RUHRPUMPEN

Specialist for Pumping Technology

Sessions 13 & 14 –

Performance Testing and Inspection of API 610 Pumps

Simon Smith February 2022







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 40 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.

RUHRPUMPEN

Ruh*RP*umpen Short Courses

Here is a listing of all the previous courses.

- No 1 – API610 12th v 11th editions
- No 2 - Curve Shape
- No 3 – The Importance of System Curves
- No 4 - Selecting the Right Pump for the Application
- No 5 - NPSH & Nss
- No 6 - Mechanical Seals & Systems
- 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

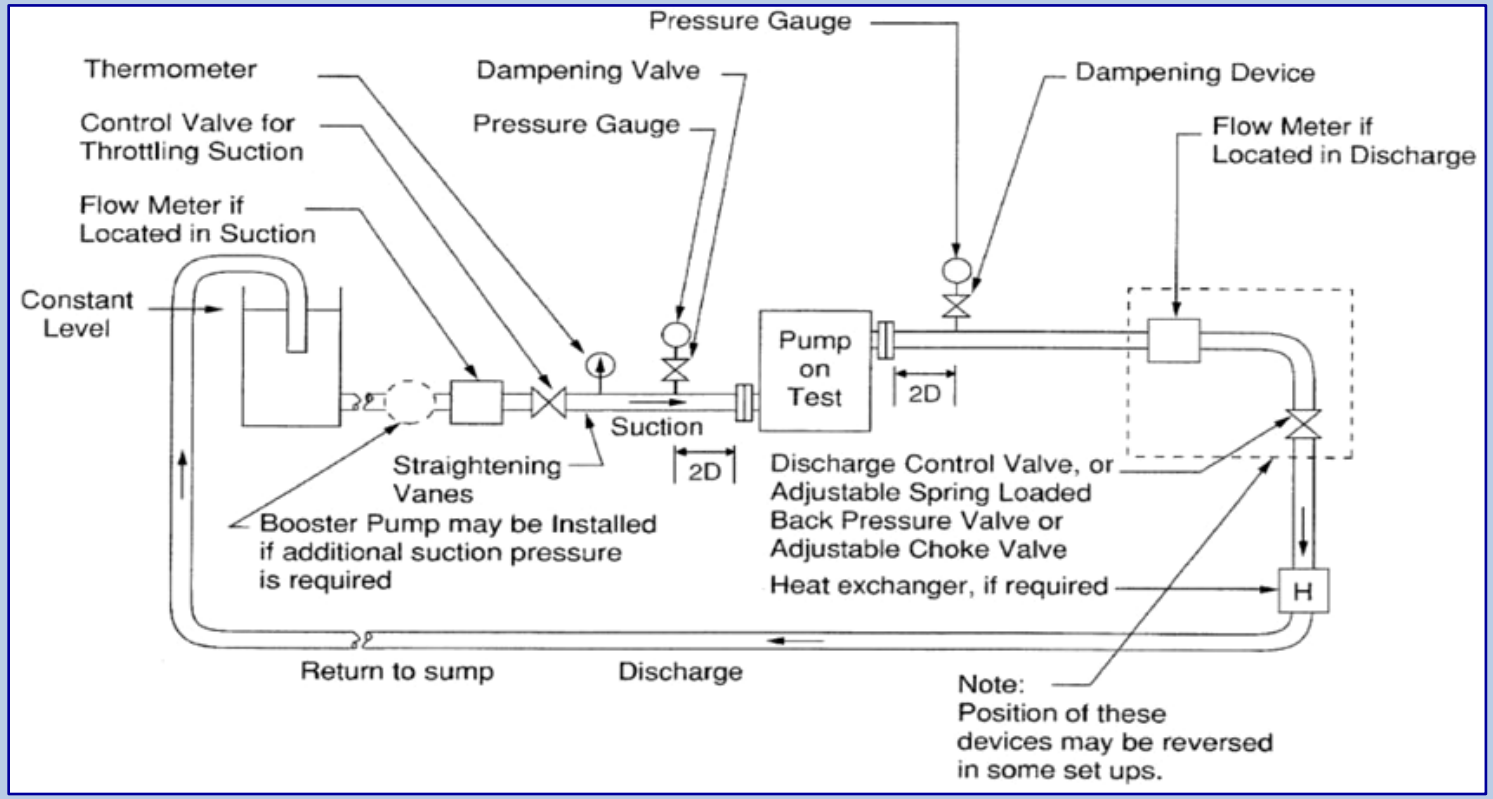
Any you have missed you can get from our Marketing Dept. Please send an e-mail to info@ruhrpumpen.com referencing the "Short Courses hosted by Simon Smith"

Session 13 – “Performance Testing & Inspection of API 610 Pumps”

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
This session will look at the What, the Why and the How of Pump Performance Testing (Session 13) and also look at the various Inspections & Tests that are frequently specified on the Data Sheets (Session 14).

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

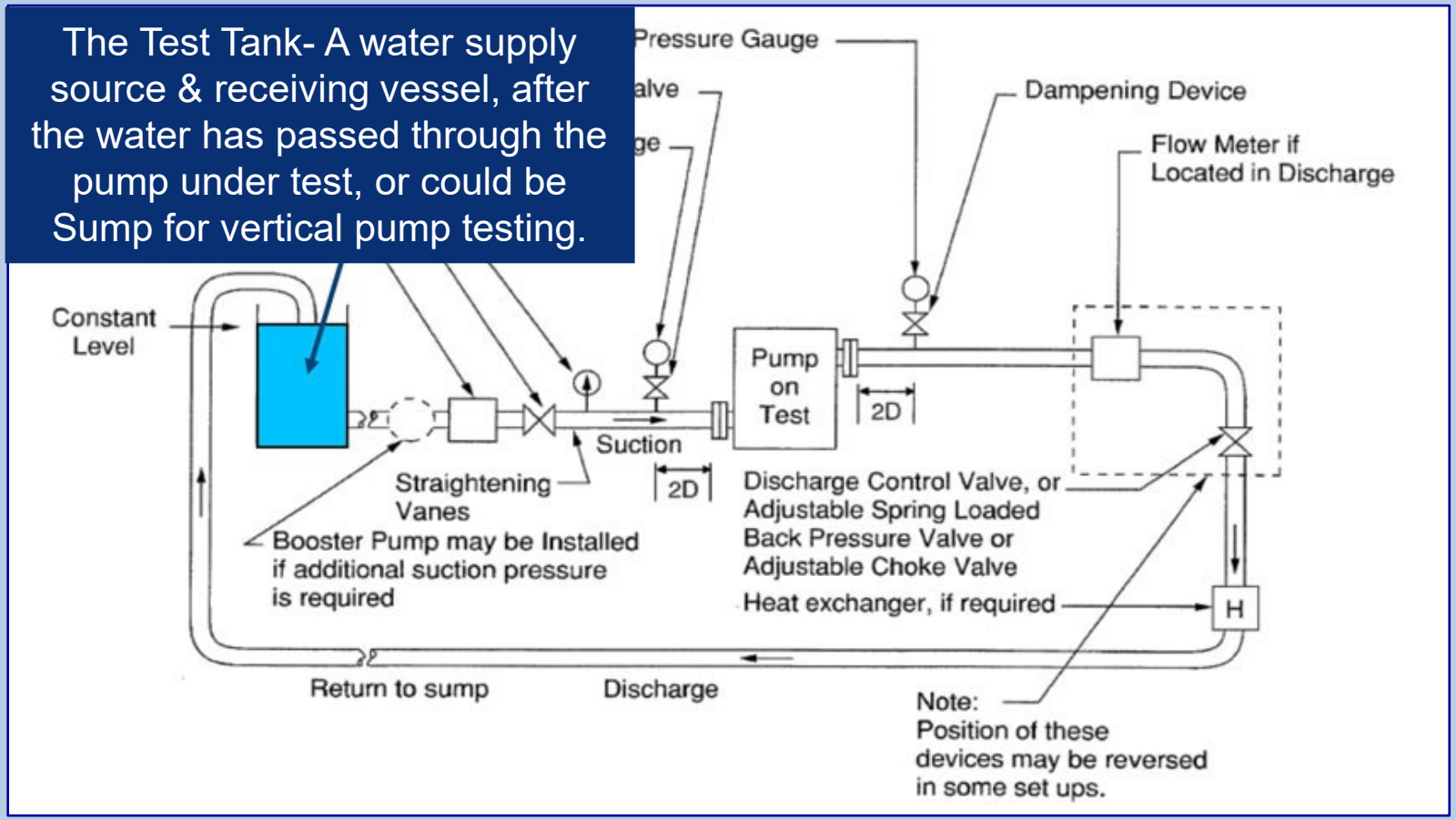


A schematic of a typical Test Bed setup, as shown in the Hydraulic Institute standards.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

