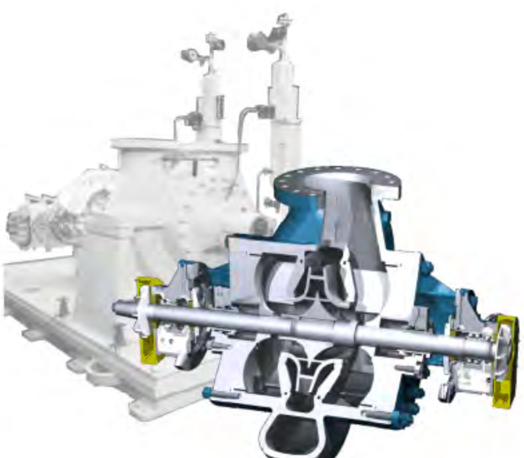
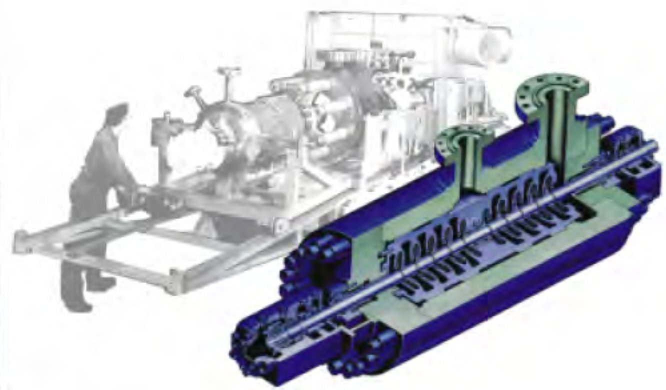
CLYDEUNION ACADEMY

API 610 PUMP REPAIRS AND UPGRADES

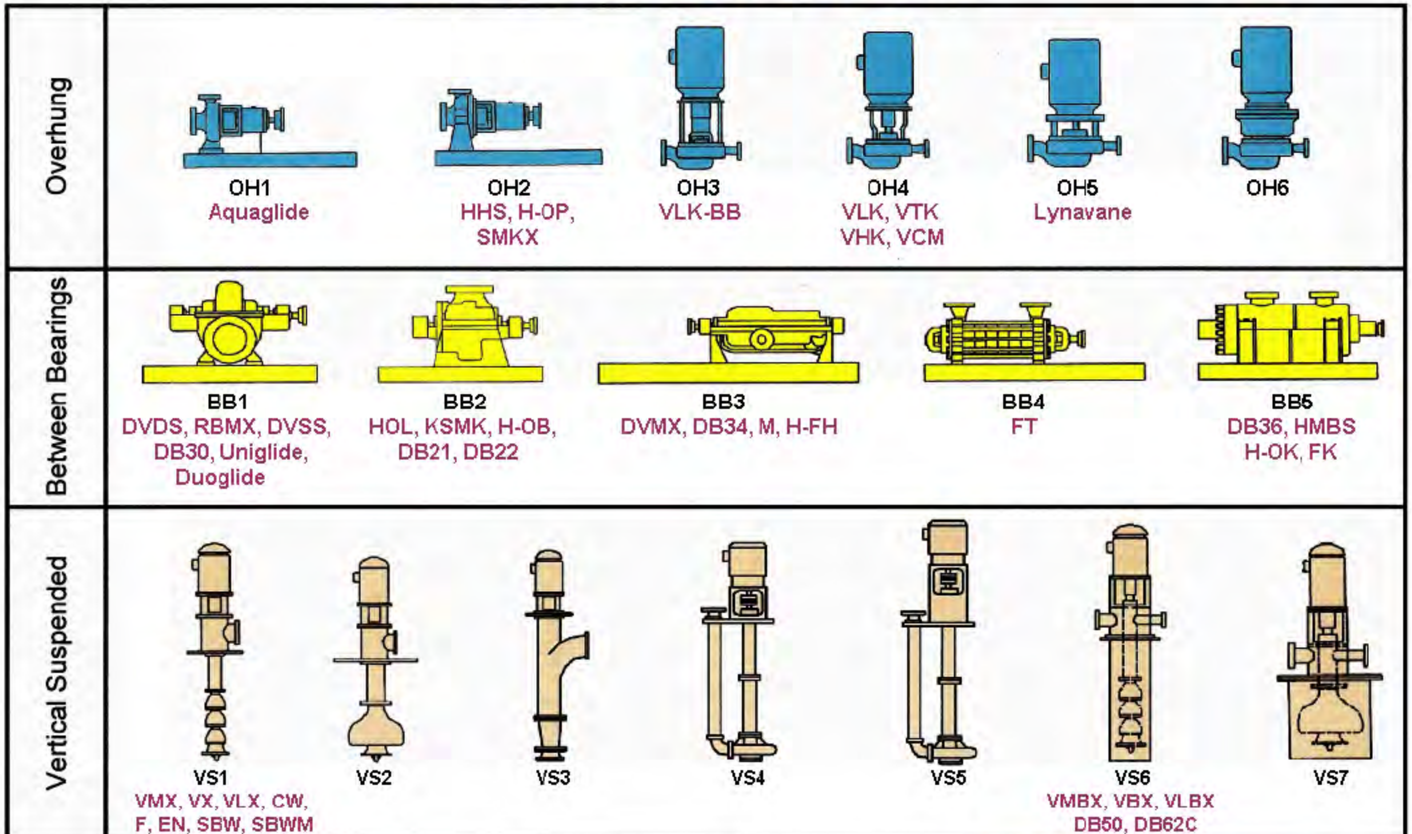
Presented by Tom Newman

Manager, Technical Services and Business Development, Aftermarket Engineering





API DESIGNATIONS



Other

Propeller Pumps, Model DB70

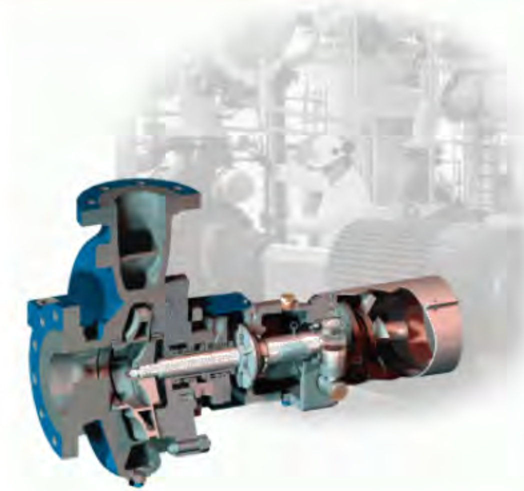
Multiphase, Model Turbopress and Turbine

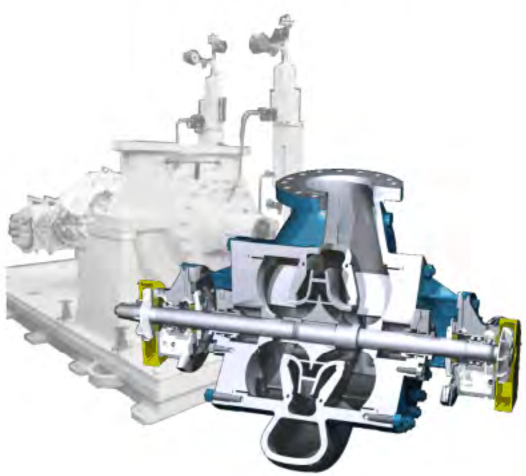
Sealless Pumps (Canned Motor Type), Model EVE, EHE

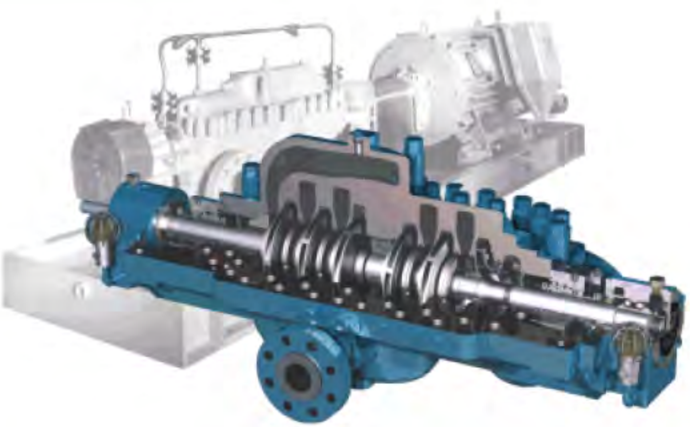
Positive Displacement, Models SE, SM, SS, SV, CH, FH, DE, DM, DS, DH, DV, MP, EN, SX-Twin, SX, DX, TX, TD, QD, TG

Repair/Upgrade Opportunities

- General Repair/Documentation
- Piping Upgrades/Gusseting
- Hydraulic Re-rates
- Material Upgrades
- Drop-In Replacement Pumps
- Back Pull-Out
- 360 Degree Bearing Housing Supports
- Emission Control
- OH4 Upgrades
- Field Testing
- Q&A







CLYDEUNION ACADEMY

Major Pipeline

Equipment Information
Pump Make: ABC Pump
Pump Type: 3 x 6 x 9 BB-3
Serial Number: S/N999999
Equipment Number: P-101
Repair Job Reference: ABC123

- KEY ITEMS TO INCLUDE
  - Table of Contents
  - Scope of Work
  - Quality Documents
    - Inspection Test Plan
    - Weld Procedures
    - Heat Treat Procedures
    - Material Specifications
  - Inspection Reports
    - As Found Reports
    - Testing/NDE
    - Balance Report
    - As Built Report
    - Heat Treat Records
    - Material Test Reports
  - Updated Bill of Material
  - Applicable Drawings
  - In Progress Photos

General Repair / Documentation – ITP

CLYDEUNION ACADEMY

CLYDEUNION

Inspection & Test Plan

Pump Model: 16x18x27 DB-30 Item No: 480-PU-003 A Pump Serial No: CA4626C 104

TASK DESCRIPTION	PROCEDURE	ACCEPTANCE CRITERIA	VERIFYING DOCUMENT	APPLICABLE TO	INSP CODE			NOTES
Pump								
Weld Repair Casing Crack and Wear ring Fit Area	S-209	ASME	Report	Lower Pump Casing	U, H, C			
Post Weld Heat Treat	PWHT S-209	ASME	Report	Lower Pump Casing	U, C			
Liquid Penetrant Inspection (LPI)	CES 3008.00	ASME	Certificate	Lower Pump Casing Repairs	U, C			
Ultrasonic Inspect Casing Weld Repair (UT)	CES 3016.00	ASME	Certificate	Lower Pump Casing Repairs	U, C			
Radiographic Inspection of Weld Repairs if LPI / UT is inconclusive (RT)	CES 3015.00	ASME	Certificate	Lower Pump Casing Repairs	U, C			
Review Weld Inspection documents before Hydrostatic Test	Per Shell DEP requirements	API 610 & Shell DEP	Certificate	Lower Pump Casing Repairs	H, W			
Casing Machining	Per Drawings	Drawing Tolerances	CU Internal Work Order	Casing halves	•			
Hydrostatic Test	CES 3001.00	API-610 8th ed.	Certificate	Casing, cover	• W,C			
Performance Test	CES 3002.01	API-610 8th ed.	Perf. Curve	Pump Performance	U,H,C			
Vibration Spectra	CES 3002.01	API-610 8th ed.	Data / Report	Pump Performance	U,H,C			
Hydrodynamic bearing check after test	N/A	N/A	Report	Mechanical Performance	U, H, C			
NPSH Test	CES 3002.01	API-610 8th ed.	Perf. Curve	Pump Performance	U,H,C			
Hardness Check - Shaft	Vendor Standard	ASTM E112	Certificate	Shaft	U,C			
Hardness Check – Wear Rings	Vendor Standard	API-610	Certificate	Wear Rings	U,C			
Material Certification	Vendor Standard	ASTM Standard	Certificate	Impeller, Shaft	• U,C			
As Found Data (TDIQ)	N/A	N/A	As Built Report	Pump	• U			

LEGEND:

H - Hold: "By UP" - Internal QS requirements only. "By customer" - Manufacturing will not proceed without customer approval or waiver.

W - Witnessed: Manufacturing will not proceed until customer has witnessed the required task.

C - Certified: Certificate or Report will be provided as part of final data package.

U - Unwitnessed: No customer witness requirements identified. Certificate or Report will be provided as part of final data package.

•: Activity carried out to satisfy UP internal quality system requirements.

BUR-24c Rev 4 Feb-04-05

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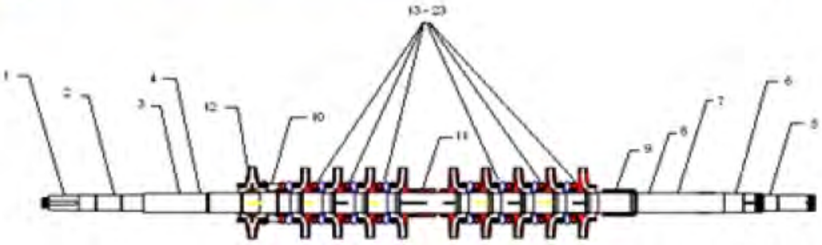
CLYDEUNION UNION PUMPS

As Found Inspection Report
Rotor TIR



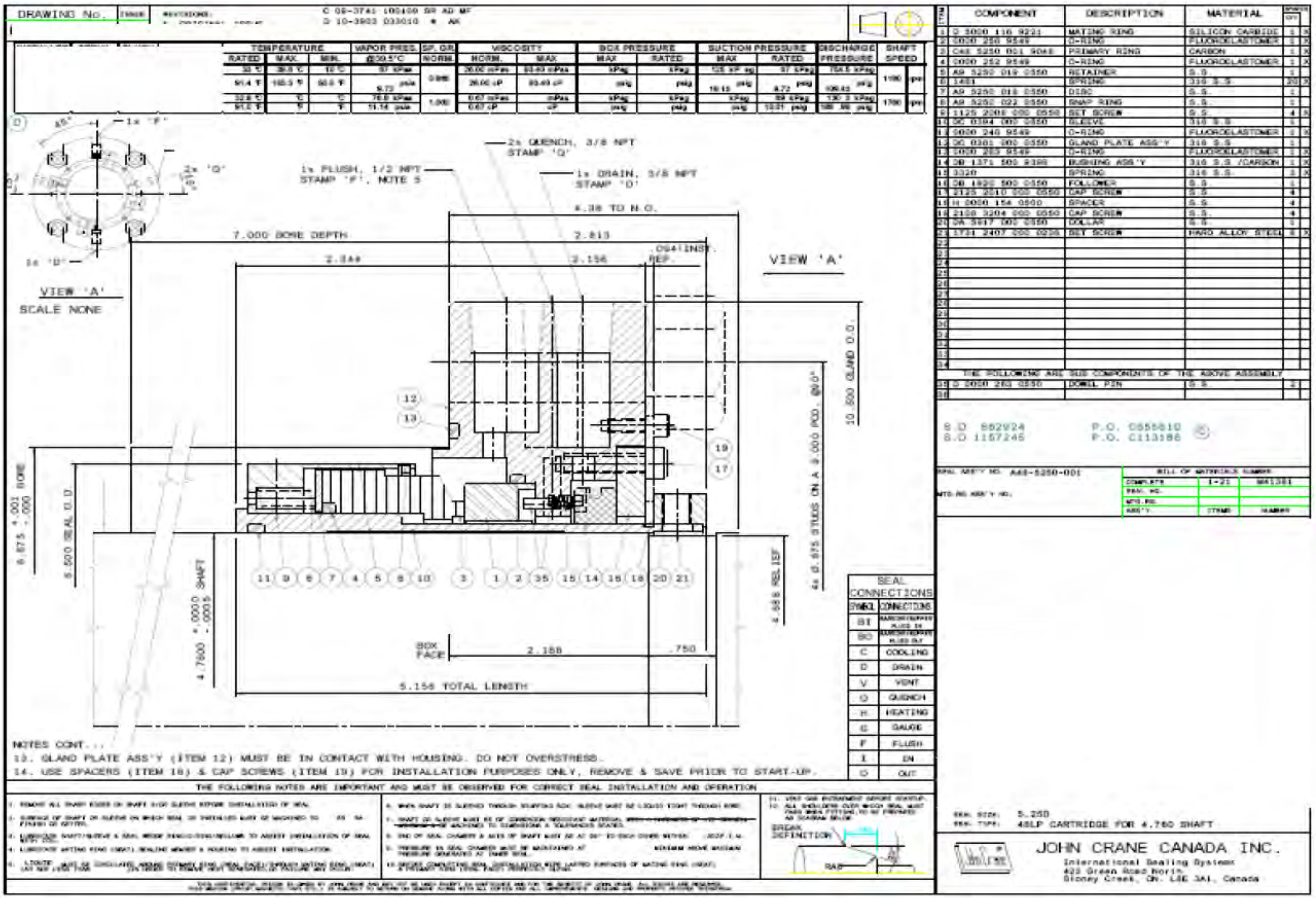
DESCRIPTION
1. TIR @ Coupling
2. TIR @ Radial Brg.
3. TIR @ IB Seal Box
4. TIR @ IB Throat Bushing
5. TIR @ Thrust Collar
6. TIR @ Thrust Brg.
7. TIR @ OB Seal Box
8. TIR @ OB Throat Bushing
9. TIR @ Comp. Bushing
10. TIR @ 1st Stg Pc
11. TIR @ Center Bushing
12-23. TIR @ Impeller

