

Engineered Re-Rate of SWI Pumps for Produced Water Service

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Union Pump

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Production Services Network

Agenda

SWI to Produced Water – An Explanation

- Pump Modifications
 - Wear Rings
 - Base-plate
 - Bearings
 - Sealing
 - Performance
- Project Lessons Learned

What is Produced Water? Why is it a Problem?

- **Produced Water – Combination of contaminated injection and formation water**
- **Formally discharged into sea**
- **Now carefully controlled and re-injected into well**
- **No emission of formation water allowed**
- **Zero Emission Sealing Solution Required**

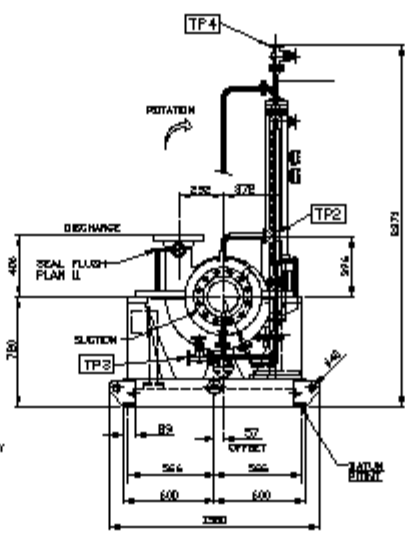
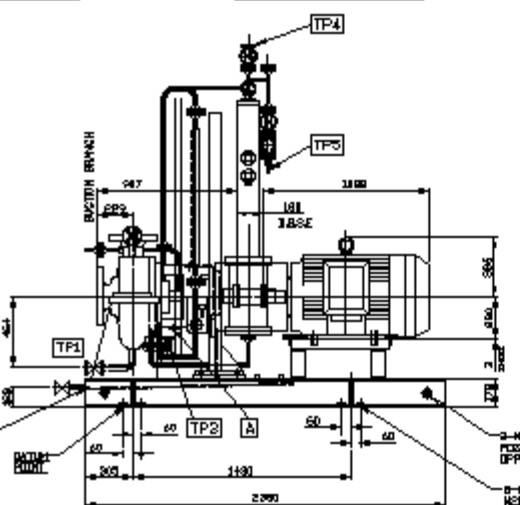
The challenge for PSN and Union together was to re engineer the existing SWI units to meet the produced water duty requirements.

Summary of Re-Rate Parameters for SWI and Booster

- **Metallurgy:** Wear ring metallurgy had to be modified to incorporate a hard HVOF coating as particulate contamination was anticipated in the re-injection service.
- **Sealing:** The existing sealing methodology did not give zero fugitive emissions of the pumpage. A plan 53C pressurized seal system was used with double mechanical seal to guarantee the zero emissions.
- **Base-plate:** Anti vibration mountings required on the base-plate and the existing base was not suitable for this conversion
- **Bearings:** The existing bearings were self contained sleeve tilting pad type with a lubricating/pumping mechanism incorporated into the bearing design. These had suffered from poor reliability on the platform. The existing bearing housing were modified and re-engineered and their lubrication system replaced with a skid mounted lube oil system.

Summary of Re-Rate Parameters for SWI and Booster

- **Discharge Pressure:** Dramatically reduced from the existing service. Re-injection pressures are commonly lower than the original SWI duty conditions.
- **Re-rate of head:** Easy to accommodate by de-staging the unit and reducing the impeller diameters
- **Spare Cartridge:** included in the scope of supply. All hydraulic components were checked using Computation Fluid Dynamics to assess the potential for hydraulic changes to refine the unit performance.



REV.	DESCRIPTION	DATE	BY	CHKD.	APPD.
A	UPDATED IN LINE WITH CLIENTS COMMENTS	06/10/06	PK	DBD	PK
B	AS BUILT YES / FLANGE SIZE AMOKD.	11/18/06	PK		
D	DEAL INFORMATION CORRECTED	12/19/06	PK		

PUMP DETAILS		
PUMP TYPE	LW/SD/CM	
NUMBER OF STAGES	ONE	
ROTATION	SEEN FROM DRIVER	
PUMP SPEED	1750 RPM	
DISCHARGE FLANGE	6" ANGE 300# RF	
SUCTON FLANGE	6" ANGE 300# RF	
LUBRICATION	RING OILED / CONSTANT LEVEL OILER	
MECHANICAL SEAL	MESSAL PLC	
TYPE	CAPT AL SEAL	