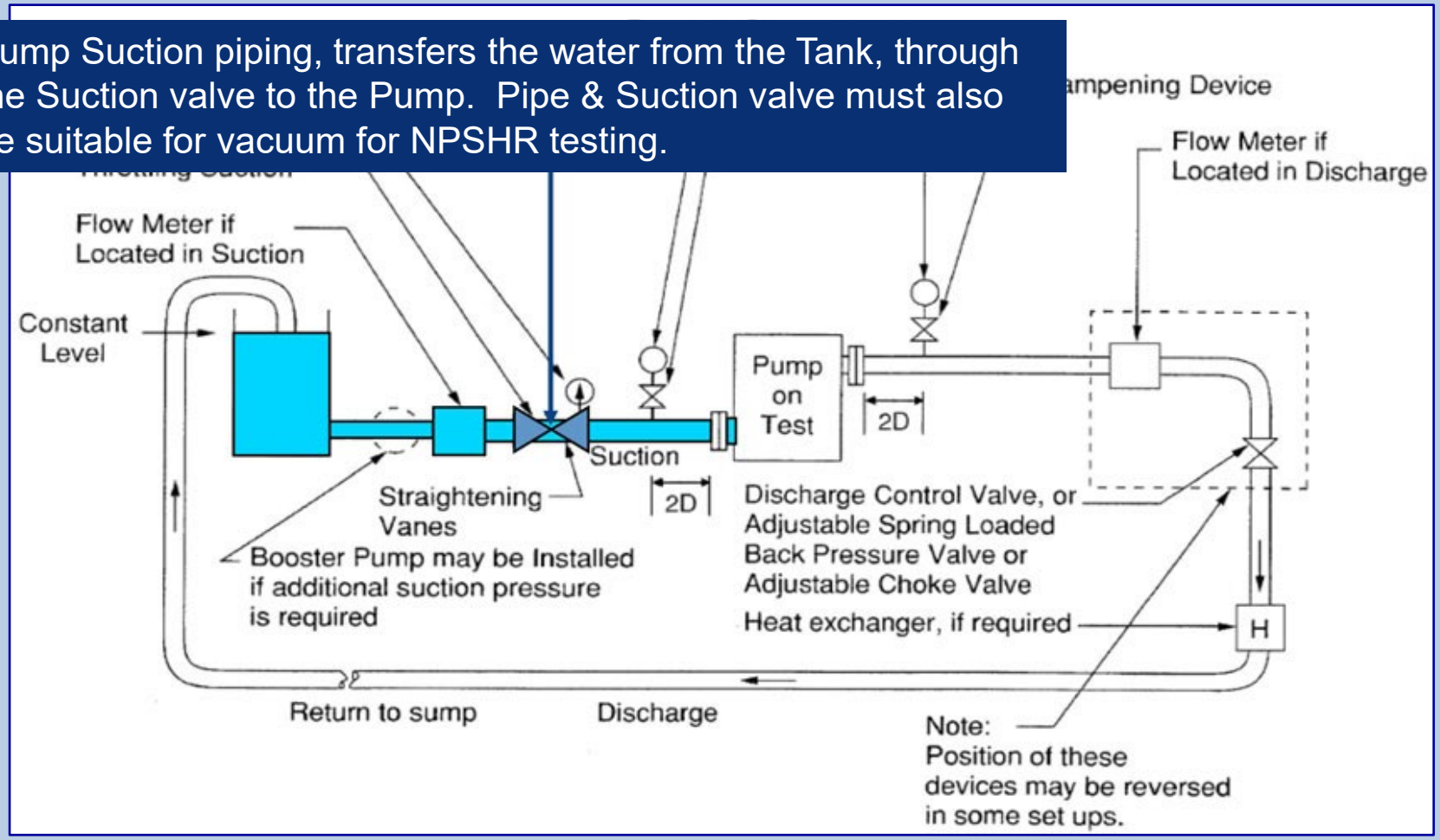
The Test Tank- A water supply source & receiving vessel, after the water has passed through the pump under test, or could be Sump for vertical pump testing.



PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

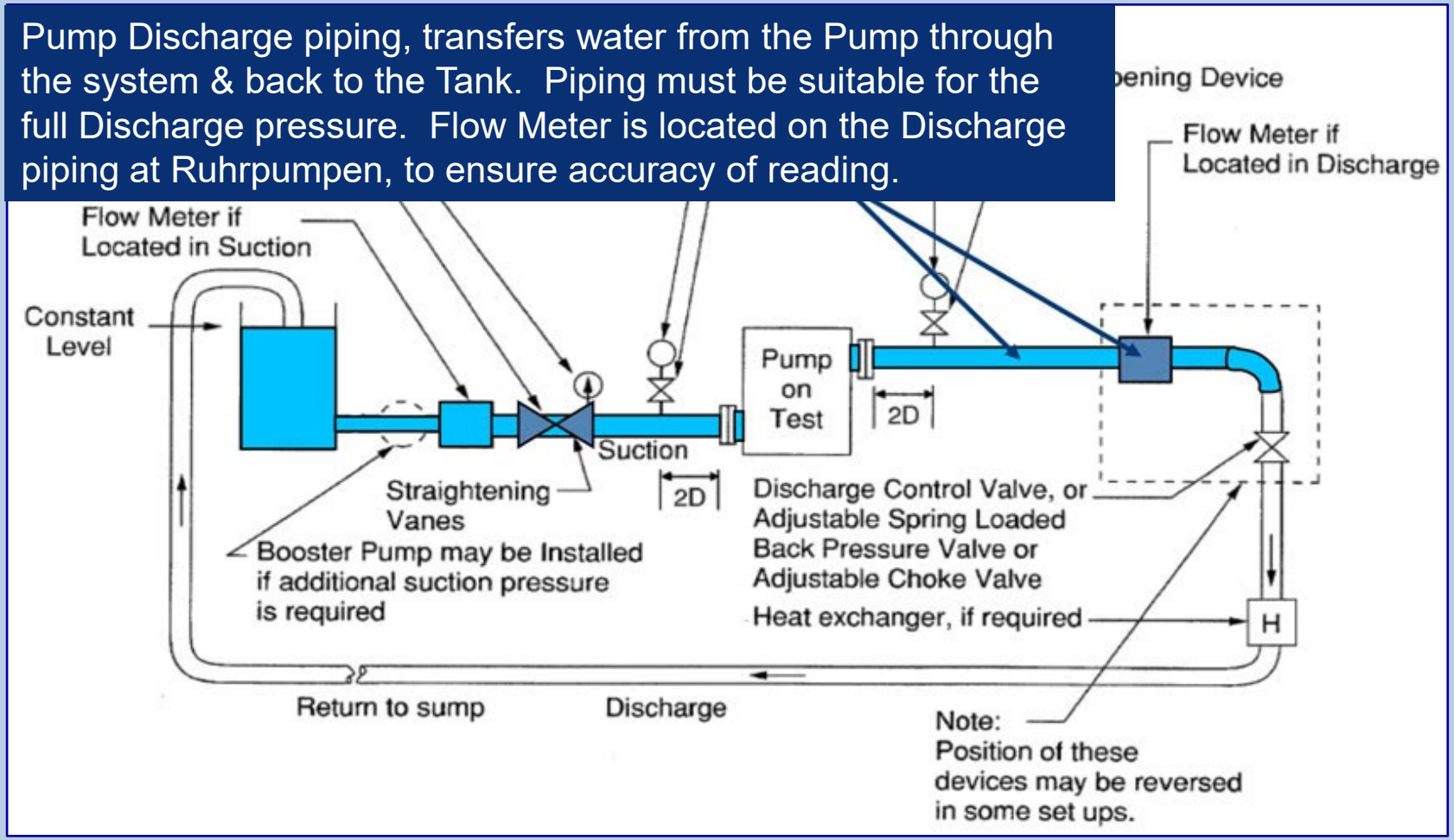
Pump Suction piping, transfers the water from the Tank, through the Suction valve to the Pump. Pipe & Suction valve must also be suitable for vacuum for NPSHR testing.



PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

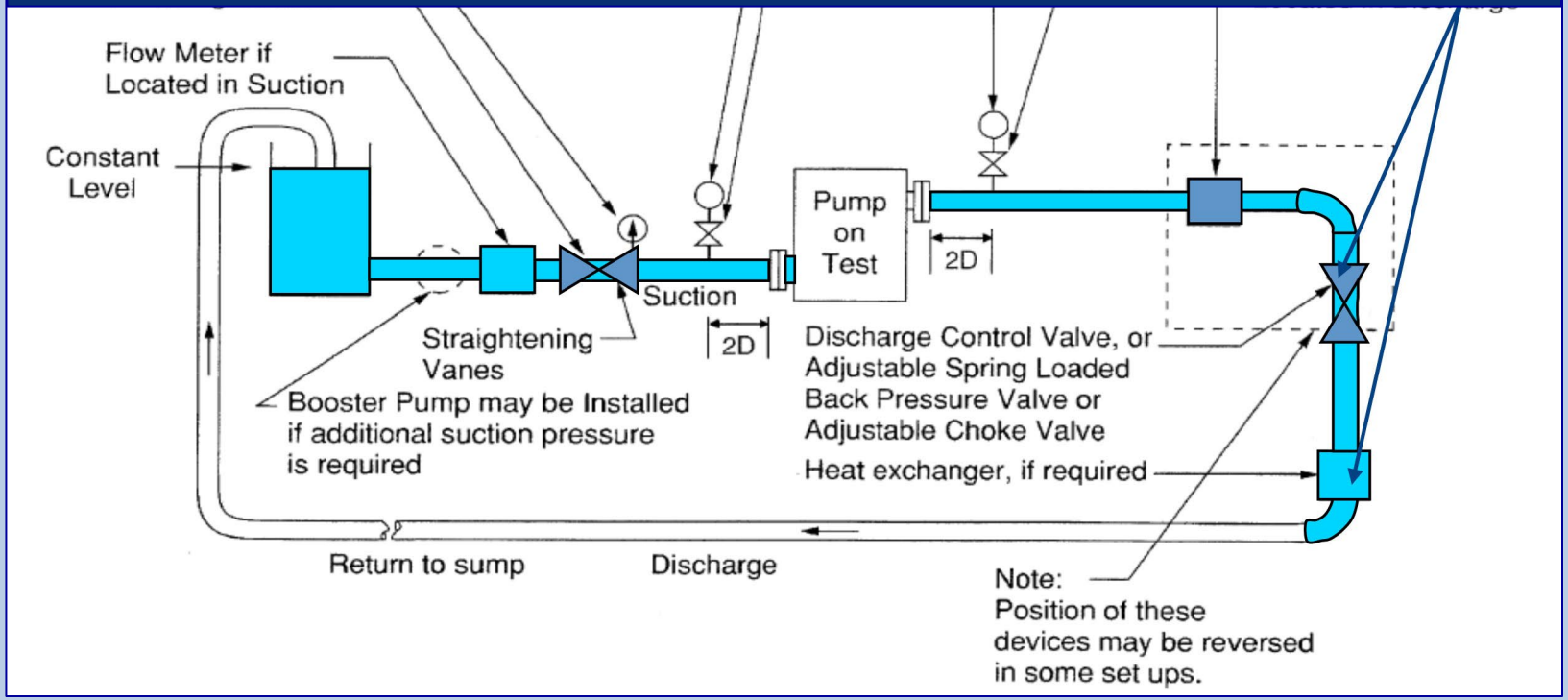
Pump Discharge piping, transfers water from the Pump through the system & back to the Tank. Piping must be suitable for the full Discharge pressure. Flow Meter is located on the Discharge piping at Ruhrpumpen, to ensure accuracy of reading.