ROTOR RUN-OUT		Status
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

ROTOR RUN-OUT			Status
	Impeller Stage		
12	Suction		
13	2		
14	3		
15	4		
16	5		
17	6		
18	7		
19	8		
20	9		
21	10		
22	11		
23	12		

	Status
R-	Rework
S-	Scrap
OK-	Okay

General Repair / Documentation – Seal Drawing



General Repair / Documentation – As Built

CLYDEUNION ACADEMY

CLYDEUNION
UNION PUMPS

As Built Inspection Report
Rotor

Date: ____________

Customer: ____________

Job Number: ____________

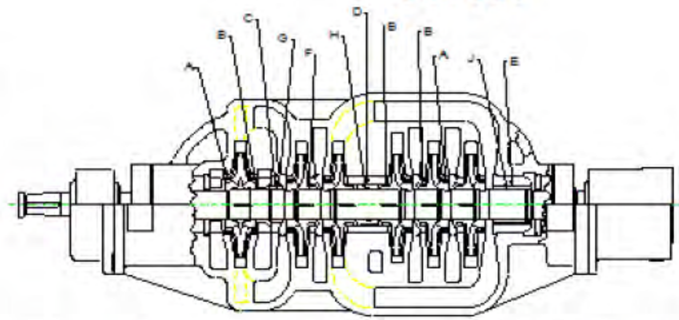
Serial Number: ____________

Pump Type: ____________

Pump Size: ____________

No. of Stages: ____________

Inspected By: ____________

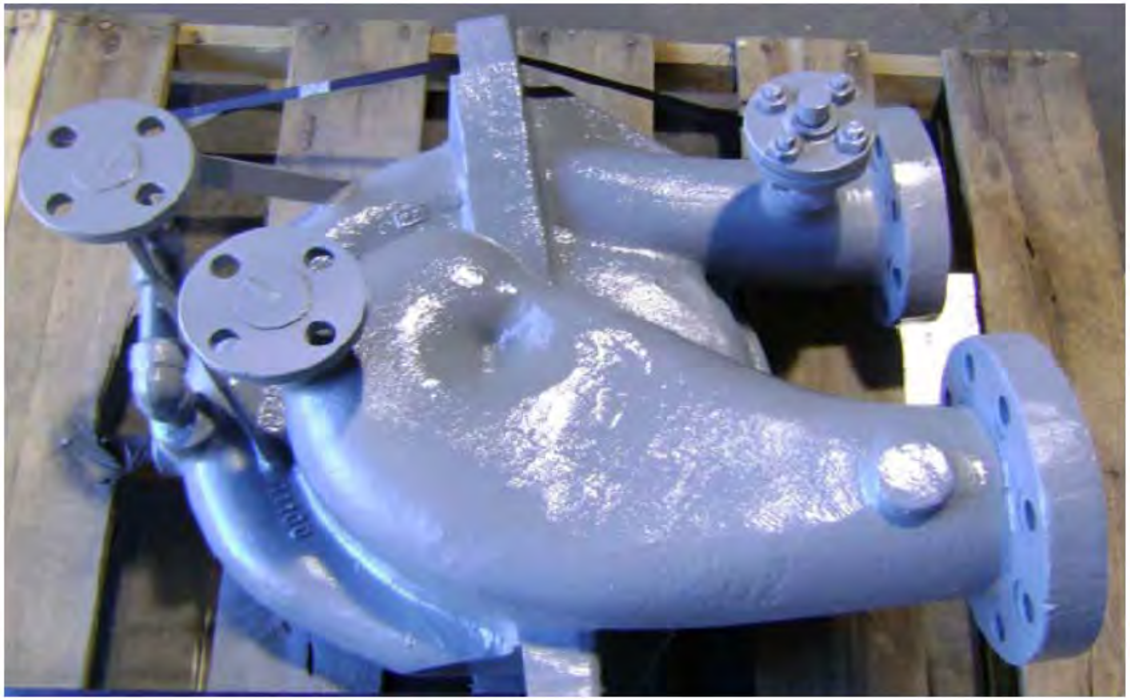


Description
A-Case Wear Ring ID to Impeller Wear Ring OD (Front)
B-Case Wear Ring ID to Impeller Wear Ring OD (Back)
C-1st Stage Piece ID to 1st Stage Sleeve OD
D-Center Bushing ID to Center Sleeve OD
E-Compensating Bushing ID to Compensating Sleeve OD
F-Impeller Bore ID to Impeller Journal OD Fit
G-1st Stage Sleeve ID to Shaft OD Fit
H-Center Sleeve ID to Shaft OD Fit
J-Compensating Sleeve ID to Shaft OD Fit

Stage	Starting Point	DESCRIPTION	SIZES (F)	SIZES (B)	DESCRIPTION	SIZES
Suction		Casing Ring ID			Impeller ID	
Imp. Diameter		Impeller Ring OD			Shaft OD	
No. of Vanes		**Clearance**			**Clearance**	
1st Stage Piece		1st Stage Piece ID			1st Stage Sleeve ID	
		1st Stage Sleeve OD			Shaft OD	
		Clearance			**Clearance**	
		Casing Ring ID			Impeller ID	
Imp. Diameter		Impeller Ring OD			Shaft OD	
No. of Vanes						
		Casing Ring ID			Impeller ID	
Imp. Diameter		Impeller Ring OD			Shaft OD	
No. of Vanes						
2nd		Casing Ring ID			Impeller ID	
Imp. Diameter		Impeller Ring OD			Shaft OD	
No. of Vanes		**Clearance**			**Clearance**	
3rd		Casing Ring ID			Impeller ID	
Imp. Diameter		Impeller Ring OD			Shaft OD	
No. of Vanes		**Clearance**			**Clearance**	

Piping Modifications

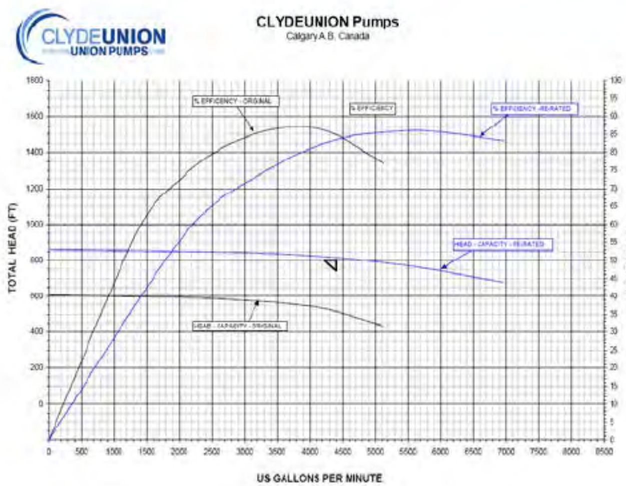
- Upgrade NPT connections to socket weld
- Two plane gusseting of piping
- Applicable to WCB, CA6NM and 300 SS
- Reduce risk of fires on older high temperature pumps



CLYDEUNION ACADEMY

Hydraulic Re-Rate Classifications:

- Impeller Modifications:
  - Trimming
  - De-Staging
  - Under File (U/F)
  - Inlet Vane Cutback
- Casing/Volute Modifications:
  - Volute Lip Cutback
  - Angled Volute Lip Cutback
  - Volute Lip Extension
  - Custom Hydraulics



HYDRAULIC RE-RATES

CLYDEUNION ACADEMY

AFFINITY TRIM LAWS

$$\text{FLOW} = \frac{Q1}{Q2} = \frac{D1}{D2}$$

$$\text{HEAD} = \frac{H1}{H2} = \left[\frac{D1}{D2}\right]^2$$

$$\text{BHP} = \frac{BHP1}{BHP2} = \left[\frac{D1}{D2}\right]^3$$

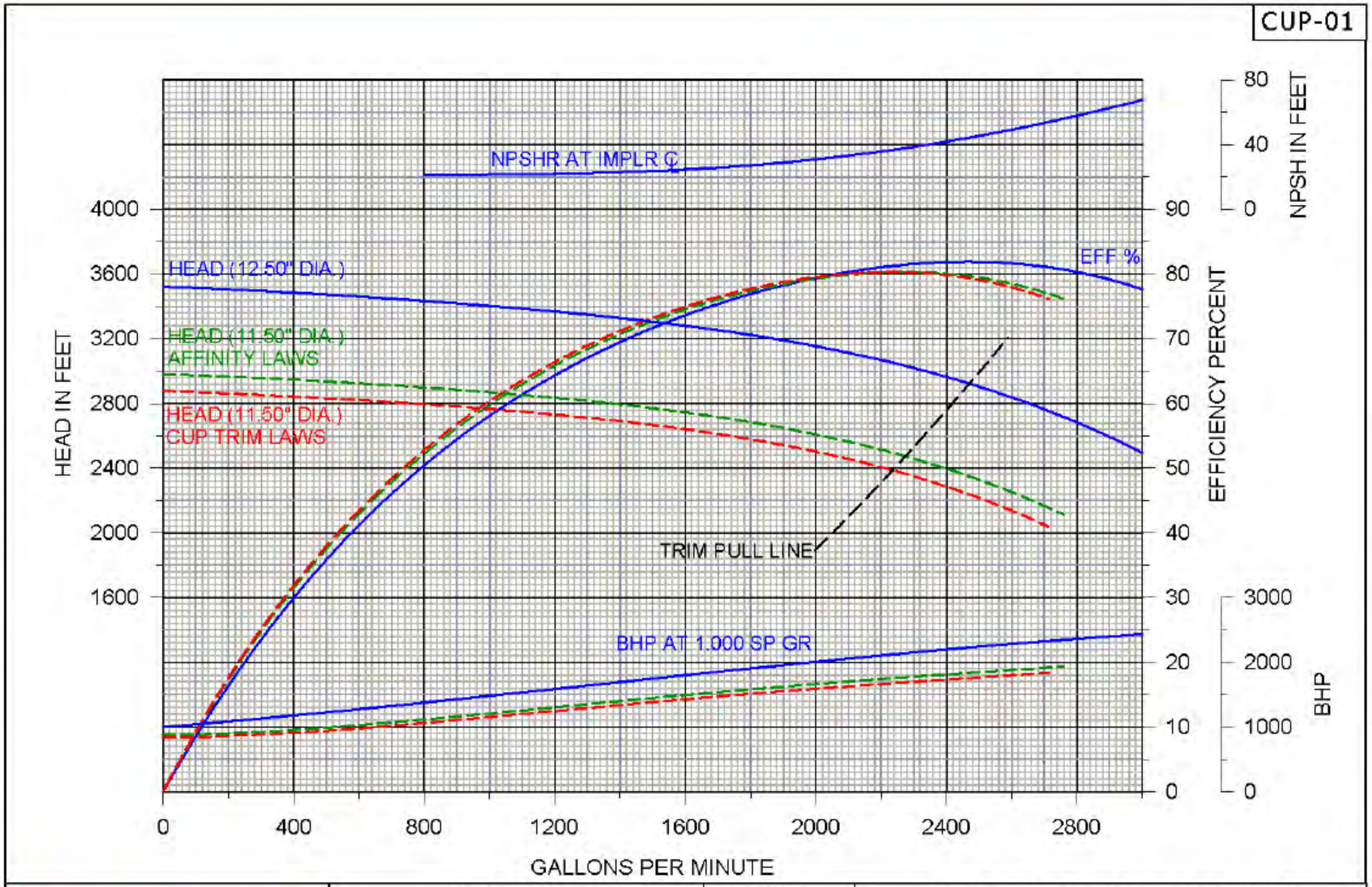
CLYDEUNION TRIM LAWS

$$\text{FLOW} = \frac{Q1}{Q2} = \frac{D1}{D2} \quad \text{+/- Variable}$$

$$\text{HEAD} = \frac{H1}{H2} = \left[\frac{D1}{D2}\right]^2 \quad \text{+/- Variable}$$

$$\text{BHP} = \frac{BHP1}{BHP2} = \left[\frac{D1}{D2}\right]^3 \quad \text{+/- Variable}$$

