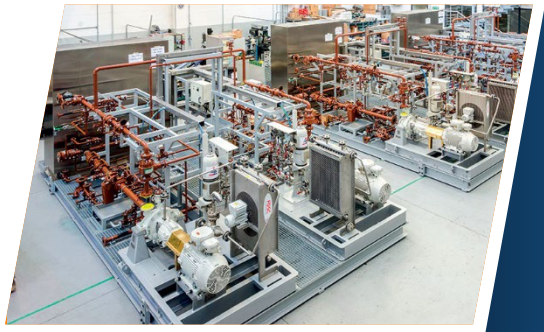
Our pumps can handle head requirements as high as 13,000 ft (4,000 m) and capacities up to 300,000 gpm (68,000 m^3/hr). Moreover, our pump designs cover temperatures from cryogenic temperatures of -310 °F (-196 °C) up to 752 °F (400 °C).

Products include:

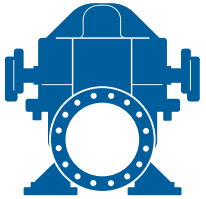
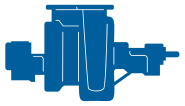
- Single Stage Overhung Pumps
- Between Bearings Pumps
- Horizontal Multi-Stage Pumps
- Vertical Multi-Stage Pumps
- Vertical Mixed Flow & Axial Flow Pumps
- Positive Displacement Pumps
- Full Range of Industrial Pumps
- Submersible Pumps
- Magnetic Drive Pumps
- Decoking Systems
- Packaged Systems
- Fire Systems

OVERHUNG PUMPS

CATEGORY	RP MODEL	DESIGN STANDARD
Sealless Magnetic Drive Pumps	**CRP-M / CRP-M-CC**	ISO 2858 & 15783 HI design (OH11)
	SCE-M	API 685
Foot Mounted OH1 and General End Suction Pumps	**IPP**	HI design (OH1)
	CPP / CPP-L	HI design (OH1) ANSI B73.1
	CPO / CPO-L	HI design (OH1) ANSI B73.1
	CRP	HI design (OH1) ISO 2858 & 5199
	GSD	HI design (OH0)
	SHD / ESK / SK / SKO SKV / ST / STV	HI design (OH1)
	SWP	HI design (OH3A)
Centerline Mounted	**SCE**	API 610 (OH2)
Vertical In-Line Pumps	**SPI**	API 610 (OH3)
	IVP / IVP-CC	HI design (OH4 / OH5)
	IIL	HI design (OH5) Dimensionally compliant with ANSI B73.2
	SPN	API 610 (OH5)



BETWEEN BEARING PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
1 and 2 stage	Axially split	**HSC / HSD / HSL HSR / ZW**	HI design (BB1)	
		HSM	HI design (BB3)	
		ZM / ZMS ZLM / ZME	API design (BB1)	
	Radially split	**HVN / J**	API design (BB2)	
		RON / RON-D	API design (BB2)	
Multi-stage	Axially split	**SM / SM-I**	API design (BB3)	
		JTN	API design (BB3)	
	Radially split *single casing*	**GP**	API design (BB4)	
	Radially split *double casing*	**A LINE**	API design (BB5)	

VERTICAL PUMPS

CATEGORY		RP MODEL	DESIGN STANDARD	
Single casing	Diffuser	**VTP**	HI & API 610 (VS1)	
		VCT	HI & API 610 (VS1)	
		HQ	HI & API 610 (VS1)	
		VLT	HI & API 610 (VS1)	
	Volute	**DSV / DX**	HI & API 610 (VS2)	
	Discharge through column – Axial flow	**VAF**	HI & API 610 (VS3)	
	Separate discharge line	**VSP / VSP-Chem**	HI & API 610 (VS4)	
Double casing	Diffuser	**VLT / VMT**	HI & API 610 (VS6)	
	Volute	**DSV / DX**	HI & API 610 (VS7)	
Submersible pumps		**SMF**	HI design (OH8A)	
		VLT-Sub / VTP-Sub	HI design (VS0)	

SPECIAL SERVICE PUMPS

CATEGORY	RP MODEL	DESIGN STANDARD	
Pitot tube pumps	**COMBITUBE**	HI design	
Reciprocating pumps	**RDP**	API 674 ISO 13710	
Vertical turbine generator	**VTG**	HI design (VS6)	
Barge	**LS BARGE**	HI design	
Floating dock pumps	**ZVZ**	HI design	
	LVZ	HI design	
Cryogenic pumps	**SVNV**	-	
	VTG Cryogenic	-	
	VLT Cryogenic VLTV	-	
Pre-packaged fire pump systems	Fire systems incorporate pumps, drivers, control systems and pipework in a single container. They can be skid mounted, with or without enclosure and supplied with electric motor or diesel engine.	**NFPA-20-850** UL and FM approved components