PUMP TESTING

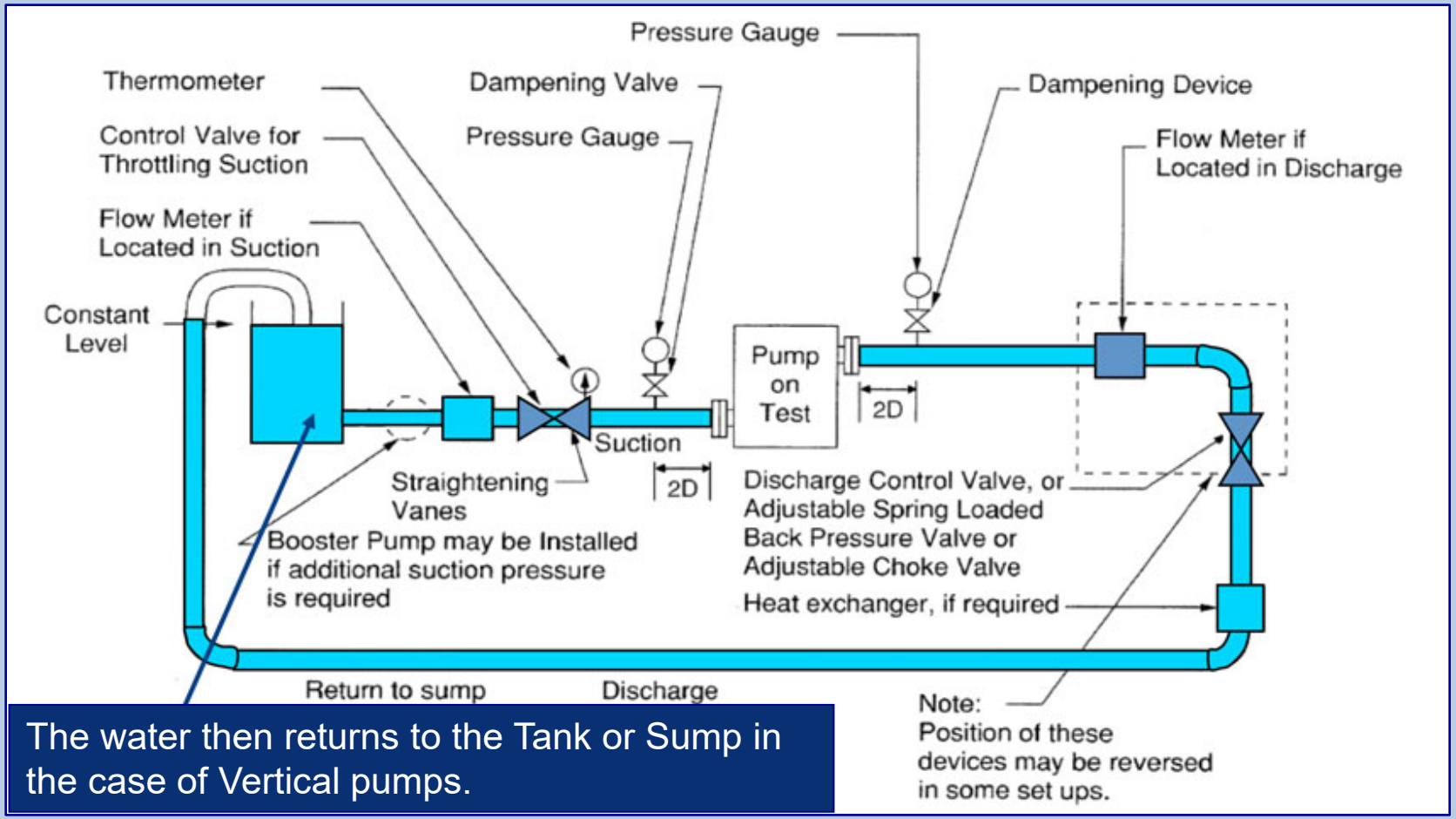
The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

The water flows through the Discharge valve, which provides Flow control by throttling. The water may also be cooled to reduce the temperature to be within the API610 limit of 130F (55C), if extended duration runs are required. This would be achieved either by flowing through a Cooler, or the Tank may have a cool recycled flow.



PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

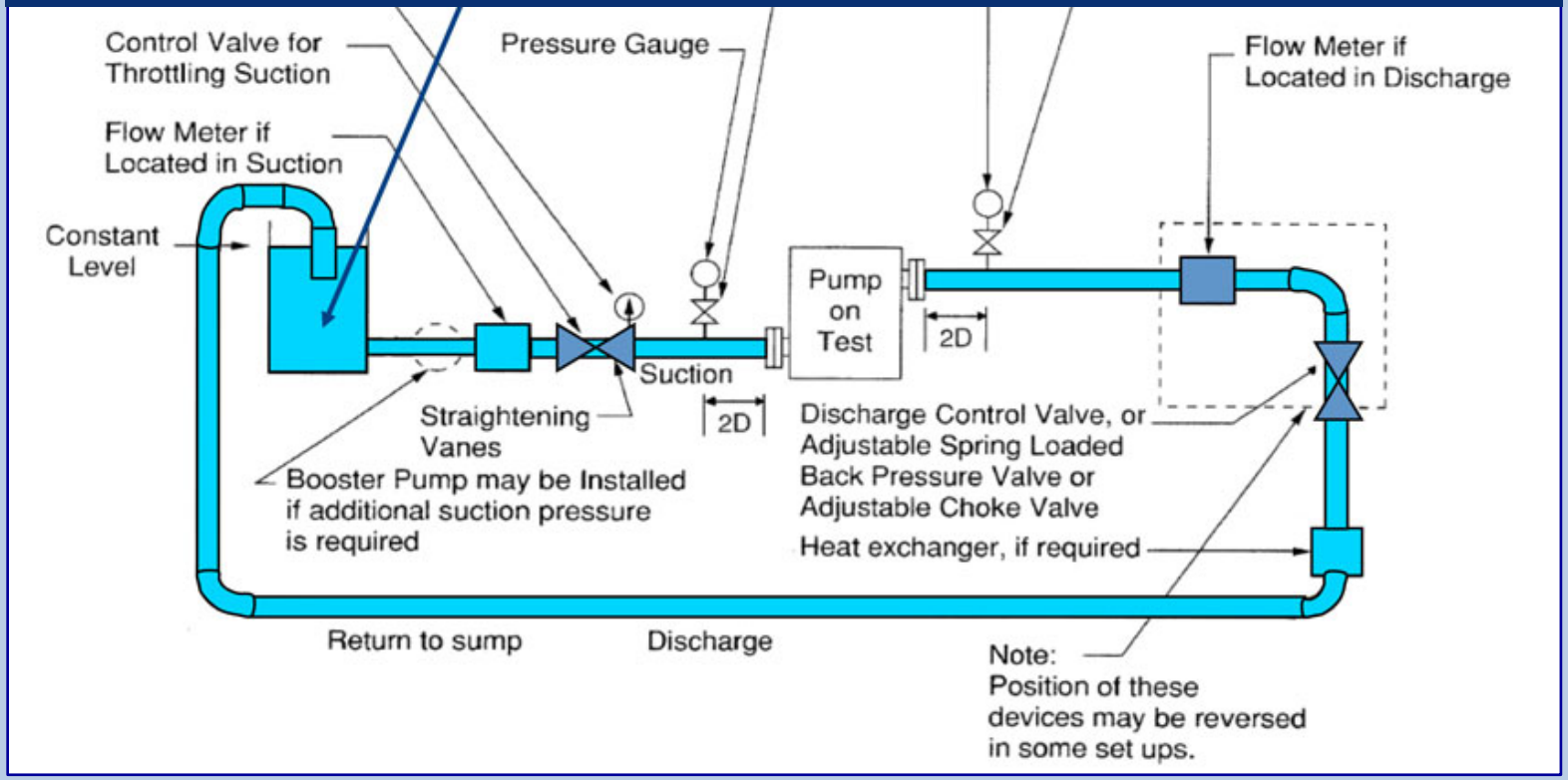


The water then returns to the Tank or Sump in the case of Vertical pumps.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