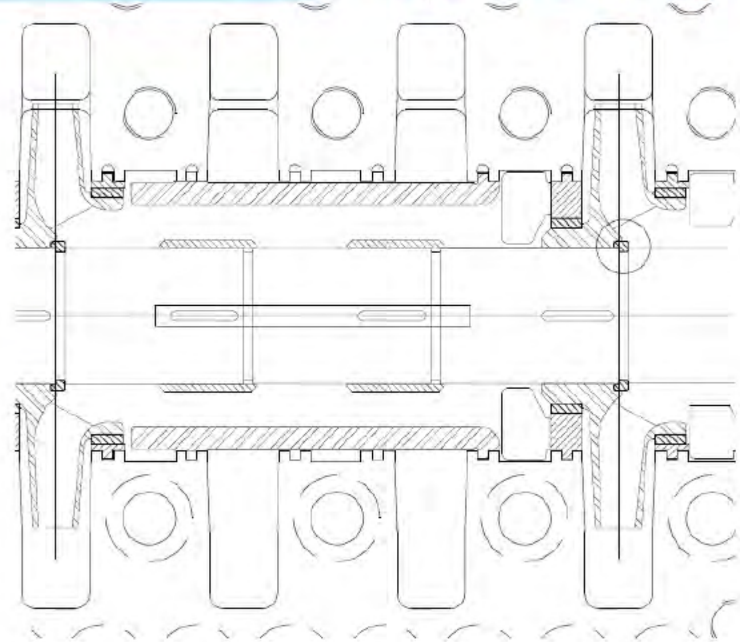
HYDRAULIC RE-RATES

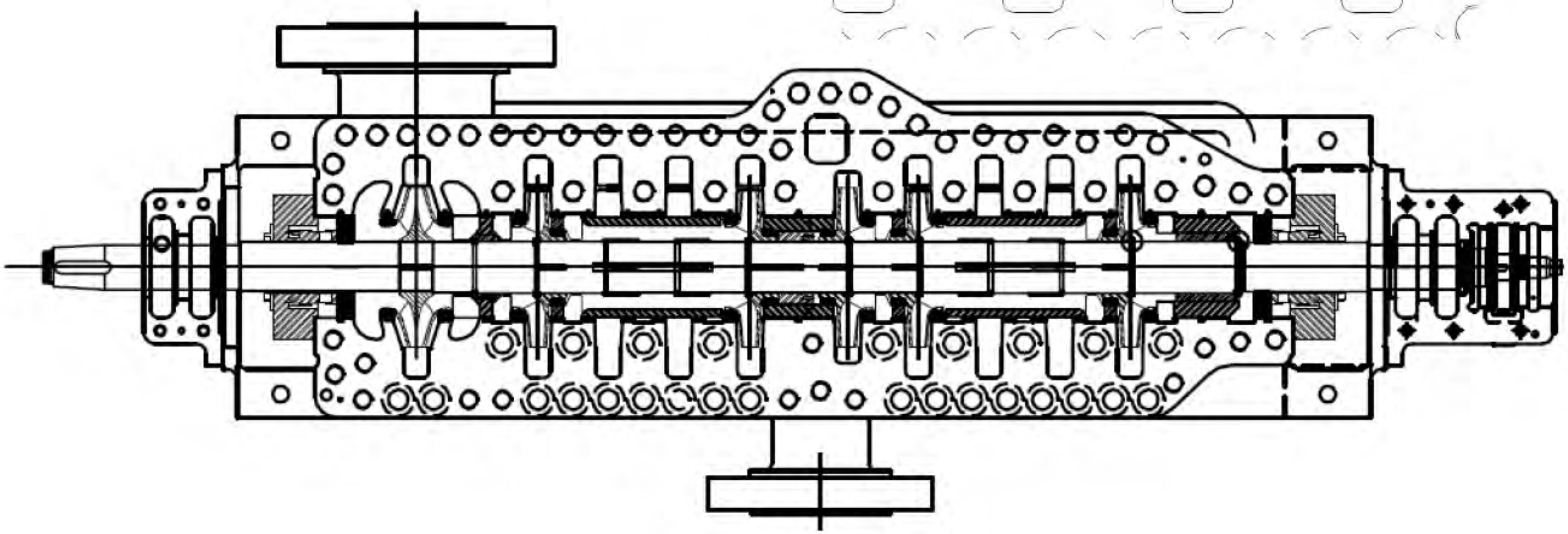


CLYDEUNION PUMPS	TRIM EXAMPLE AFFINITY TRIM LAWS vs CLYDEUNION TRIM LAWS	IMPELLER MAX DIA 12.50"	6 x 8 x 13X CUP-BB3-S 5-STG		
			DIA IMPELLER 11.50"	IMPELLER PATT	3560 RPM
		EYE AREA SQ IN 40.0	REFERENCE C10020		CURVE NO CUP-01
					REV _

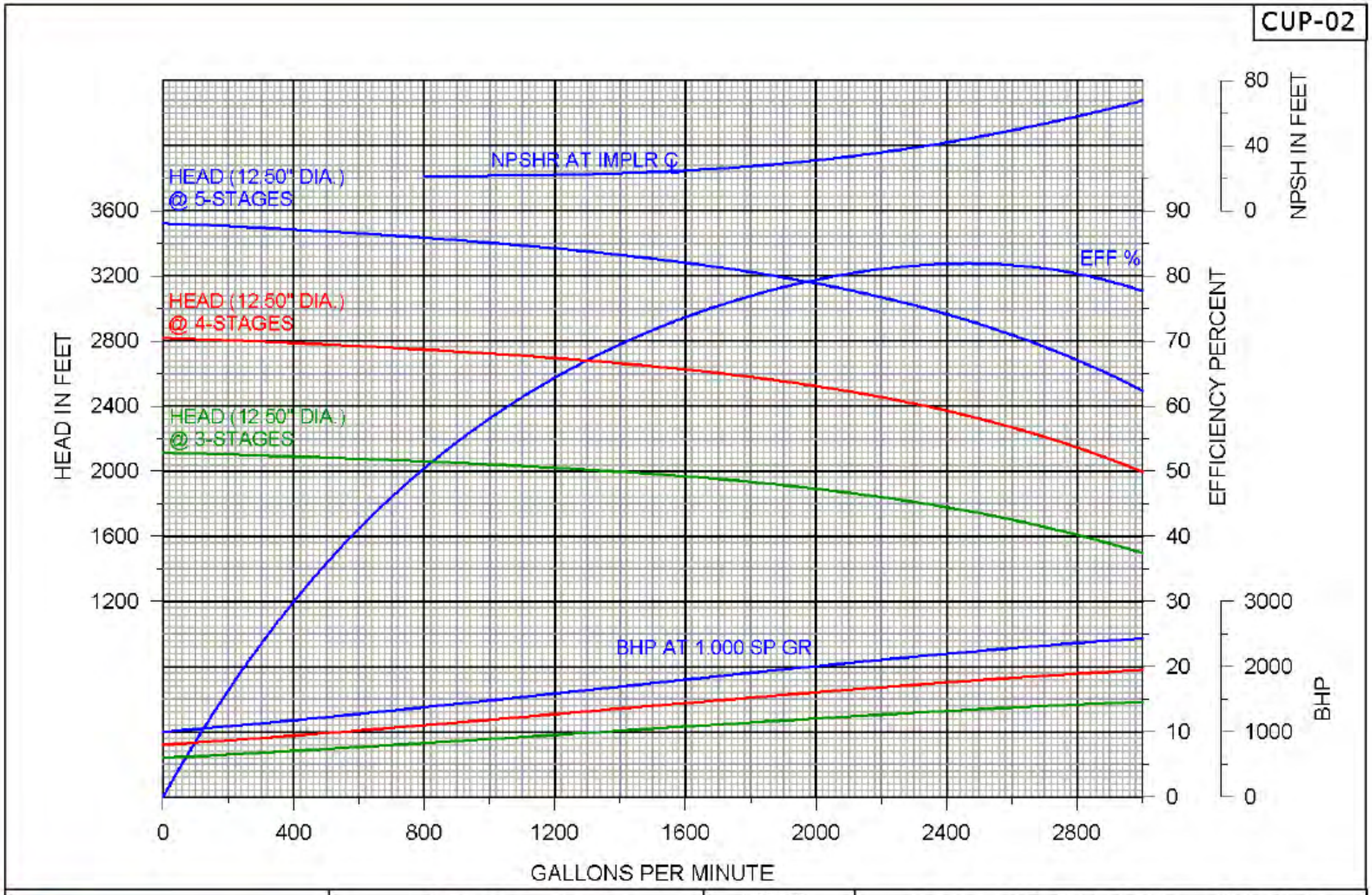
HYDRAULIC RE-RATES, Pump De-staging

It is not unusual for pipelines to start up at low pressure then later change to high pressure at constant throughput. This change in pump head requirements can be suitably handled by selecting a multi-stage pump for the ultimate high pressure condition. For the initial low pressure condition, appropriate impellers are removed and the inter-stage chambers isolated by de-staging cylinders and sleeves. When changing to high pressure the de-staging cylinders and sleeves are removed and additional impellers installed (see illustrations below)

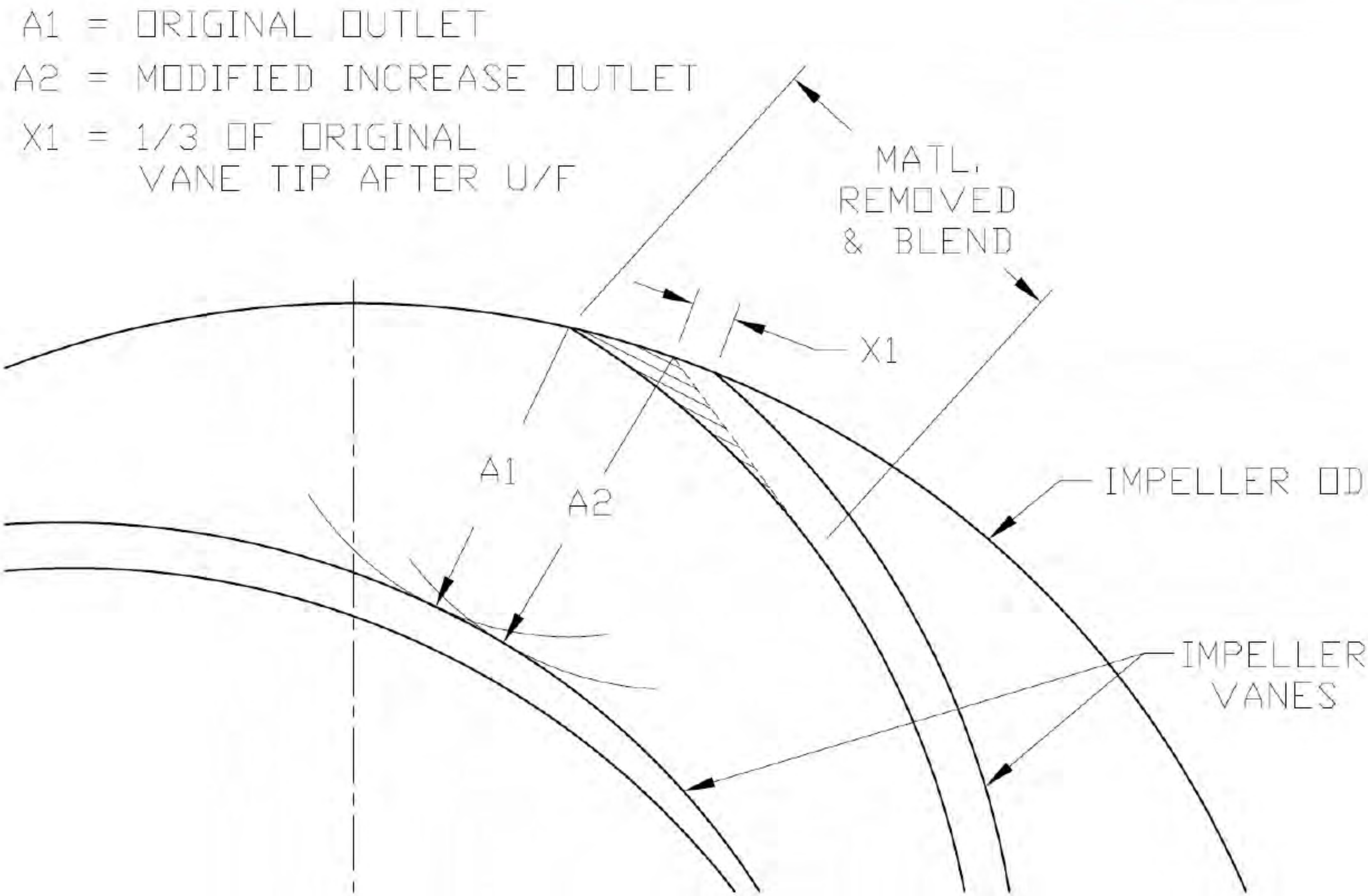




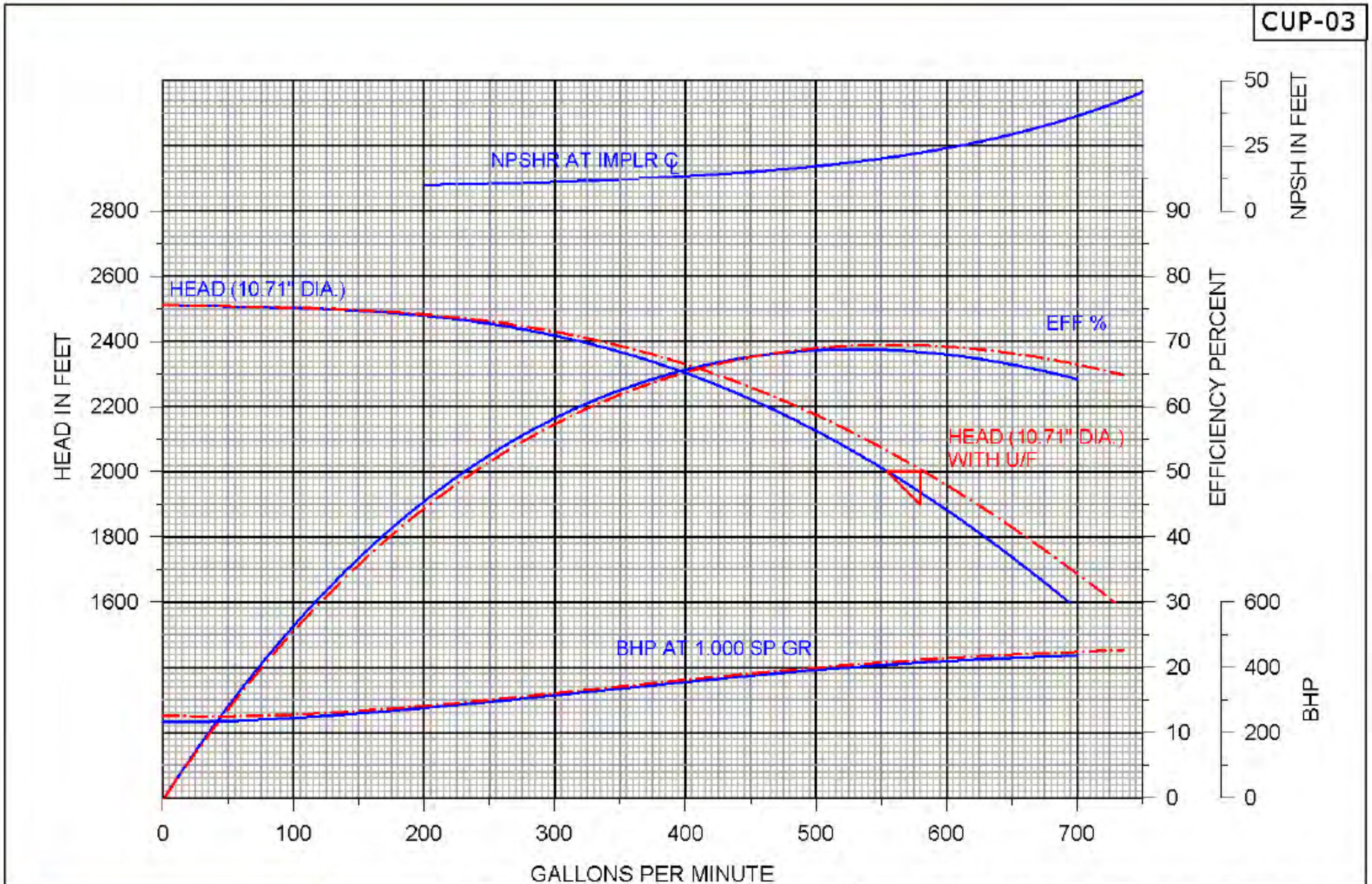
HYDRAULIC RE-RATES, Pump De-staging



CLYDEUNION PUMPS	DE-STAGE EXAMPLE 5-STAGE PERFORMANCE 4-STAGE PERFORMANCE 3-STAGE PERFORMANCE	IMPELLER MAX DIA 12.50"	6 x 8 x 13X CUP-BB3-S 5/4/3-STG			
			DIA IMPELLER 11.50"	IMPELLER PATT	3560 RPM	
		EYE AREA SQ IN 40.0	REFERENCE C10020		CURVE NO CUP-02	REV _