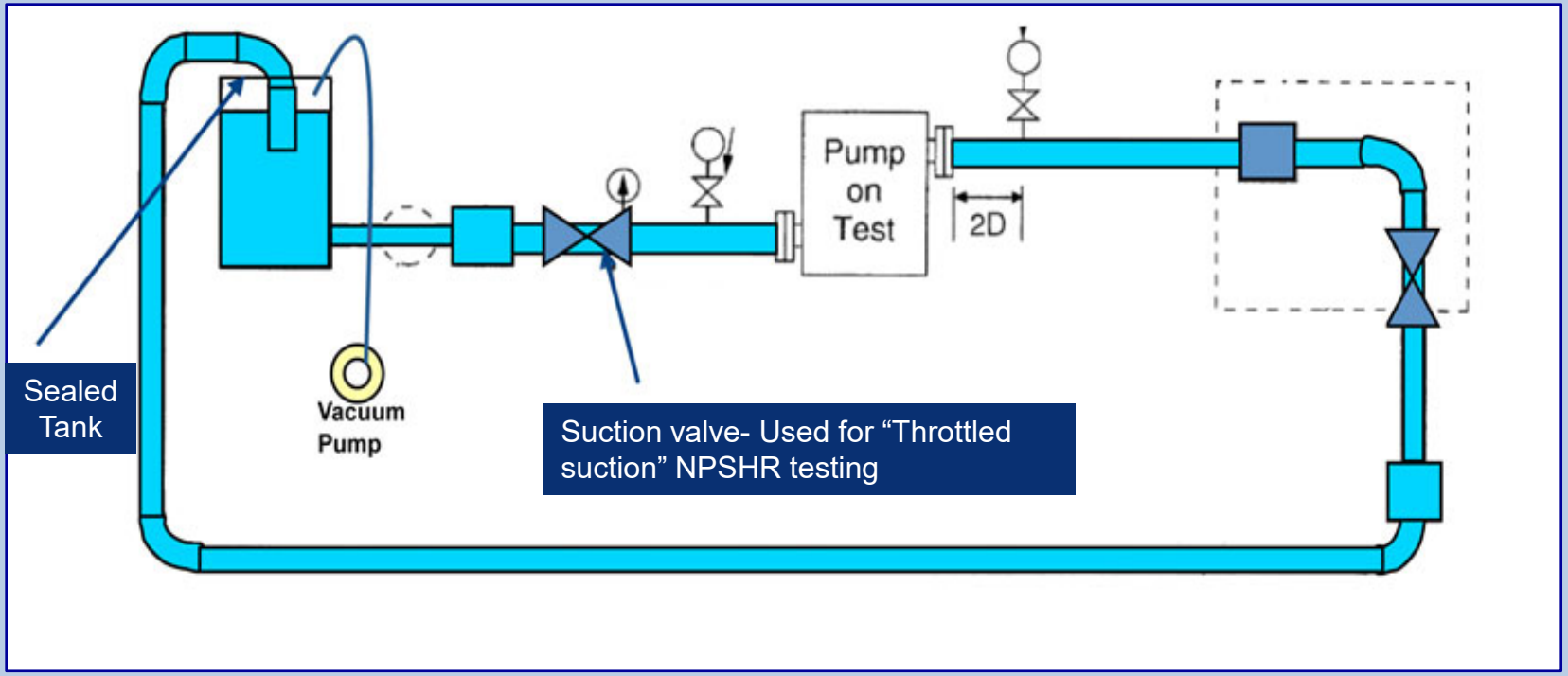
The Tank & the Sump are sized to allow a retention time of an average of 2 Minutes, to allow turbulence and aeration to settle down, before any given particle of liquid begins the cycle again.



PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

For NPSH Testing



PUMP TESTING

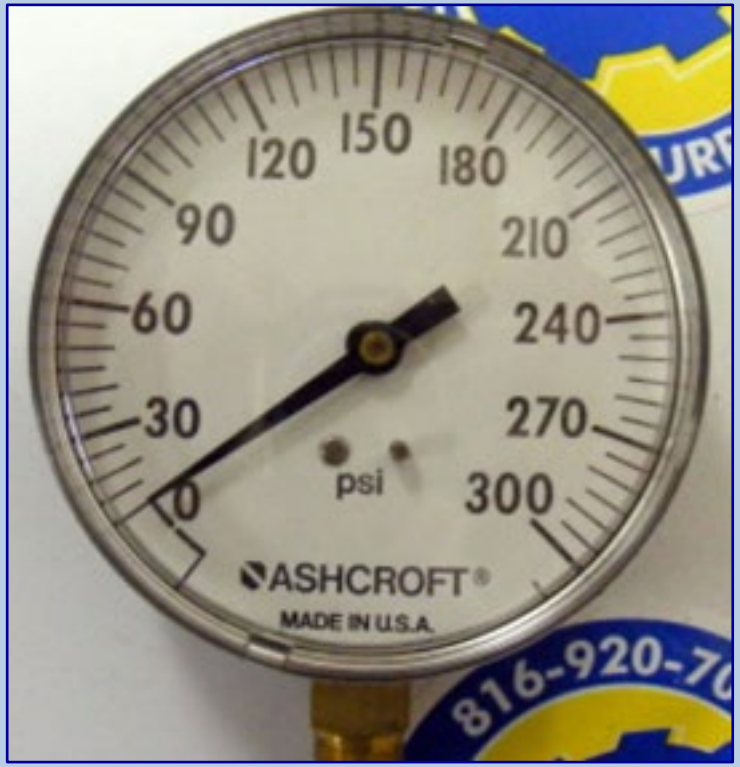
The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Factory Locations & NPSHR Test Type Carried Out.				
FACTORY LOCATION →	TULSA	MONTERREY, MEXICO	WITTEN, GERMANY	EGYPT
NPSHR TEST TYPE				
SUPPRESSION TYPE VACUUM TESTING	X			
THROTTLED-SUCTION TYPE TESTING		X	X	X

PUMP TESTING

Suction and Discharge pressures are measured on the test bed at each test flow point, using gauges similar to those shown below. These are located either side of the pump, sufficiently far away to be unaffected by turbulence, and the readings are standardized to the same height.

Typical compound Suction pressure Gauge.



Typical Discharge pressure Gauge.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

The electrical power flowing into the Test Motor driving the pump is measured by the Test bed Wattmeter, similar to the unit shown below.

The pump power being absorbed is calculated by multiplying the Wattmeter reading by the Motor Efficiency, at each of the test flow points.

Typical Wattmeter

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Alternative Method of Measuring the Pump Power:-

Another method of measuring the Pump absorbed power, is by using a Torque Transducer.

This is a more accurate method as it directly measures the pump torque & speed, and so directly establishes the pump absorbed Power. Here is the HP Formula.

HP=2x Pi x N x T /33,000,

(Because 1HP= 33,000 Ft.Lbs/Minute,

Pi=3.142 & N= RPM & T= The TORQUE Measured).

Typical Torque Transducer

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

The actual action of testing the pump, and calculating the results is actually quite simple, although the pump setup for a large unit can take time.

The procedure for performance testing pumps are:-

1. Determine how many flow points are needed to meet the test standard, eg. API, HI, etc, and what the value of the Flows are.

2. Run the pump at each Flow point and record the values shown on the next slide…..

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

At initial setup, after recording all contract & pump details, then record the:-

- Height of these gauges above the pump centreline or a known datumn
- Suction and Discharge pipe size * connected to the pump, at the Gauge take-off points
- Impeller diameter(s), including any underfile details

Also, at each flow point record the:

- Flow
- Suction pressure
- Discharge pressure
- Speed (rpm)
- Water temperature
- Wattmeter reading, giving electrical power flowing into the motor
- Vibration levels

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

From these readings the pump Flow, Speed, differential Head produced & the absorbed Power are calculated at the various flow rates, including the Rated guaranteed point.

These values and the raw data that produced them, are then shown on the Test Log, and pump Curves are produced, and both these are sent to the customer.

Also, Vibration readings are collected, measured at the standard locations on the pumps, which are:-

- For Horizontal pumps:- At the Bearing Housings.
- For Vertical pumps:- At the top flange of the Discharge Head, where the motor is bolted to the pump.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

• The first test is carried out with a slightly larger trim diameter Impeller than estimated.

• Then, by evaluating the test results using experience and Affinity Laws, the final test trim needed to reach the Rated duty within the Test tolerances, is calculated.

• The impeller is then trimmed to this slightly smaller diameter, re-balanced, and the pump retested.

• Some test standards state that if, after the first test, it is predicted that the impeller diameter reduction required is 5% or lower, then predicted test values are adequate, without the needing an actual retest. (*API 610 allows this as standard*).

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

- **Test Tolerances:**

Of course, the acceptability of the test results for the customer, will depend on the results meeting the target values promised when the pump is sold, Plus or Minus the agreed test tolerances.

These tolerances will vary depending on the Test Standard the customer has selected.

Typical Test standard tolerances are shown in the next few slides.

- **After test completion:**

After all test data has been tabulated and plotted, the results are submitted to the customer as the Test Log package.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

TEST TOLERANCES: API 610 LATEST EDITION

TABLE 16 – PERFORMANCE TOLERANCES

CONDITION	RATED POINT %	SHUTOFF %
RATED DIFFERENTIAL HEAD: 0 m to 75 m (0 ft to 250 ft) >75 m to 300 m (>250 ft to 1,000 ft) > 300 m (1,000 ft)	± 3 ± 3 ± 3	± 10 (a) ± 8 (a) ± 5 (a)
RATED POWER	4 (b)	—
EFFICIENCY	(c)	
RATED NPSH	0	—

a. If a rising head flow curve is specified (see 6.1.11), the negative tolerance specified here shall be allowed only if the test curve still shows a rising characteristics.
b. With test results corrected to rated conditions (see 8.3.3.3 b) for flow, speed, density (specific gravity) and viscosity, it is necessary that the power not exceed 104% of the rated value, from all causes (cumulative tolerances are not acceptable).
c. The uncertainty of test efficiency by test code specified is ± 2,5 %; therefore, efficiency is not included in the pump's rated performance. In those applications where efficiency is of prime importance to the purchaser, a specific value and related tolerance should be negotiated at the time of the order (see 8.3.3.4).