A1 = ORIGINAL OUTLET
A2 = MODIFIED INCREASE OUTLET
X1 = 1/3 OF ORIGINAL VANE TIP AFTER U/F
MATL. REMOVED & BLEND
X1
A1
A2
IMPELLER OD
IMPELLER VANES

Hydraulic Re-Rates, Impeller Underfile (U/F)



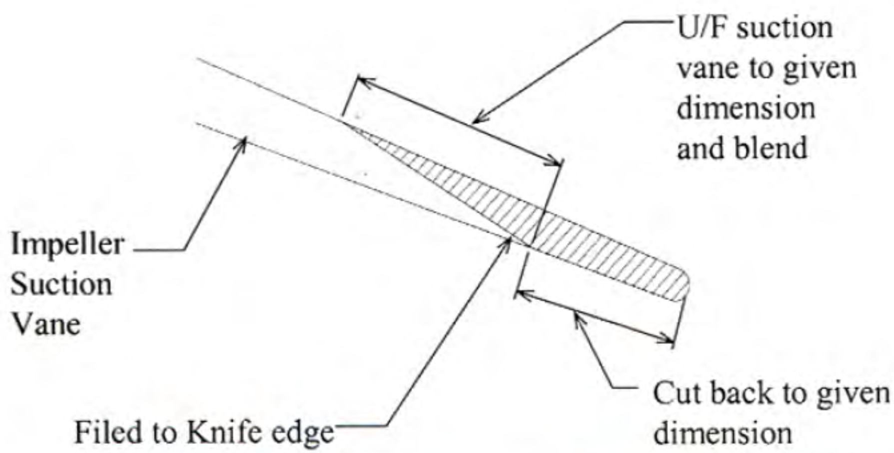
CLYDEUNION PUMPS	U/F EXAMPLE	IMPELLER MAX DIA 10.71"	3 x 4 x 11W CUP-BB3-S 5-STG		
			DIA IMPELLER 10.71"	IMPELLER PATT	3560 RPM
		EYE AREA SQ IN 15.0	REFERENCE C10006		CURVE NO CUP-03
					REV _

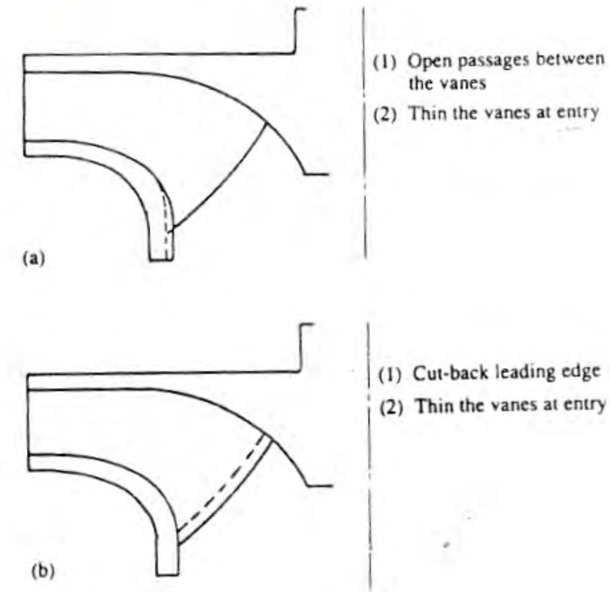
Hydraulic Re-Rate, Inlet Vane Cutback

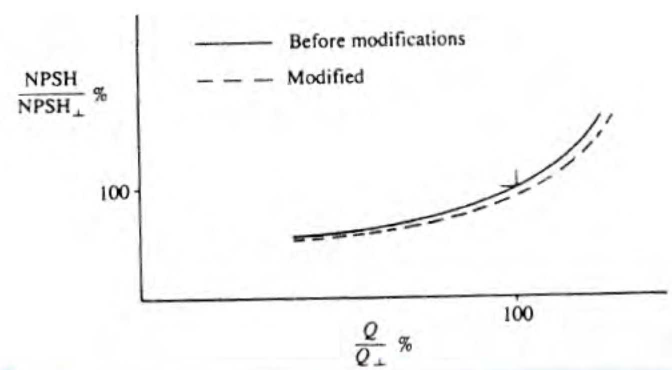
CLYDEUNION ACADEMY

Cutback and file from the back (non-visible) side of the suction vane inlet

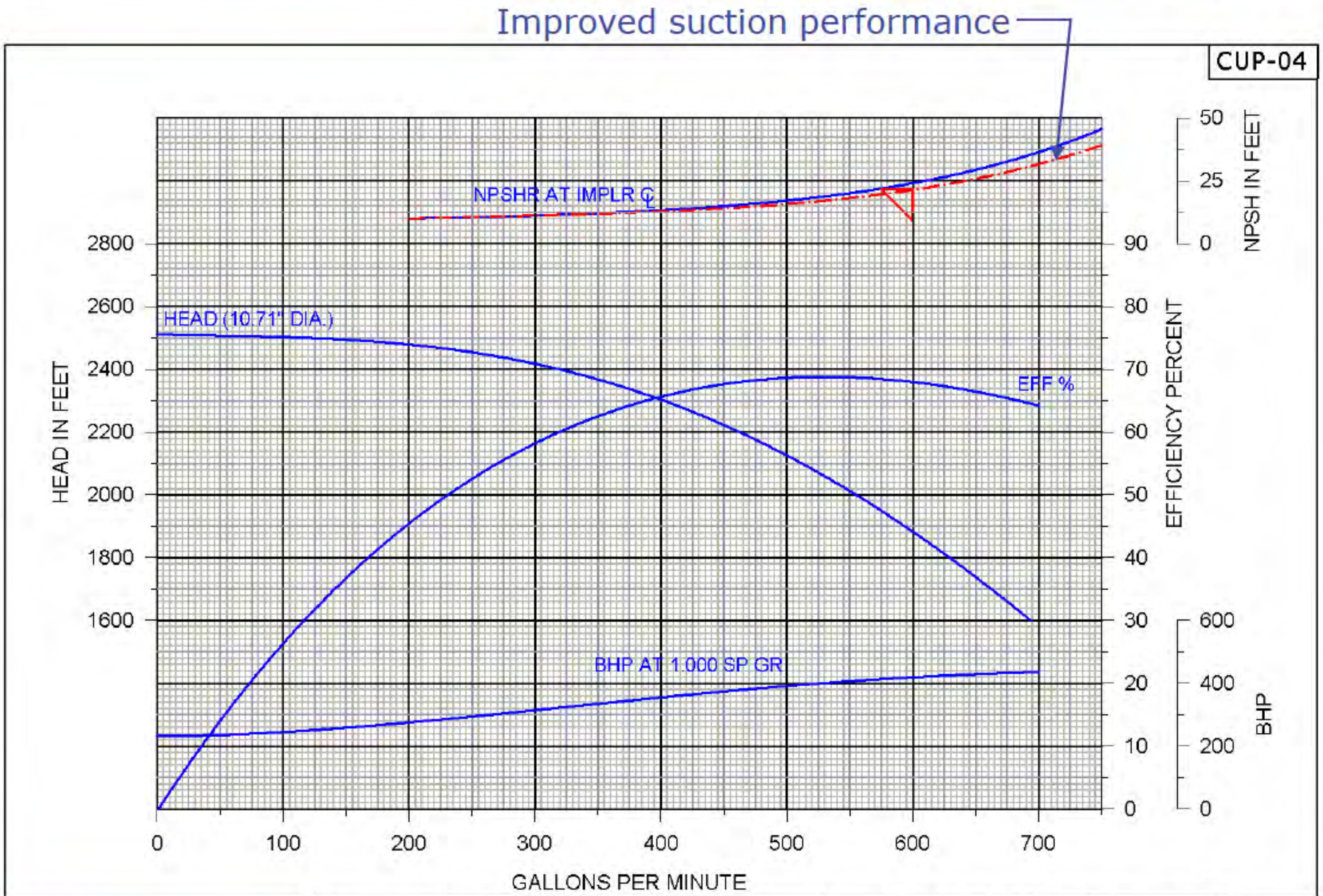
Cutback & File of Suction Vanes





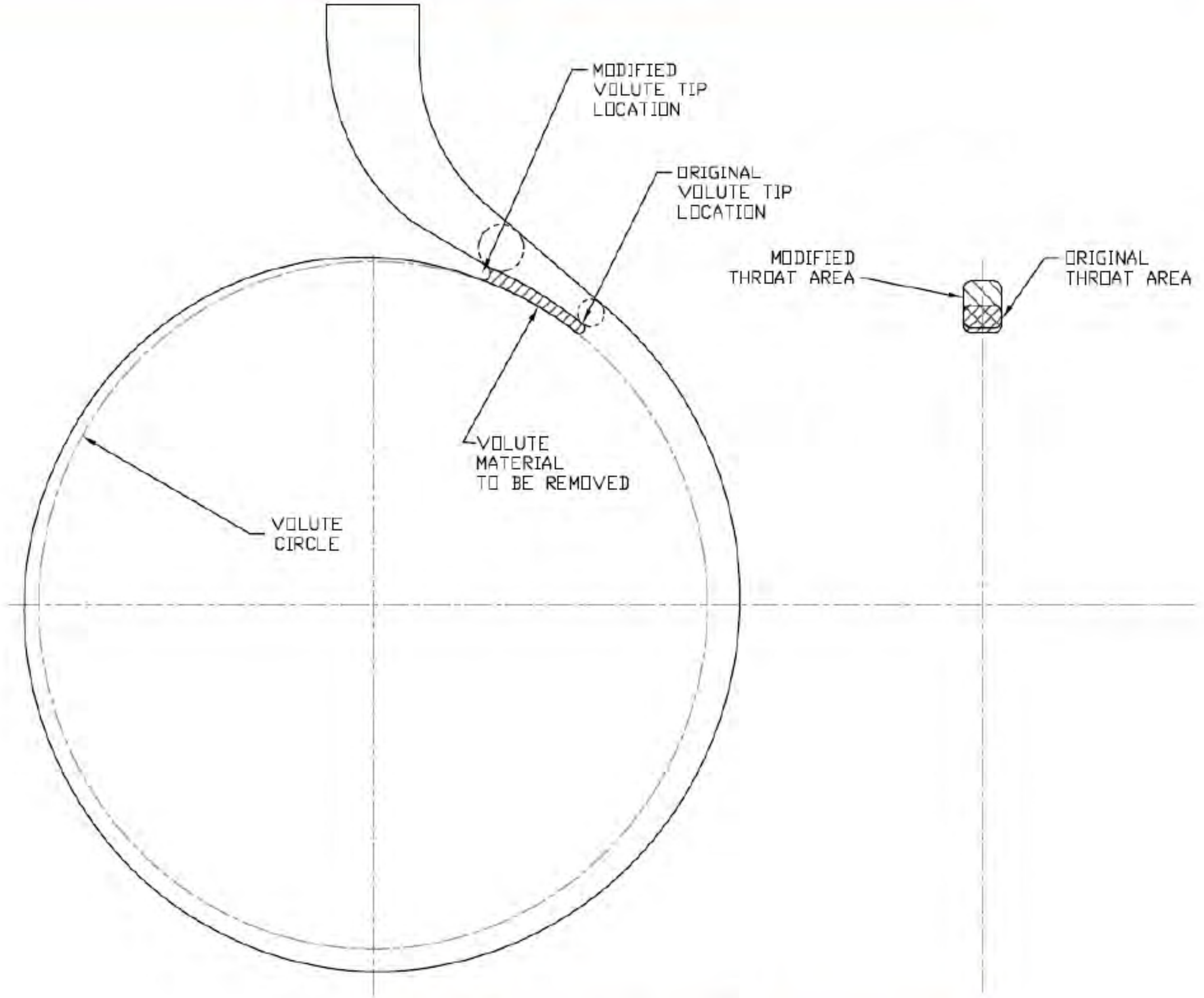


Hydraulic Re-Rate, Inlet Vane Cutback



CLYDEUNION PUMPS	O/F EXAMPLE	IMPELLER MAX DIA 10.71"	3 x 4 x 11W CUP-BB3-S 5-STG			
			DIA IMPELLER 10.71"	IMPELLER PATT	3560 RPM	
		EYE AREA SQ IN 15.0	REFERENCE C10006		CURVE NO CUP-04	REV _