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Test Tolerances: Hydraulic Institute 14.6

Test parameter	Guarantee requirement	Grade	Grade 1			Grade 2		Grade 3
		Δt_Q	10%			16%		18%
		Δt_H	6%			10%		14%
		Symbol	Acceptance grade					
			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[a]	Optional (either/or)	t_P (%)	+ 4%	+ 4%	+ 10%	+ 8%	+ 16%	+ 9%
Efficiency[a]		t_η (%)	– 3%	– 0%	– 0%	– 5%	– 5%	– 7%

Table 1 — ANSI/HI 14.6 performance acceptance grade table

[a] Efficiency is a calculated value that is dependent on pump power input and, therefore, either minimum efficiency or maximum pump power input at the guarantee point can be specified, but not both.

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Test Tolerances: Hydraulic Institute

Six pump performance test acceptance grades are used: 1B, 1E, 1U, 2B, 2U and 3B. Grade 1 is the most stringent, and the “U” specifies having a unilateral tolerance band.
The “B” specifies having a bilateral tolerance band. Acceptance grade 1E can be used when energy efficiency is of importance and is also bilateral.

HI have a good white paper you can download
“Understanding the Effects of Selecting a Pump Performance Test Acceptance Grade”
Here is the link:
https://europump.net/uploads/HI%20White%20Paper%20-%20Understanding%20the%20Effects%20of%20Selecting%20a%20Pump%20Performance%20Test%20Acceptance%20Grade.pdf

PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

Performance Testing the Pump:

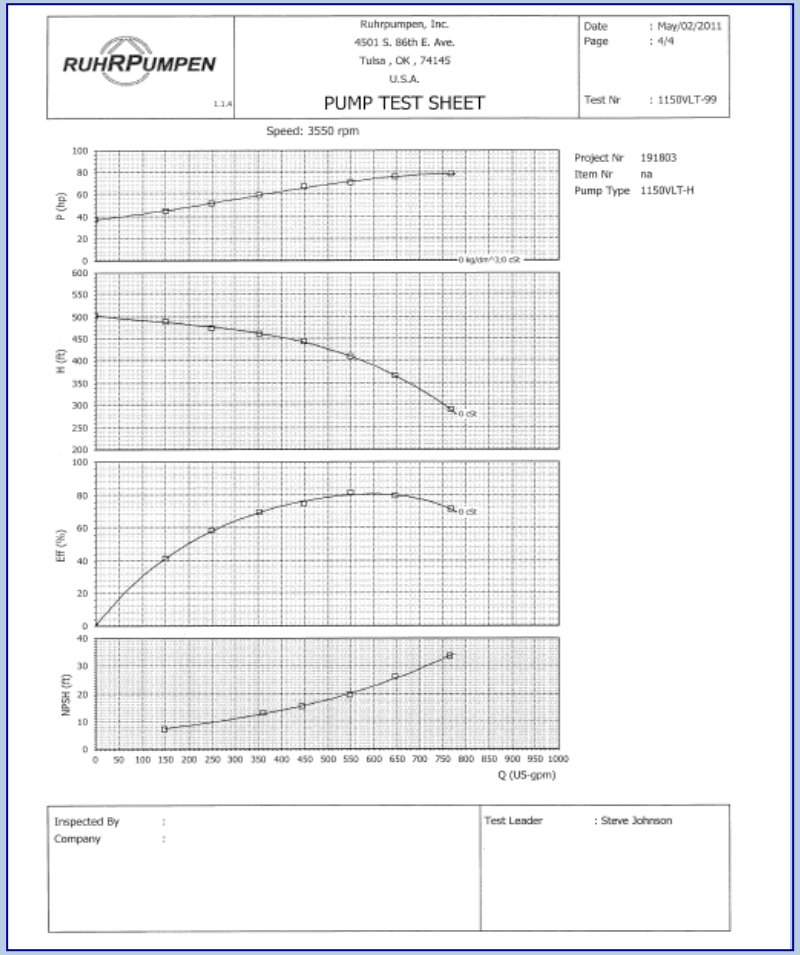
- **Performance Test printout.**

Here we see a typical printout of a Performance Test.

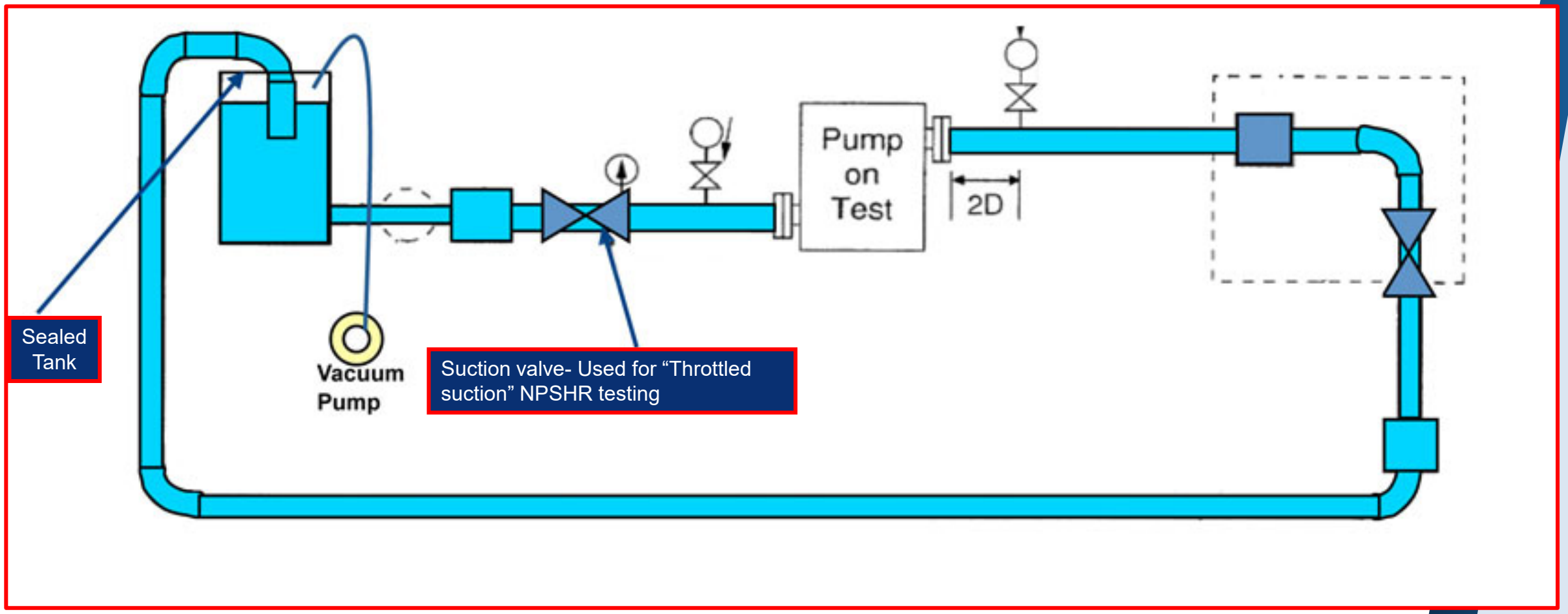
Note that as NPSHR tests have also been carried out, a full NPSHR curve is also shown.

This has been developed from the NPSHR head drop-off tests shown later in these slides.

This sheet, and the Tabulated Data, are sent to the customer as part of the data package.