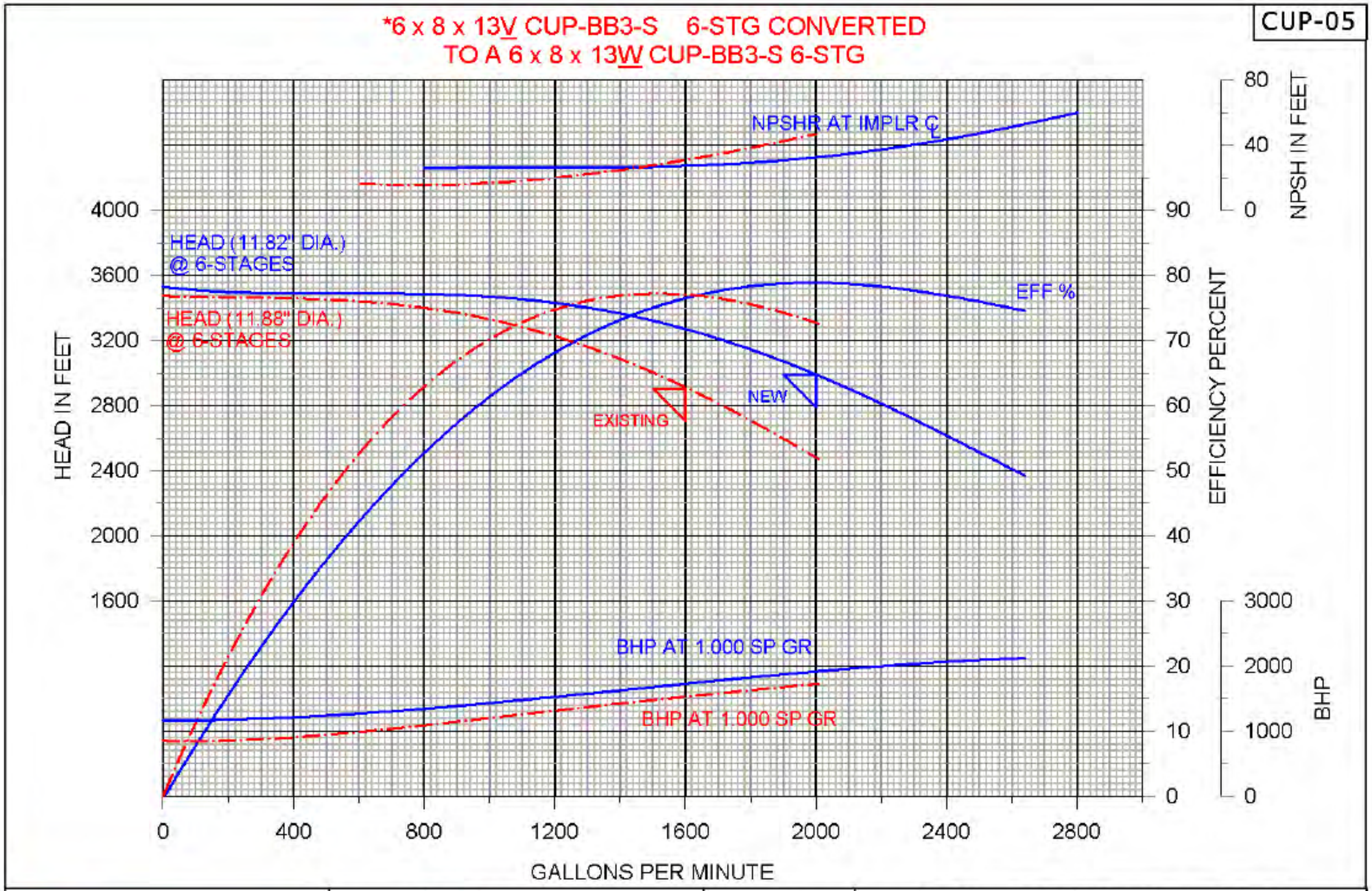
Hydraulic Re-Rate, Volute Lip Cutback



TYPICAL VOLUTE LIP CUTBACK

Hydraulic Re-Rate, Volute Lip Cutback

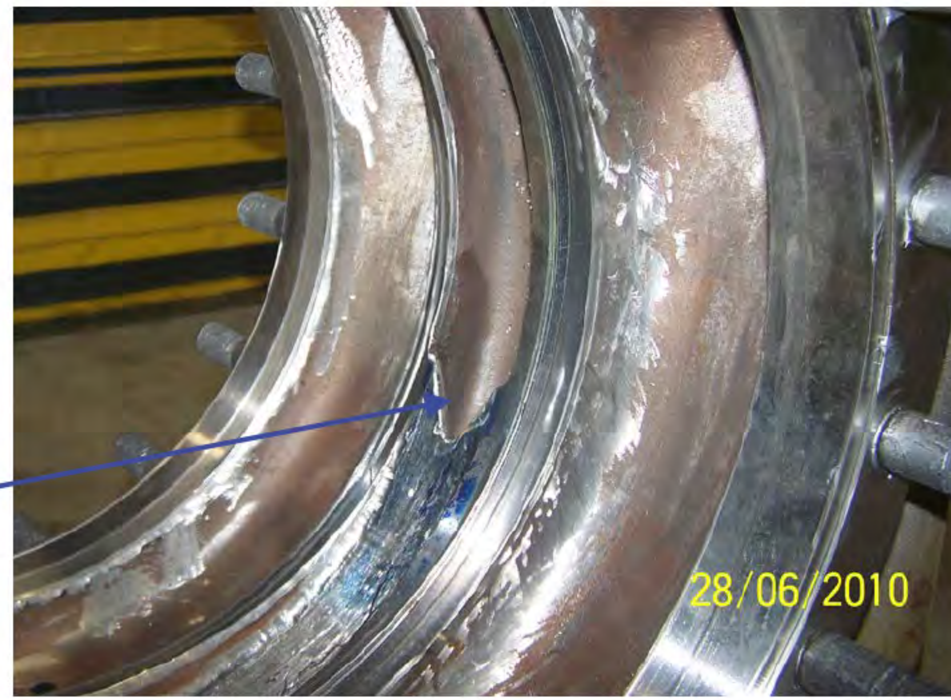
CLYDEUNION ACADEMY



CLYDEUNION PUMPS	VOLUTE LIP CUTBACK VOLUTE LIPS CUTBACK ROTOR CHANGE OUT	IMPELLER MAX DIA 12.50"/12.88"	*6 x 8 x 13V CUP-BB3-S 6-STG			
			DIA IMPELLER 11.88"/11.82"	IMPELLER PATT	3560 RPM	
		EYE AREA SQ IN	REFERENCE C10018/19		CURVE NO. CUP-05	REV _

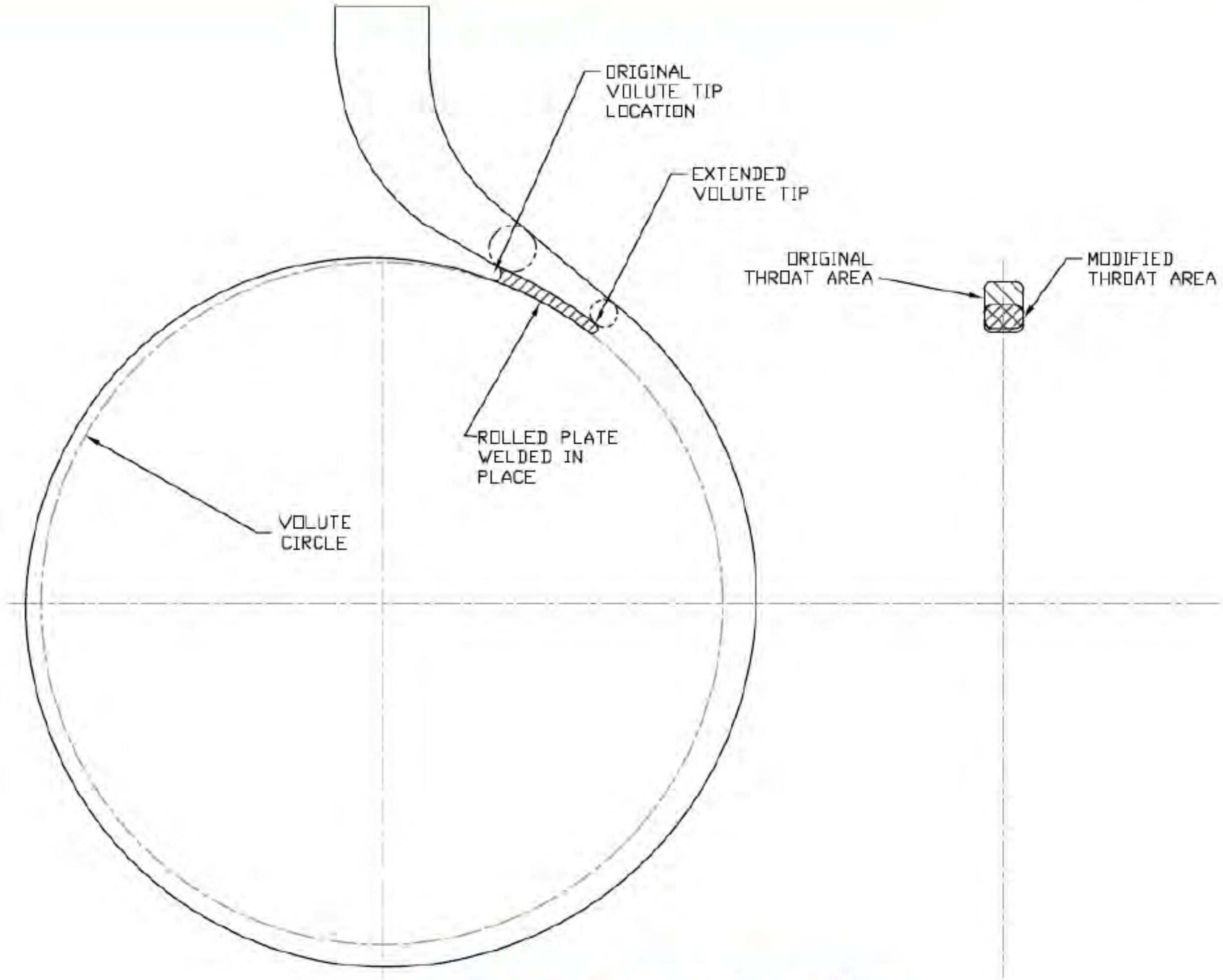
Hydraulic Re-Rate, Volute Lip 'V' Cutback

<u>VOLUTE 'V' NOTCHING</u>



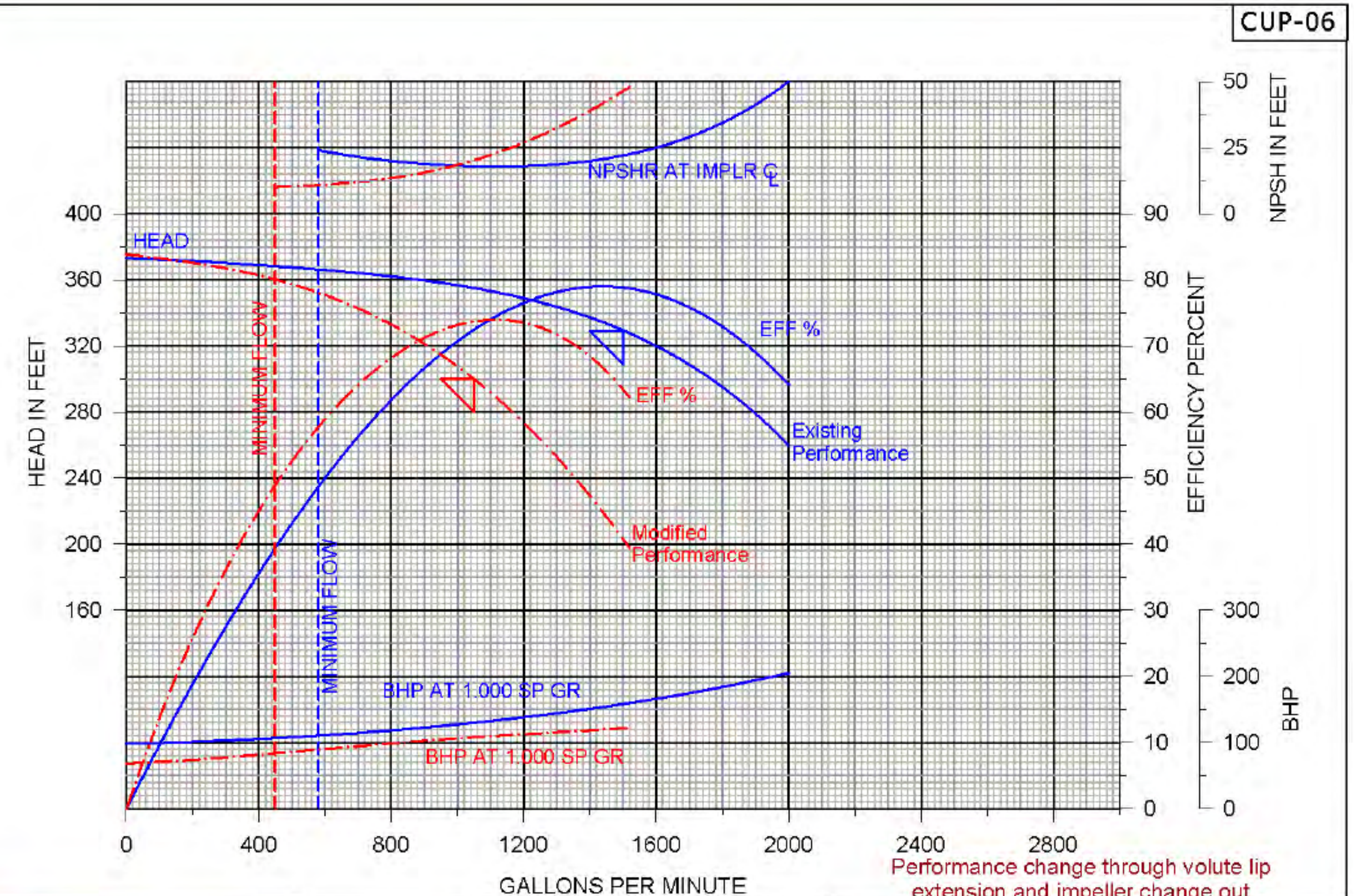
Restore volute and cutback

Hydraulic Re-Rate, Volute Lip Extension



TYPICAL VOLUTE LIP EXTENSION

Hydraulic Re-Rate, Volute Lip Extension



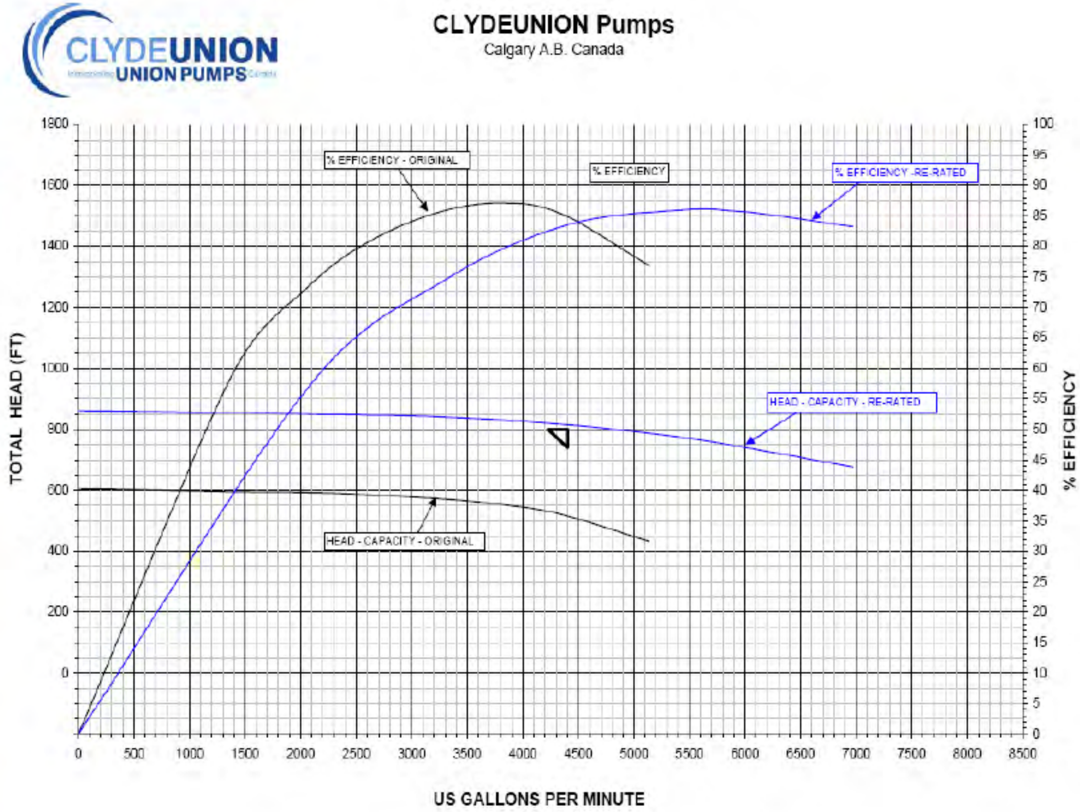
Performance change through volute lip extension and impeller change out

CLYDEUNION PUMPS	VOLUTE LIP EXTENSION 6 x 6 x 10A CUP-OH2 6 x 6 x 10C CUP-OH2	IMPELLER MAX DIA 10.50"	6 x 6 x 10A/C CUP-OH2 1-STG			
			DIA IMPELLER 9.82"	IMPELLER PATT	3560 RPM	
		EYE AREA SQ IN	REFERENCE HHS6610a/c1		CURVE NO CUP-06	REV _

Hydraulic Re-Rate, Custom Hydraulics

Re-rate a United S-10 X 14 DVS (BB1) to meet new system curves based on four products with varying viscosities. The motor horsepower would be increased from 800 to 1250, with a goal of maximizing flow based on new available horsepower, system curves, and viscosity range from 45 cSt to 981 cSt