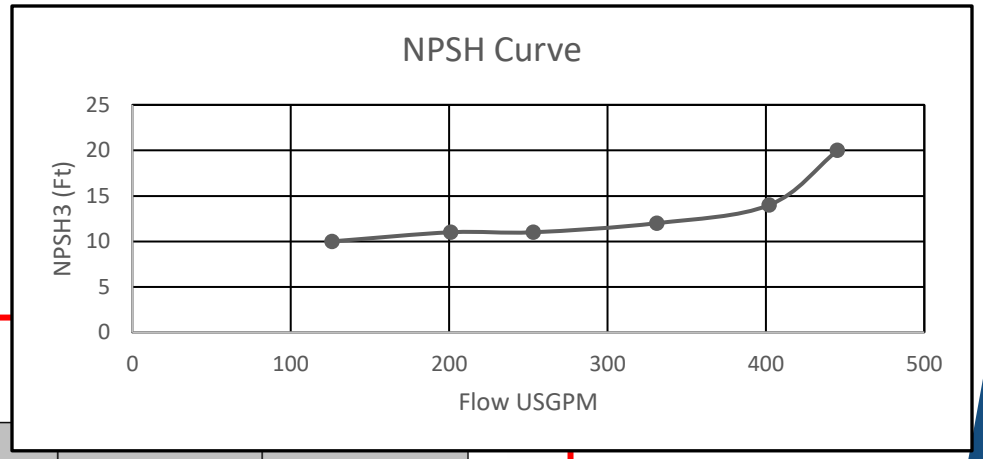
$NPSH_R$ NPSHR Testing Procedure

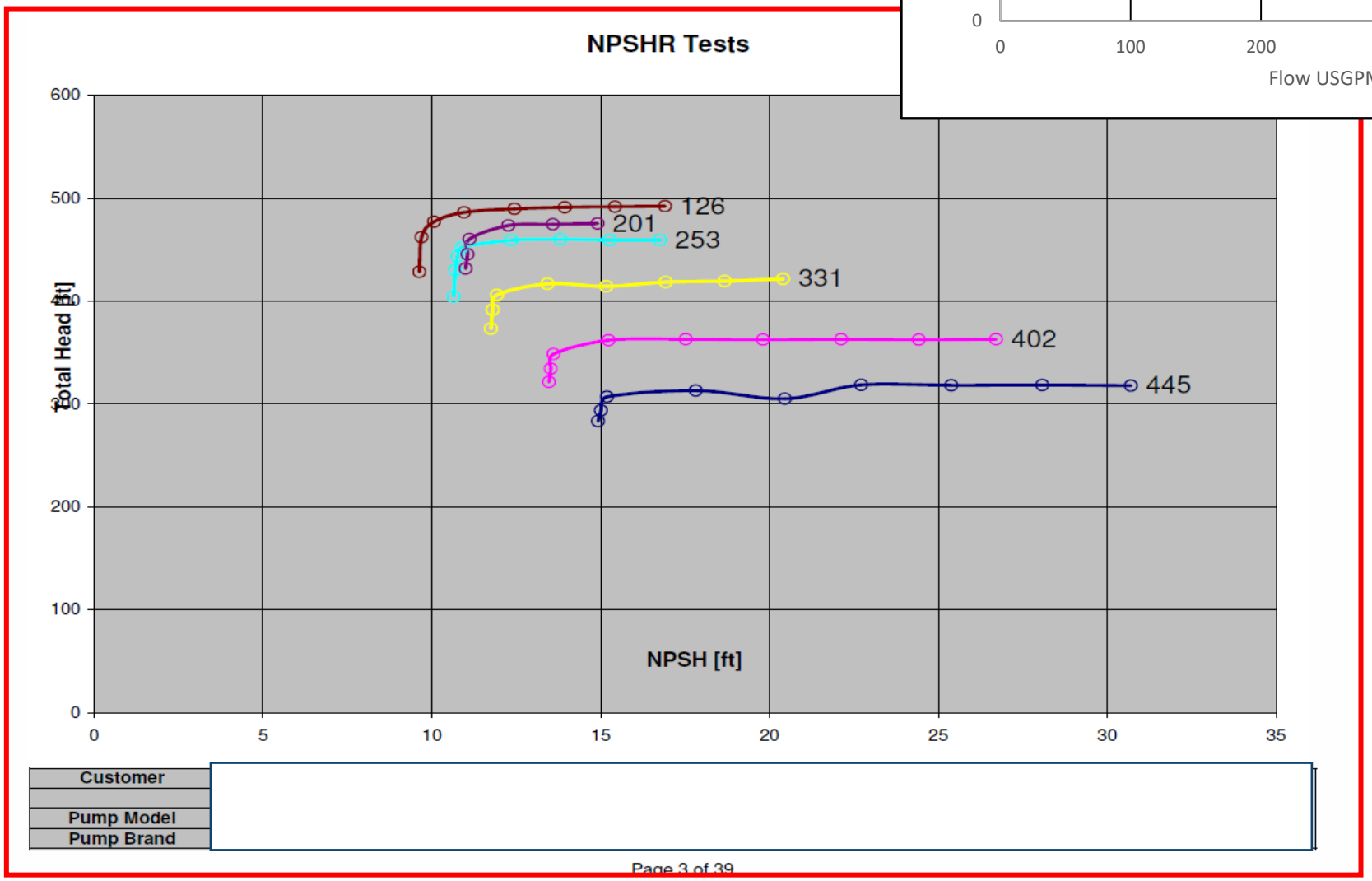


$NPSH_R$ NPSHR Testing Procedure

- The pump is set to the rated speed.
- At each flow point (typically 5 or 6 flows), while the Suction Pressure is reduced, the Discharge Valve is opened slightly to maintain the constant set Flowrate.
- At each NPSHR Test point, Flow, Head, Suction pressure & Water Temperature readings are taken at progressively lower and lower Suction pressures. Whether the reduction in Suction pressure is due to a Vacuum Suppression Test or a Throttled Suction valve Test.
- At some point, as the Suction Pressure is reduced more and more, the Pump Differential Head will get closer to a 3% Head reduction. So now the Suction Pressure Reduction values are taken closer together.
- After the Head drop has reached 3% at every Flowrate, the NPSH3 test is completed.

$NPSH_R$ NPSH Test Curve





PUMP TESTING

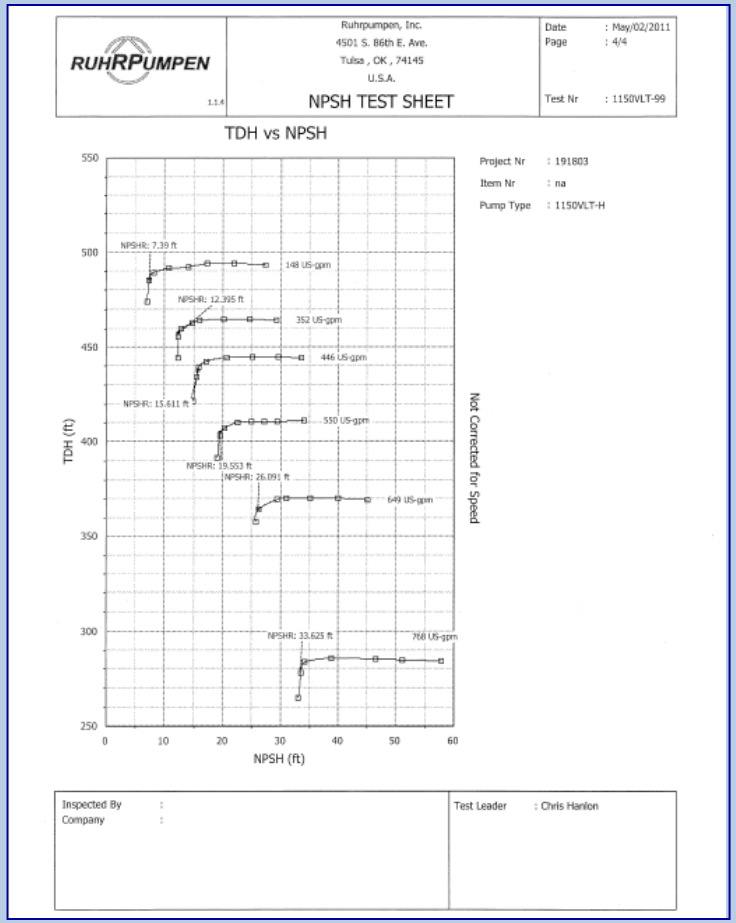
The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

NPSHR Testing:

- **NPSHR Test procedure:**

Here we see a typical printout of an NPSHR head drop-off tests.

This sheet, and the Tabulated Test Data, are sent to the customer as part of the data package.



PUMP TESTING

The WHAT, the WHY, & the HOW of Centrifugal Pump Testing

NPSHR Testing:

Note:- 3% is the pump industry standard definition of NPSHR.

However, customers can re-define NPSHR.

For example:-

• “1% Head drop defines NPSHR”

• Occasionally even 0%, which is called the Inception of Cavitation

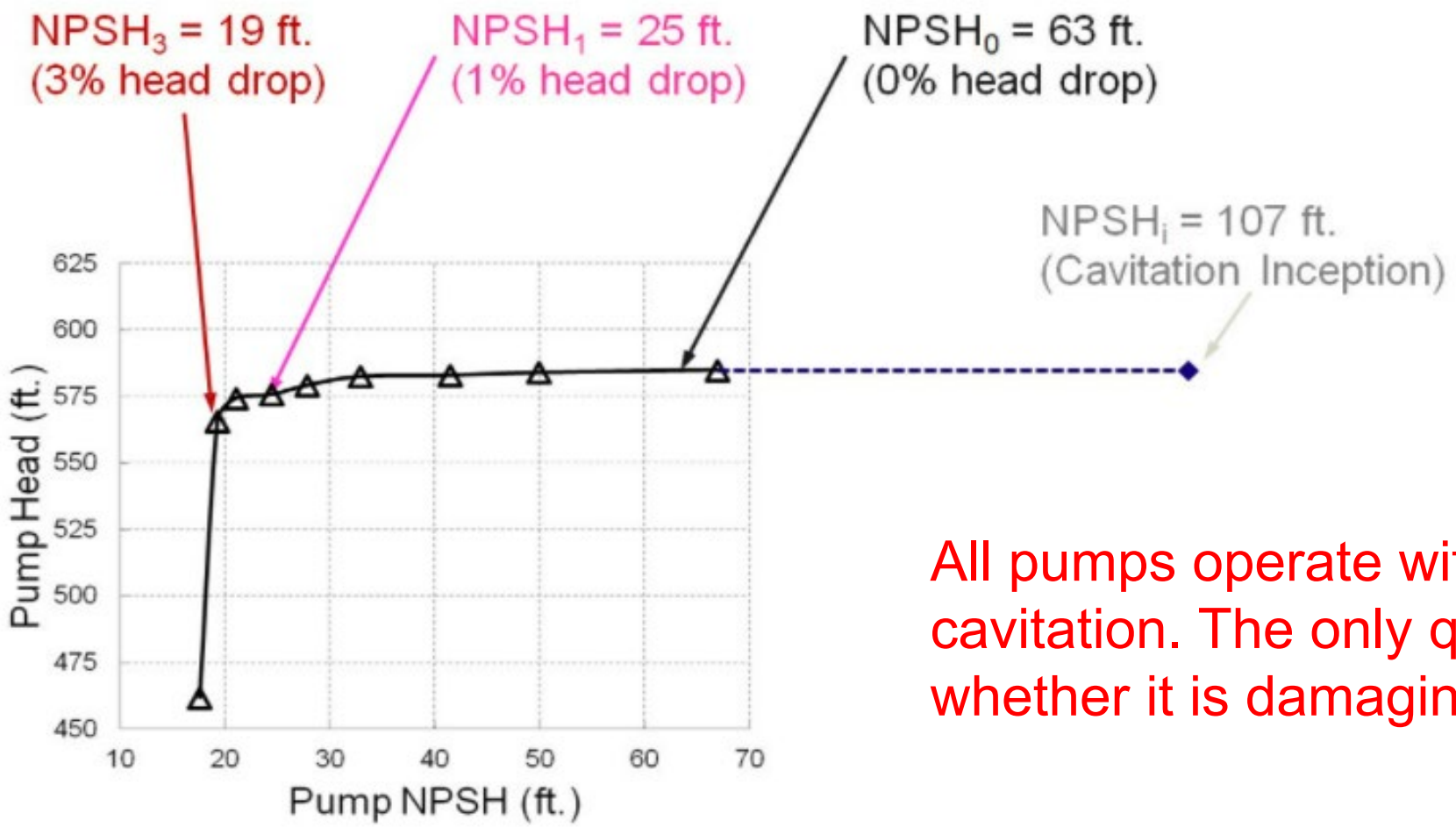
• ARAMCO often requires an NPSHR figure based on “ that value of NPSHR that will give a predicted Impeller life of 40,000 Hours”.