- Design and Manufacture a new impeller
- Hydraulic modifications to the existing volute
- Base plate modifications to accept new motor



MATERIAL UPGRADES

- Change API Material Designation
- Non-Metallic Wear Parts
  - PEEK
  - Vespel
  - Graphalloy
- Cladding/Weld Overlay
  - Inconel Overlay
  - Monel Overlay
- Wear Resistant Coatings

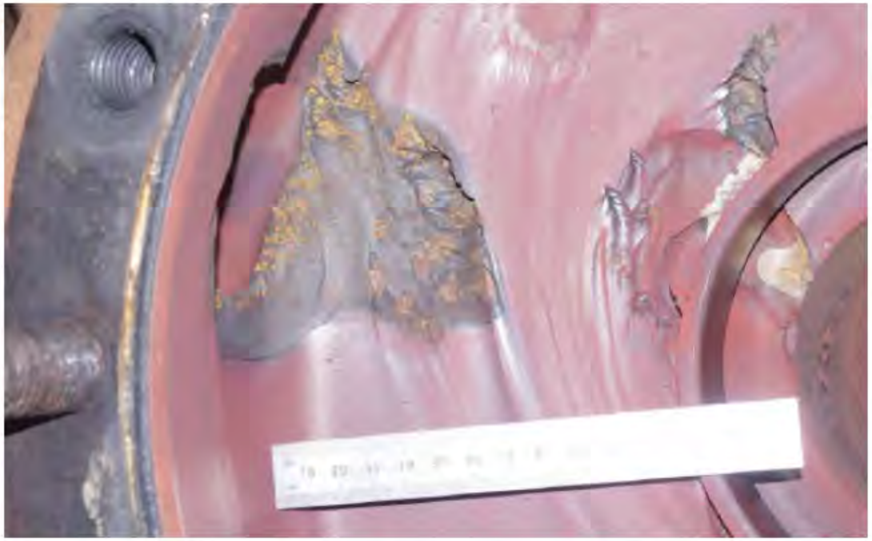


Table H.1 — Material classes for pump parts

PART	Full compliance materials[b]	Material classes and abbreviations													
		I-1	I-2	S-1	S-3	S-4	S-5	S-6	S-8[f]	S-9[l]	C-6	A-7	A-8	D-1[j]	D-2[j]
		CI[a]	CI	STL	STL	STL	STL	STL	STL	STL	12 % CHR	AUS	316 AUS	Duplex	Super Duplex
		CI	BRZ	CI	NI-RESIST	STL	STL 12 % CHR	12 % CHR	316 AUS	Ni-Cu Alloy	12 % CHR	AUS[c, d]	316 AUS[d]	Duplex	Super Duplex
Pressure casing	Yes	Cast iron	Cast iron	Carbon steel	Carbon steel	Carbon steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	12 % CHR	AUS	316 AUS	Duplex	Super Duplex
Inner case parts: (bowls, diffusers, diaphragms)	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	Carbon Steel	12 % CHR	316 AUS	Ni-Cu Alloy	12 % CHR	AUS	316 AUS	Duplex	Super Duplex
Impeller	Yes	Cast iron	Bronze	Cast iron	Ni-Resist	Carbon steel	Carbon Steel	12 % CHR	316 AUS	Ni-Cu Alloy	12 % CHR	AUS	316 AUS	Duplex	Super Duplex
Case wear rings[k]	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	12 % CHR Hardened	12 % CHR Hardened	Hard-faced 316AUS[e]	Ni-Cu Alloy	12 % CHR Hardened	Hard-faced AUS[e]	Hard-faced 316 AUS[e]	Hard-faced Duplex[e]	Hard-faced Super Duplex[e]
Impeller wear rings[k]	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	12 % CHR Hardened	12 % CHR Hardened	Hard-faced 316AUS[e]	Ni-Cu Alloy	12 % CHR Hardened	Hard-faced AUS[e]	Hard-faced 316 AUS[e]	Hard-faced Duplex[e]	Hard-faced Super Duplex[e]
Shaft[d]	Yes	Carbon steel	Carbon steel	Carbon steel	Carbon steel	Carbon steel	AISI 4140	AISI 4140[f]	316 AUS	Ni-Cu Alloy	12 % CHR	AUS	316 AUS	Duplex	Super Duplex
Throat bushings[k]	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	12 % CHR Hardened	12 % CHR Hardened	316 AUS	Ni-Cu Alloy	12 % CHR Hardened	AUS	316 AUS	Duplex	Super Duplex
Interstage sleeves[k]	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	12 % CHR Hardened	12 % CHR Hardened	Hard-faced 316AUS[e]	Ni-Cu Alloy	12 % CHR Hardened	Hard-faced AUS[e]	Hard-faced 316 AUS[e]	Hard-faced Duplex[e]	Hard-faced Super Duplex[e]
Interstage bushings[k]	No	Cast iron	Bronze	Cast iron	Ni-Resist	Cast iron	12 % CHR Hardened	12 % CHR Hardened	Hard-faced 316AUS[e]	Ni-Cu Alloy	12 % CHR Hardened	Hard-faced AUS[e]	Hard-faced 316 AUS[e]	Hard-faced Duplex[e]	Hard-faced Super Duplex[e]
Case and gland studs	Yes	Carbon steel	Carbon steel	AISI 4140 steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	Ni-Cu Alloy Hardened[i]	AISI 4140 Steel	AISI 4140 Steel	AISI 4140 Steel	Duplex[i]	Super Duplex[i]
Case gasket	No	AUS, Spiral wound[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	316 AUS Spiral wound[g]	Ni-Cu Alloy, Spiral wound, PTFE filled[g]	AUS, Spiral wound[g]	AUS, Spiral wound[g]	316 AUS Spiral wound[g]	Duplex SS Spiral wound[g]	Duplex SS Spiral Wound[g]

Material Upgrades, Non-Metallic Wear Parts

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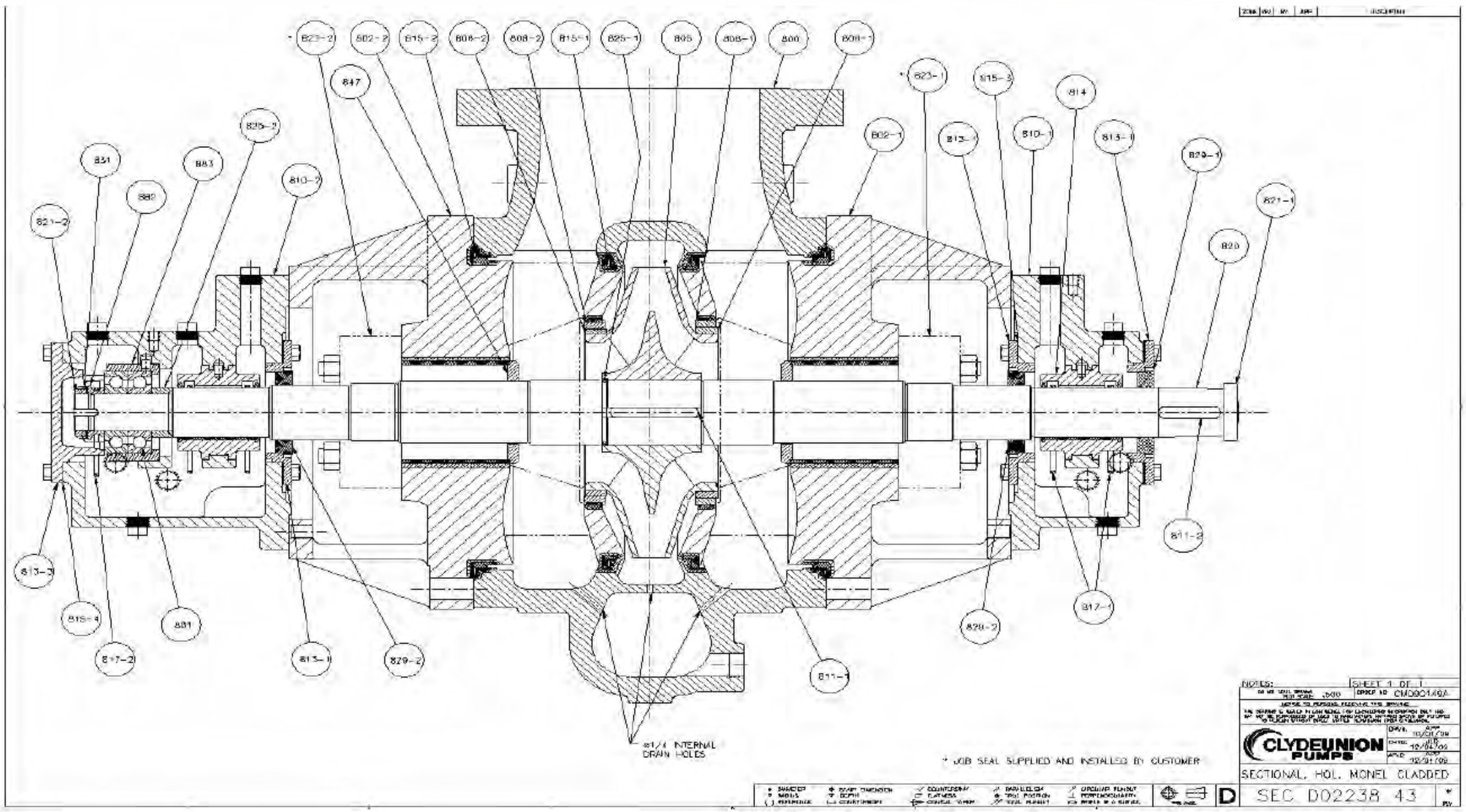
ADVANTAGES:

- Non-Galling Materials
- Increased efficiency with reduced clearances
- Chemical Resistance

DISADVANTAGES:

- Cost
- Temperature Limitations
- Installation Difficulties

Material Upgrades, Cladding/Overlay



Material Upgrades, Wear Resistant Coatings

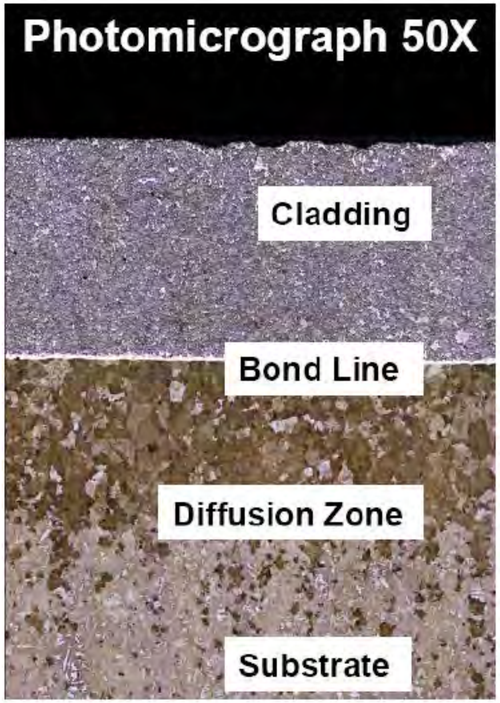
- Tungsten Carbide (WC) Spray, HVOF
  - Line of site process
  - Low bond strength (10,000 – 12,000 psi) – easily undermined
- Boron Diffusion (BD)
  - Only 0.008-0.010" thickness on carbon steel
  - Even thinner ~0.003" on 12-chrome
  - Large abrasive particles can puncture the coating
  - Once thin coating punctured, the substrate is left without wear protection
- Weld Overlay
  - Soft binder holding carbide particles
  - Uneven carbide distribution in the matrix – Preferential erosion path
- Solid Stellite impellers
  - Difficult to source consistent castings
- Welded Stellite
  - Delayed cracking potential
  - Low carbide content (12%-15%) – Not optimum protection for erosion wear
- Infiltration Brazed Tungsten Carbide Cladding Technology
  - Flexible, confirms to complex geometries
  - Not limited to line of site application
  - Provides premium wear protection in previously difficult to reach locations

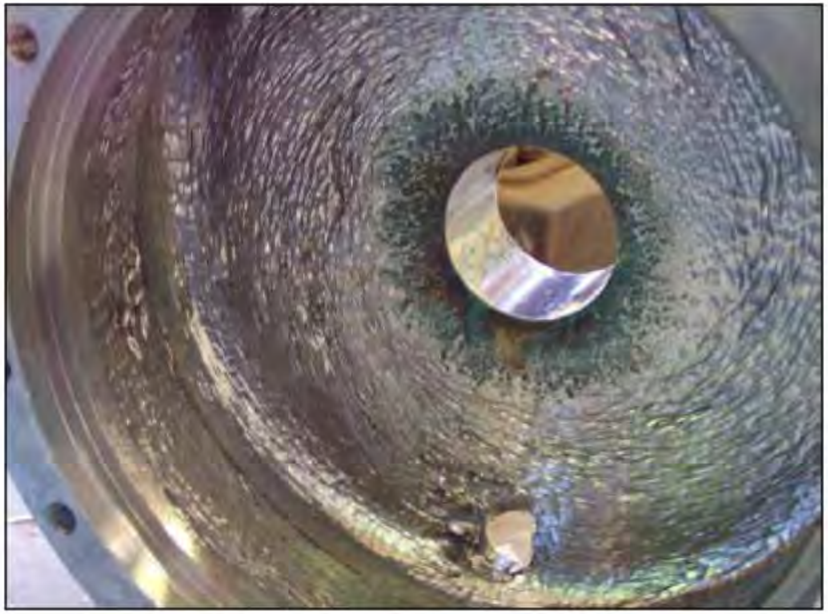
The Process

- Flexible Tungsten Carbide cloth can conform to complex geometries.
- The cloth is adhered to the targeted wear surface on the substrate and over-layered with a brazen cloth of filler metal.
- Then placed in a vacuum furnace until the brazing material melts and infiltrates the tungsten carbide cloth.

Lessons Learned

- Preferred base material is carbon steel versus CA6NM since any welding done to CA6NM after the coating process would require heat treatment.
- Pre-heating of large castings using temperatures similar to the coating process has been found to reduce the warpage of the part during the coating process.
- Balancing of the impeller after the coating process requires metal to be added by using tungsten carbide weld rod. It has been found that large impellers can require a large amount of weld material to be added to obtain final balance requirements. The large amount of weld has caused axial clearance issues during final assembly and has also affected the pump performance.
- The affect of the coating on pump performance needs further review and actual testing. To date the coating has only been used and performance tested on one size of a HOL pump. The affect on performance on smaller pumps is unknown.





Original Material
6 Weeks

Infiltration Brazed Tungsten Carbide Cladding
12 Weeks

Clarified oil with heavy catalyst slurry

- Prior to cladding the unit was scrapped after one year of service
- After one year with clad technology, 0.12 – 0.2 mm Material Loss
- Pump Life Extended from 1 Year to 3-4 Years

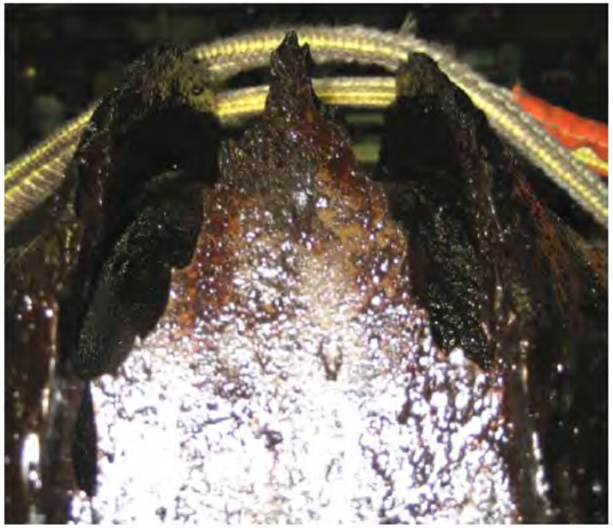
Drop-In Replacement Pumps

Design and Manufacture replacement pump

- Match existing mounting dimensions and nozzle locations
- Provide custom or standard hydraulics
- Provide mechanical upgrades including:
  - Bearing Housing Upgrades
  - Mechanical Seal Upgrades
  - Material Upgrades

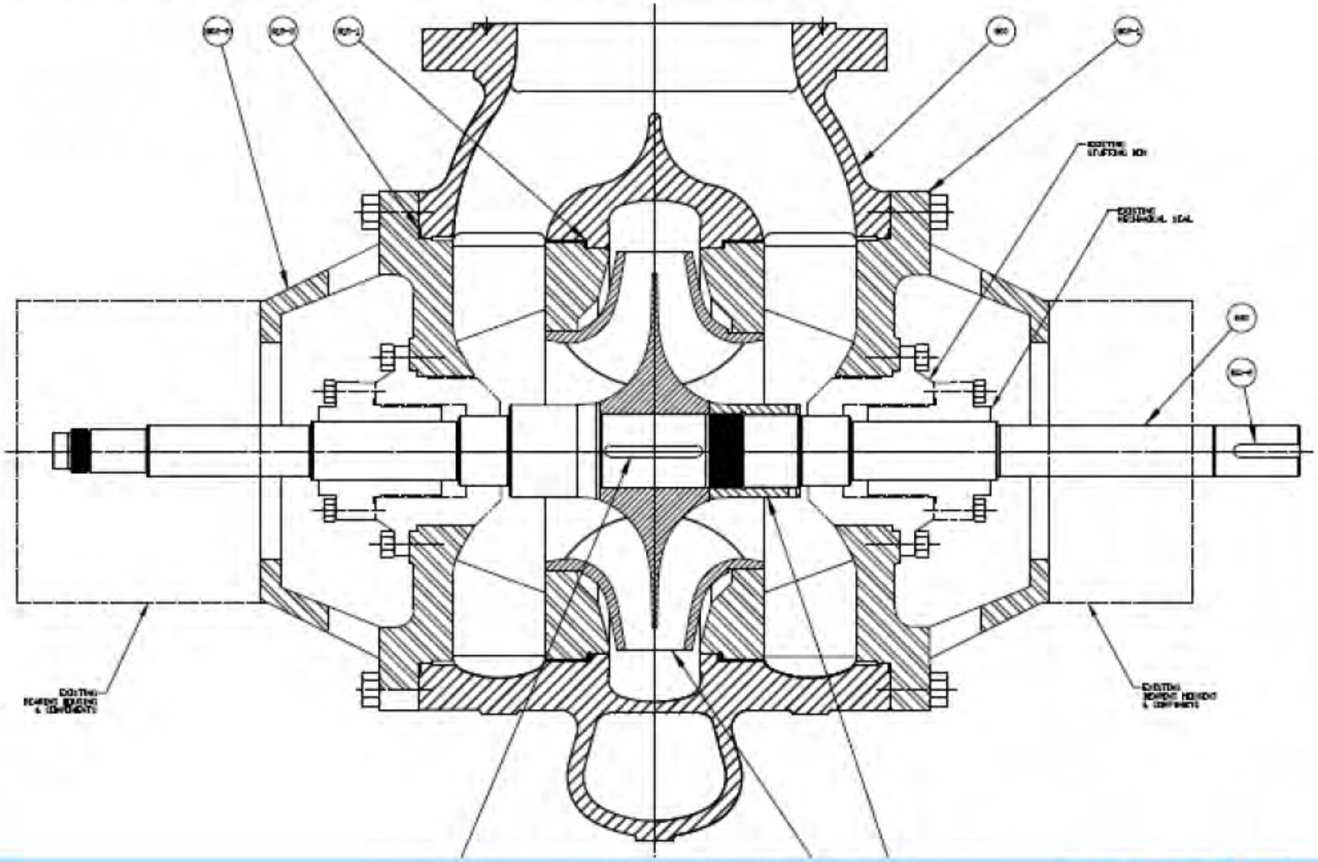
Drop-In Replacement Pump with IBTCC Coating

- Gulf Coast Refinery – Original FCCU Catalyst Slurry Pump



Drop-In Replacement Pump with IBTCC Coating

- Drop-In Design – No piping or foundation modifications
- Wear Plates, High Chrome Iron Impeller, and stuffing box inserts eliminated
- All wetted parts are IBTCC coated
- 360 degree bearing support upgrade included
- New hydraulics to match current operating conditions



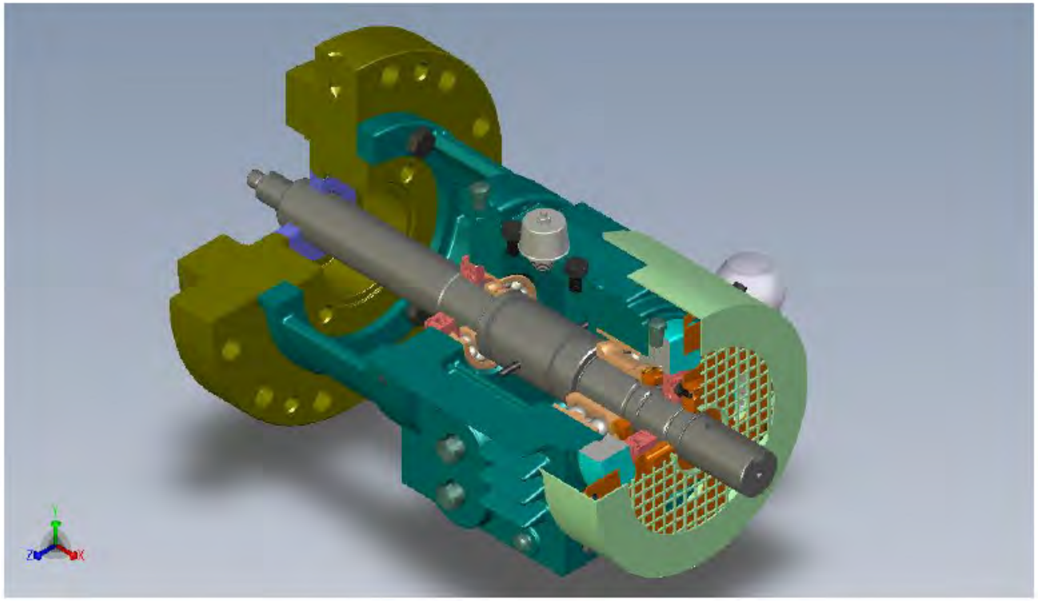
Drop-In Replacement Pump with IBTCC Coating

CLYDEUNION ACADEMY

Gulf Coast Refinery – Replacement FCCU Catalyst Slurry Pump

OH2 Back Pull Out

Typical API-610 10th Edition
OH2 Back Pull Out (BPO)



OH2 Back Pull Out

CLYDEUNION ACADEMY

Back Pull Out (BPO) Advantages

Features	Benefits
Direct drop-in replacement	Minimum installation cost
Seal chamber meets API 682 Standards	Extended seal life & reduced emissions.
Large shaft diameter with lower L3/D4 ratio	Improved mechanical seal life
Designed for outside drive collar and cartridge mech. seals	Ease of seal setting and maintenance
Oiling pin lubrication	Reduced oil contamination and extended bearing life
7300 series angular contact thrust bearings	Extended bearing Life
Finned bearing housing	Improved cooling and extended bearing life
External fan for cooling housing	Eliminates cooling water to 700 F

OH2 Back Pull Out

CLYDEUNION ACADEMY

Hydraulic & Mechanical Retro-fit Kit

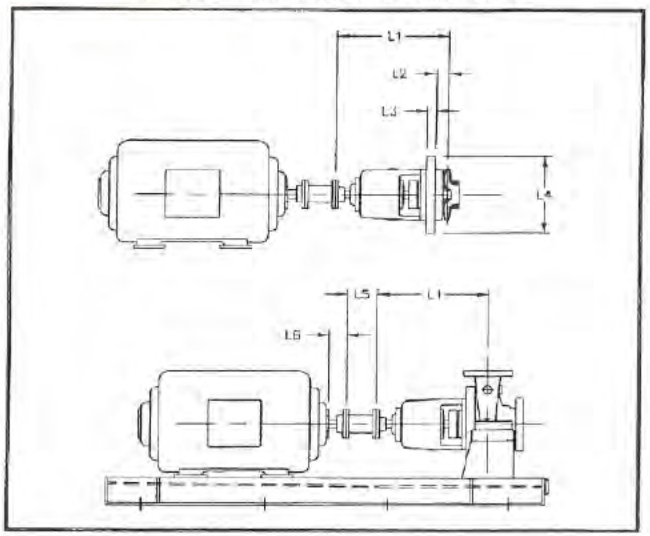
Site Inspection Forms

CLYDEUNION PUMPS

Hydraulic and Mechanical Retro-Fit Kit
Up-Grade to API-610 10th Edition BPO

CUP SWRS No: ____________________

Retro-Fit Dimensional Data Sheet - External Data



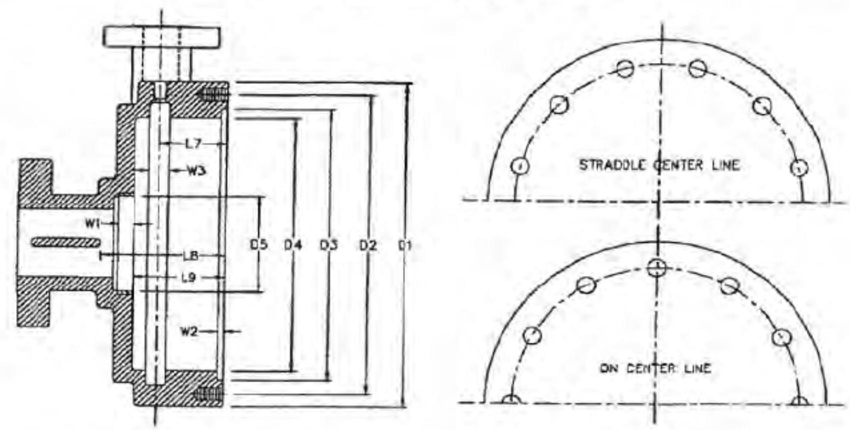
Dimension Description	Dimension	Measurement (in)	Notes
Case CL to Pump Shaft End	L1		
Cover Flange Face to CL of Imp.	L2		
Cover Flange Thickness	L3		
Cover Flange OD	L4		
Coupling Spacer Length	L5		
Motor Shaft Extension	L6		

CLYDEUNION PUMPS

Hydraulic and Mechanical Retro-Fit Kit
Up-Grade to API-610 10th Edition BPO

CUP SWRS No: ____________________

Retro-Fit Dimensional Data Sheet



Materials of Construction (circle one): S-6 C-6 C-8 A-8 Other

Dimension Description	Dimension	Measurement (inches)
Casing OD	D1	
Bolt Circle Diameter	D2	
Gasket Fit ID	D3	
Case ID	D4	
Wear Ring ID	D5	
Case Face to CL of Volute	L7	
Case Face to Flow Splitter	L8	
Case Face to Wear Ring	L9	
Case Wear Ring Width	W1	
Gasket Fit Depth	W2	
Volute Width	W3	

Bolt Circle (check one):

- ☐ Straddles CL
- ☐ On CL

360 Degree Bearing Housing Supports

- 360 Degree Bearing Housing Support/Bearing Housing Upgrades
  - Reduced Vibration
  - Increased Stability
  - Decreased Deflection during warm-up
  - Bearing Options – Ball/Ball, Sleeve/Ball, Sleeve/Kingsbury
  - Lubrication Options – Oil Mist, Ring Oil, Pressure Lube
  - Cooling Options – Fan Cooled, Water Cooled

CP System

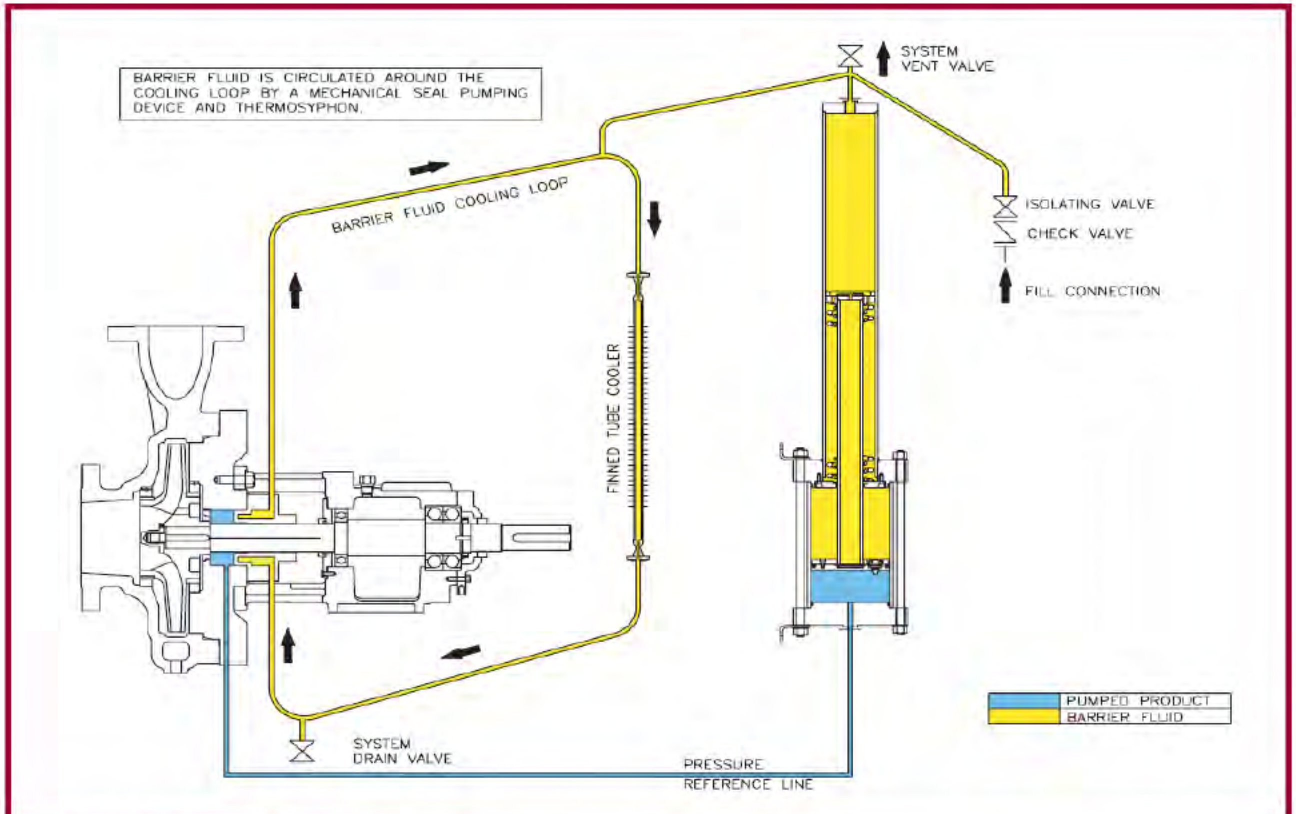
Constant Pressure Barrier Fluid Sealing System

Improve Safety, Reliability and Eliminate Fugitive Emissions

- Zero leakage to atmosphere.
- Requires no external power or nitrogen gas source.
- Maintains constant differential pressure across seals regardless of fluctuations in suction or discharge pressure.