Note:-

The only values that can be proven on the test bed are NPSHR of 3% and 1%.

$NPSH_R$

Onset of Cavitation



All pumps operate with suction cavitation. The only question is whether it is damaging cavitation.

Source – Simon Bradshaw - Director Engineering, Pumps Americas at CIRCOR

$NPSH_R$

NPSH Testing of Vertically Suspended Pumps

During performance testing the pump is suspended in a below-ground suction tank or pit with an open suction bellmouth on the pump (no suction piping).

So clearly we cannot pull a vacuum on the pit or throttle the suction.

To carry out an NPSH Test you need to build the pump as a 1 stage pump and suspend it in the above ground sealed suction tank. You can then pull a vacuum on that tank to carry out the NPSH test.

This is what RP does in its Tulsa factory.

In some factories a VS6 pump might be tested, not in the pit, but in its own suction barrel in the same test loop as a horizontal pump.

Then you can carry out an NPSH test in the normal way either by vacuum suppression, or by suction throttling.

$NPSH_R$

NPSH Testing of Vertically Suspended Pumps

Pumpdown Test

It is often possible to offer a “Pumpdown Test” in an open sump configuration of a VS1 or VS3 pump (or a VS6 pump without its barrel)

The pump will be built for the test with test shop column sections, to get as close as possible to the Minimum Submergence level of the particular pump. Then the pump is run without recirculation of flow back to suction but sending it to drain instead.

This allows the level in the pit to drop until the pump discharge pressure drops indicating you have reached the minimum pumping level.

This is very wasteful of water and municipal water companies may well not allow it.

Performance Testing

Tulsa Test Loop

See attached PDF Photos

Performance Testing

Monterrey Test Loop

See attached PDF Photos

Performance Testing

Monterrey Test Loop

New Vertical Pump Test Pit

under construction

Depth: 13 m (43ft)

Length 22m (72ft)

Width 4m (13ft)

Volume 2000m^3 (528,000 galls)

Coming Attractions ☺

"Performance Testing & Inspection of API 610 Pumps Part 2"

Thurs 10th March – 08.00 (UK GMT) (Eastern Hemisphere) & 17.00 (UK GMT) (Western Hemisphere)

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.

This session will look at the What, the Why and the How of Pump Performance Testing (Part 1) and also look at the various Inspections & Tests that are frequently specified on the Data Sheets (Part 2).

Future sessions : 31st March

– Start-up, Commissioning & Troubleshooting of Centrifugal Pumps

OVERVIEW OF PART 2

RUHRPUMPEN
Specialist for Pumping Technology

Purpose of this presentation

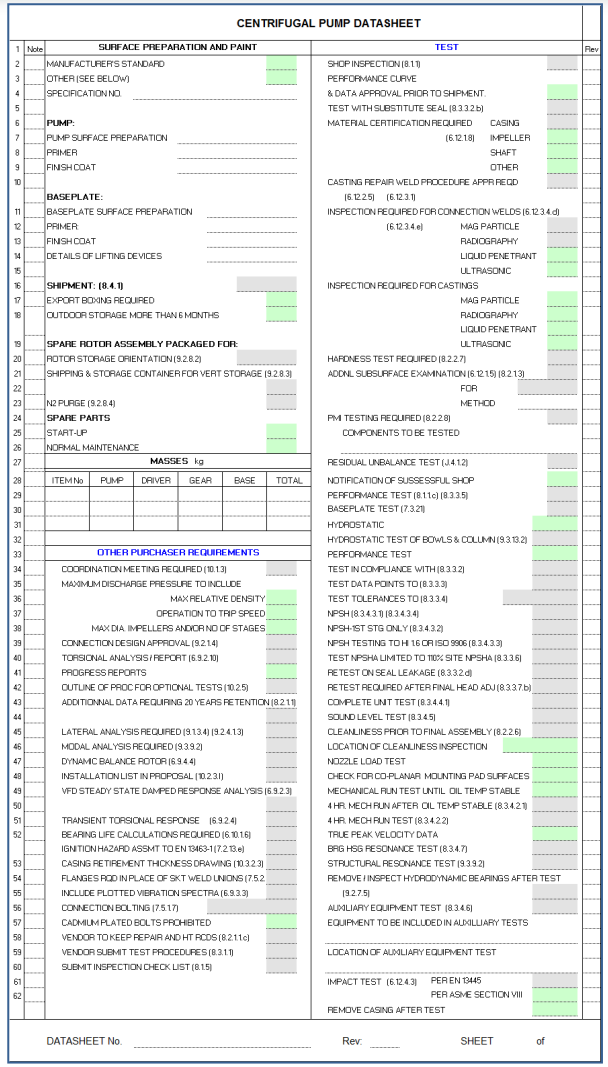
- To give an overview of the types of testing discussed in API 610 11th Edition
- Brief description of methodology and intention of tests and inspections
- Important points from perspective of sales and quotations

Additional descriptions and details of each test are provided in other presentations.

API 610 Datasheet

- Page 5 of the API 610 datasheet reflects the testing and inspection requirements for the pump
- Most lines in the datasheet include an API 610 paragraph reference
- Cell are color coded
- Drop-down options are mostly Yes/No or Non-Wit/Wit/Obs
- This is a change from previous editions on API where datasheets had check-boxes to indicate if a test was required and different columns for witnesses/non witnessed

	contain drop-down options
	contain calculated values based on input data that do not change.
	identifies a cross-referenced paragraph in the document; note may also contain a drop-down list


CENTRIFUGAL PUMP DATASHEET

Note	SURFACE PREPARATION AND PAINT		TEST	Rev
	MANUFACTURER'S STANDARD		SHOP INSPECTION (8.1.1)	
	OTHER (SEE BELOW)		PERFORMANCE CURVE	
	SPECIFICATION NO.		& DATA APPROVAL PRIOR TO SHIPMENT	
			TEST WITH SUBSTITUTE SEAL (8.3.3.2.b)	
	PUMP:		MATERIAL CERTIFICATION REQUIRED (6.12.1.8) CASING	
	PUMP SURFACE PREPARATION		IMPELLER	
	PRIMER		SHAFT	
	FINISH COAT		OTHER	
			CASTING REPAIR WELD PROCEDURE APPR REQD (6.12.2.5) (6.12.3.1)	
	BASEPLATE:		INSPECTION REQUIRED FOR CONNECTION WELDS (6.12.3.4.d)	
	BASEPLATE SURFACE PREPARATION		(6.12.3.4.e) MAG PARTICLE	
	PRIMER		RADIOGRAPHY	
	FINISH COAT		LIQUID PENETRANT	
	DETAILS OF LIFTING DEVICES		ULTRASONIC	
			INSPECTION REQUIRED FOR CASTINGS	
	SHIPMENT: (8.4.1)		MAG PARTICLE	
	EXPORT BOXING REQUIRED		RADIOGRAPHY	
	OUTDOOR STORAGE MORE THAN 6 MONTHS		LIQUID PENETRANT	
			ULTRASONIC	
	SPARE ROTOR ASSEMBLY PACKAGED FOR:		HARDNESS TEST REQUIRED (8.2.2.7)	
	ROTOR STORAGE ORIENTATION (9.2.8.2)		ADDNL SUBSURFACE EXAMINATION (6.12.1.5) (8.2.1.3)	
	SHIPPING & STORAGE CONTAINER FOR VERT STORAGE (9.2.8.3)		FOR	
			METHOD	
	N2 PURGE (9.2.8.4)		PMI TESTING REQUIRED (8.2.2.8)	
	SPARE PARTS		COMPONENTS TO BE TESTED	
	START-UP			
	NORMAL MAINTENANCE		RESIDUAL UNBALANCE TEST (J.4.1.2)	