Emission Control

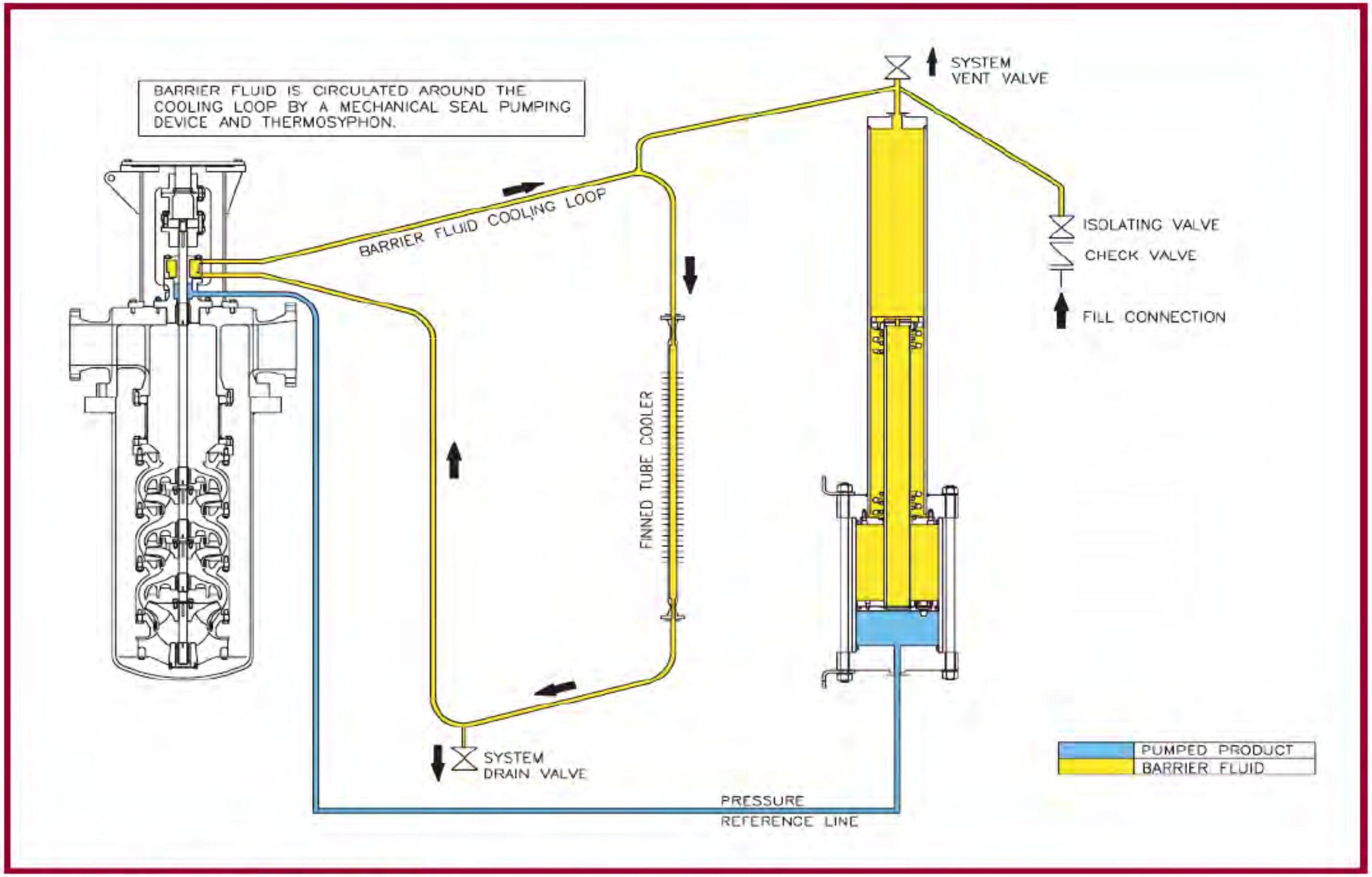
CP SYSTEM



Horizontal Pump Installation

CLYDEUNION ACADEMY

CP SYSTEM



Vertical Pump Installation

OH-4 Upgrades

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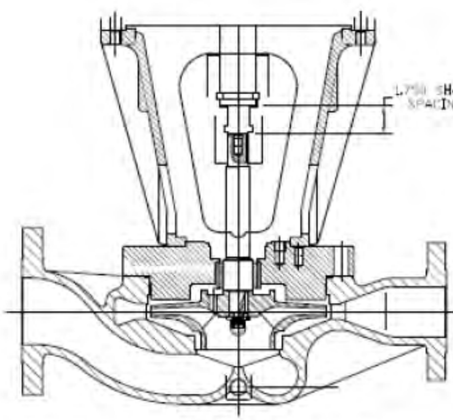
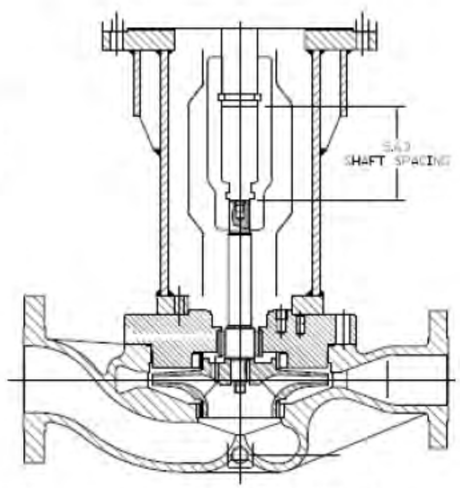
Common Mechanical Upgrades:

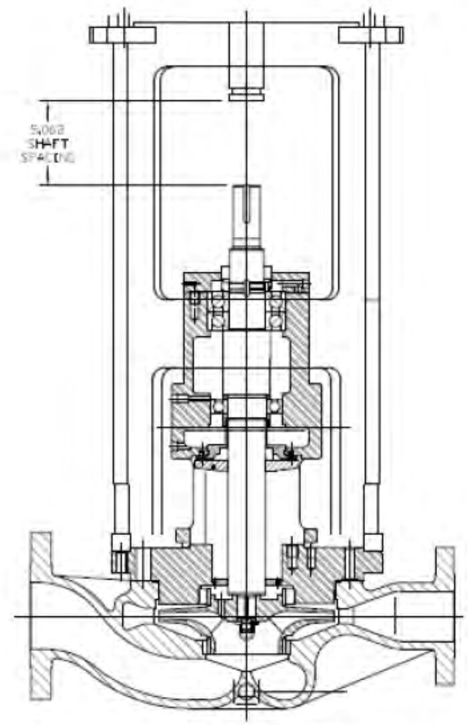
- OH4 to OH4 with Extended Coupling: Ability to remove cartridge mechanical seal without removing the motor stand
- OH4 to OH3: Eliminates rigid coupling in favor of bearing bracket design



3X4X10 VLK (LATEST DESIGN)



3X4X10 VLK-BL DESIGN



3X4X10 VLK-B DESIGN

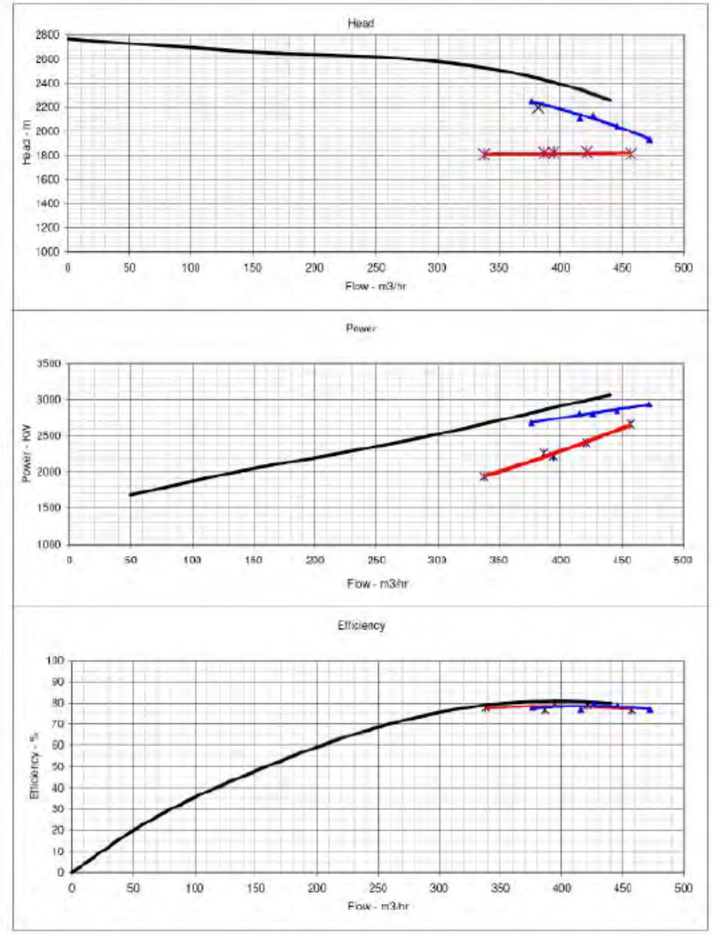
Why field test a pump?

- Field tests are run for the purpose of demonstrating satisfactory mechanical and hydraulic operation under actual conditions.
- Pumps do not operate in isolation. Rather, it is a part of a system and as such certain issues within the system can be affecting pump performance not seen on the test bed.
- Many field performance tests can be conducted without interruption to the pump or process operations.
- If the pump has been tested in the OE test lab before shipping, the field test Is used as verification that the equipment was repaired / re-rated properly.
- Field tests are used as a baseline for troubleshooting, energy efficiency studies, and life cycle cost analysis.

Field Testing

Basic Field Test Reports Includes:

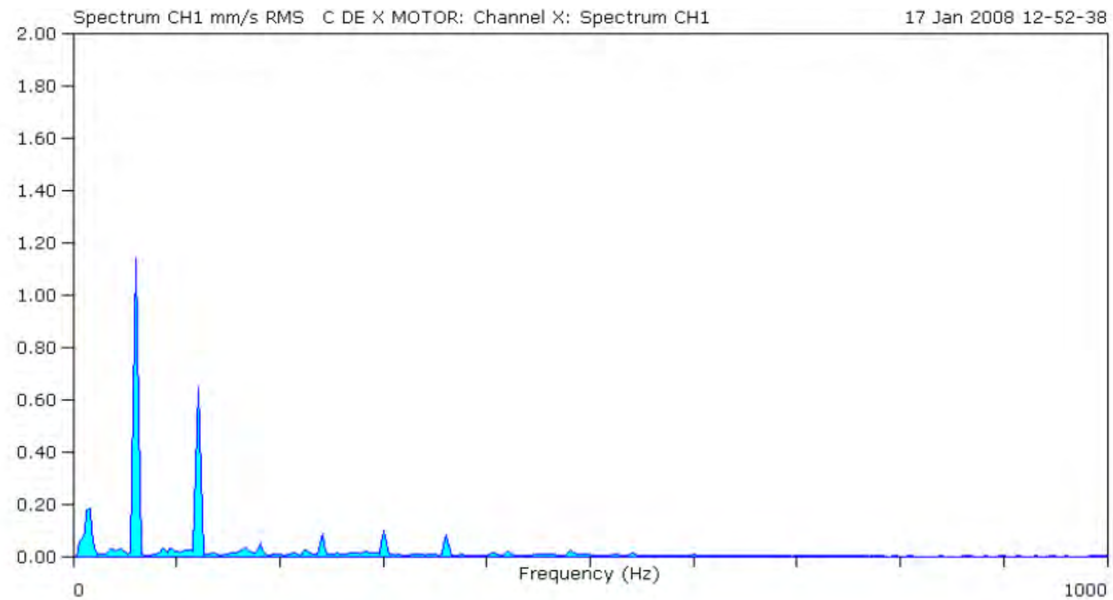
- Comparison of hydraulic and mechanical performance against known performance
- Assessment of any likely wear or known deterioration
- Recommendations for changes in operation or maintenance
- Recommendations for possible installation improvements
- Proposal for any pump modifications (where applicable) including mechanical upgrades or hydraulic re-rates



Field Testing

In depth reports include:

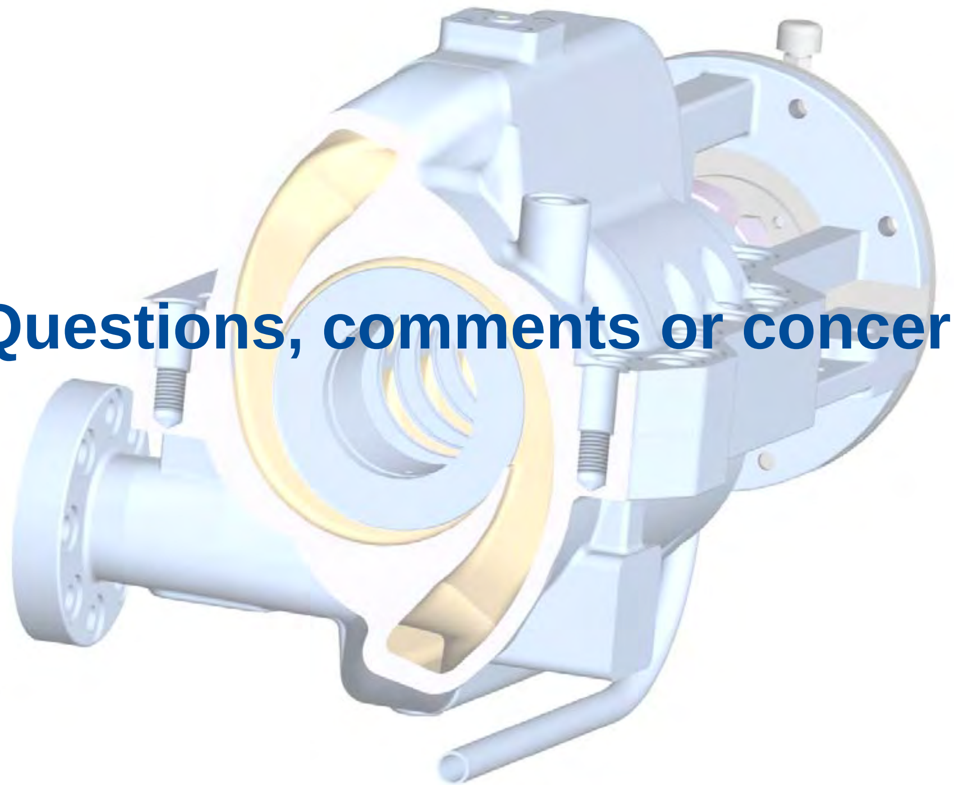
- Full FFT Vibration spectra analysis
- Energy efficiency assessment and possible cost savings
- System analysis
- Modal & resonance analysis



Field Testing

Site Photos (where allowed) are included in all reports illustrating test setup and assessment of pump condition and environment

CLYDEUNION ACADEMY



Questions, comments or concerns?