MASSES kg

ITEM No.	PUMP	DRIVER	GEAR	BASE	TOTAL

	OTHER PURCHASER REQUIREMENTS		
	COORDINATION MEETING REQUIRED (10.1.3)		NOTIFICATION OF SUSSESSFUL SHOP
	MAXIMUM DISCHARGE PRESSURE TO INCLUDE		PERFORMANCE TEST (8.1.1.c) (8.3.3.5)
	MAX RELATIVE DENSITY		BASEPLATE TEST (7.3.2.1)
	OPERATION TO TRIP SPEED		HYDROSTATIC
	MAX DIA. IMPELLERS AND/OR NO OF STAGES		HYDROSTATIC TEST OF BOWLS & COLUMN (9.3.13.2)
	CONNECTION DESIGN APPROVAL (9.2.1.4)		PERFORMANCE TEST
	TORSIONAL ANALYSIS / REPORT (6.9.2.10)		TEST IN COMPLIANCE WITH (8.3.3.2)
	PROGRESS REPORTS		TEST DATA POINTS TO (8.3.3.3)
	OUTLINE OF PROC FOR OPTIONAL TESTS (10.2.5)		TEST TOLERANCES TO (8.3.3.4)
	ADDITIONNAL DATA REQUIRING 20 YEARS RETENTION (8.2.1.1)		NPSH (8.3.4.3.1) (8.3.4.3.4)
			NPSH-IST STG ONLY (8.3.4.3.2)
	LATERAL ANALYSIS REQUIRED (9.1.3.4) (9.2.4.1.3)		NPSH TESTING TO HI 1.6 OR ISO 9906 (8.3.4.3.3)
	MODAL ANALYSIS REQUIRED (9.3.9.2)		TEST NPSHA LIMITED TO 110% SITE NPSHA (8.3.3.6)
	DYNAMIC BALANCE ROTOR (6.9.4.4)		RETEST ON SEAL LEAKAGE (8.3.3.2.d)
	INSTALLATION LIST IN PROPOSAL (10.2.3.1)		RETEST REQUIRED AFTER FINAL HEAD ADJ (8.3.3.7.b)
	VFD STEADY STATE DAMPED RESPONSE ANALYSIS (6.9.2.3)		COMPLETE UNIT TEST (8.3.4.4.1)
			SOUND LEVEL TEST (8.3.4.5)
	TRANSIENT TORSIONAL RESPONSE (6.9.2.4)		CLEANLINESS PRIOR TO FINAL ASSEMBLY (8.2.2.6)
	BEARING LIFE CALCULATIONS REQUIRED (6.10.1.6)		LOCATION OF CLEANLINESS INSPECTION
	IGNITION HAZARD ASSMT TO EN 13463-1 (7.2.13.e)		NOZZLE LOAD TEST
	CASING RETIREMENT THICKNESS DRAWING (10.3.2.3)		CHECK FOR CO-PLANAR MOUNTING PAD SURFACES
	FLANGES ROD IN PLACE OF SKT WELD UNIONS (7.5.2)		MECHANICAL RUN TEST UNTIL OIL TEMP STABLE
	INCLUDE PLOTTED VIBERATION SPECTRA (6.9.3.3)		4 HR. MECH RUN AFTER OIL TEMP STABLE (8.3.4.2.1)
	CONNECTION BOLTING (7.5.1.7)		4 HR. MECH RUN TEST (8.3.4.2.2)
	CADMIUM PLATED BOLTS PROHIBITED		TRUE PEAK VELOCITY DATA
	VENDOR TO KEEP REPAIR AND HT RCDS (8.2.1.1.c)		BRG HSG RESONANCE TEST (8.3.4.7)
	VENDOR SUBMIT TEST PROCEDURES (8.3.1.1)		STRUCTURAL RESONANCE TEST (9.3.9.2)
	SUBMIT INSPECTION CHECK LIST (8.1.5)		REMOVE / INSPECT HYDRODYNAMIC BEARINGS AFTER TEST (9.2.7.5)
			AUXILIARY EQUIPMENT TEST (8.3.4.6)
			EQUIPMENT TO BE INCLUDED IN AUXILLIARY TESTS
			LOCATION OF AUXILIARY EQUIPMENT TEST
			IMPACT TEST (6.12.4.3) PER EN 13445
			PER ASME SECTION VIII
			REMOVE CASING AFTER TEST

DATASHEET No. _____ Rev: _____ SHEET of

RUHRPUMPEN

Specialist for Pumping Technology

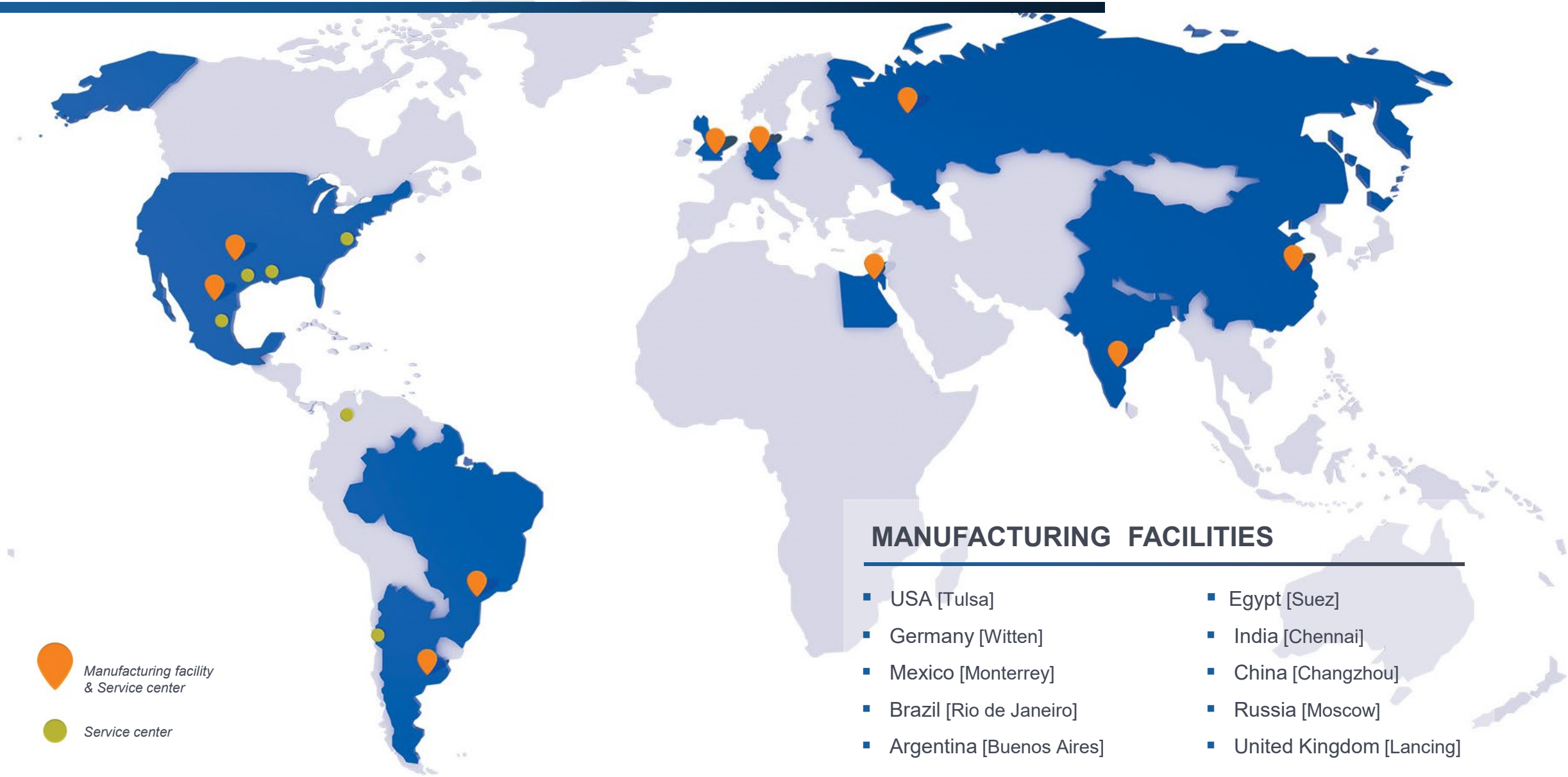
www.ruhrpumpen.com

info@ruhrpumpen.com


RUHRPUMPEN AT A GLANCE
VERTICAL INTEGRATION
SALES OFFICES IN +35 COUNTRIES
MANUFACTURING FACILITIES IN 10 COUNTRIES
+70 YEARS OF EXPERIENCE
+2,000 EMPLOYEES
15 SERVICE CENTERS
+70,000 PUMPING SOLUTIONS INSTALLED WORLDWIDE

A GLOBAL COMPANY

RUHRPUMPEN



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.

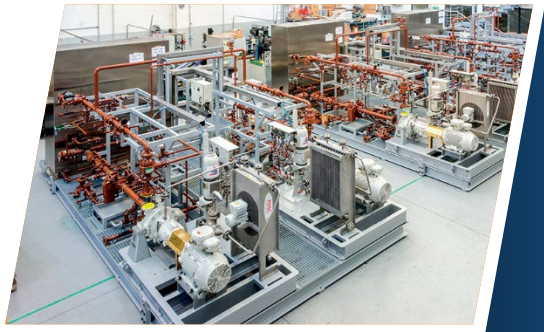
Our pumps can handle head requirements as high as 13,000 ft (4,000 m) and capacities up to 300,000 gpm (68,000 m^3/hr). Moreover, our pump designs cover temperatures from cryogenic temperatures of -310 °F (-196 °C) up to 752 °F (400 °C).

Products include:

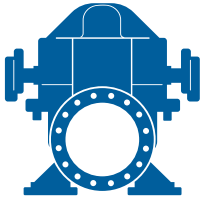
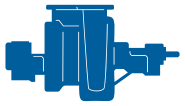
- Single Stage Overhung Pumps
- Between Bearings Pumps
- Horizontal Multi-Stage Pumps
- Vertical Multi-Stage Pumps
- Vertical Mixed Flow & Axial Flow Pumps
- Positive Displacement Pumps
- Full Range of Industrial Pumps
- Submersible Pumps
- Magnetic Drive Pumps
- Decoking Systems
- Packaged Systems
-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