DRIVER DETAILS		
SUPPLIER	DAVID BROWN UNION PUMPS	
MANUFACTURER	ABB	
FRAME SIZE	MDF DYN4 4-LE 20	
DRIVER POWER	30 KW	
DRIVER SPEED	1740 RPM	
ELECTRICAL SUPPLY	440 VOLTS 3 PHASE 60 CYCLES	
ENCLOSURE	EON / TEFV	

COUPLING DETAILS			WEIGHT	KG
MANUFACTURER	MEYER	PUMP	498	
DESIGNATION	TP3	BASE PLATE	728	
SIZE	8/15	DRIVER	745	
SPACER	180	ACCESSORIES	390	
BASED TO IS 5304	TOTAL		2450	
NATURAL WEIGHT				

FLANGE DETAILS		
	SUCTON	DISCHARGE
30A a	870	204
PCB b	390	265.5
30A c	308	310
d	41.5	56.5
e	1.6	1.6
FLANGE HOLE DIA	12	12
FLANGE HOLES TO STRIKE CENTERLINE	HOLE 30	35+
	12	22.2

SHAFT EXTENSION DETAILS		
	SHAFT	PUMP
a	75.0	65.0
b	148.0	14.0
c	8.0	16.0
d	67.0	46.0

CUSTOMER ORDER DETAILS		
CUSTOMER	S-P BILITON	
CUSTOMER ORDER No.	20010004	
CUSTOMER ITEM No.	DD-P-10002	
ULTRAMATIC LOSS	-	
LOCATION	LIVERPOOL SW DEVELOPMENT	
LIQUID PUMPED	INDUSTRIAL WATER	
SERVICE	INDUSTRIAL WATER RE-COOLING HEATER PUMP	
PUMP TYPE	SD/SD/CM	
QUANTITY ORDERED	ONE	

AUXILIARY PIPING CONNECTIONS	
REF	DESCRIPTION
TP1	2" 2000 RF CASING DRAIN
TP2	2" 2000 RF CASING VENT
TP3	1/2" 2000 RF OF SYSTEM BRAN
TP4	1/2" 2000 RF OF SYSTEM VENT
TP5	1/2" NPT MALE, HOLDRY COMPLNS. OF SYTON FILL
TP6	2" NPT IRON BASEPLATE DRIP TRAY
A	2 1/2" NPT SEALING BRACKET THROUGH DRAIN (VALUED)

ALLOW LEAN FOR VARIATION OF NOZZLE FLANGE FACED AND ALL OTHER NOMINAL DIMENSIONS UNLESS OTHERWISE SPECIFICALLY TOLERANCED.

MOTOR CABLES: BOTTOM ENTRY TO TERMINAL BOX.
 MAIN POWER 30 X 70mm
 THERMISTOR 20 X 25mm
 AND CONDENSATION HEATERS 30 X 25mm
 BLAND ENTRY SIZE: N63 X L5
 CLANG ENTRY SIZE: N63 X L5

STATIC AND DYNAMIC LOADS, KG		
REF	STATIC	DYNAMIC
R1	4200	4200
R2	3500	3500
R3	3800	3800
R4	3500	3500

MAXIMUM TOTAL DOWNLOAD ON 4-QUARTER POINTS COMBINED, 3430 KG.

THIS UNIT FITTED WITH DRIVER HORIZONTAL JACKING SCREWS

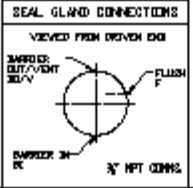
AS BUILT

David Brown Union Pumps	
<input type="checkbox"/> 1	...
<input type="checkbox"/> 2	...
<input type="checkbox"/> 3	...
<input type="checkbox"/> 4	...
Customer Order No.	20010004
Product Code	DD-P-10002
Revision	04

	DAVID BROWN UNION PUMPS	TITLE GENERAL ARRANGEMENT FROM: WFA/DA/2008-APR-08 (DRAWING No.) CHECKED: RAK/DA/2008-APR-08 APPROVED: RAK/DA/2008-APR-08 DATE: 2008-04-08	REV DBD-14195 C
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NOZZLE LOADING (2 X AP.D)				
	SUCT		DISCH	
EX	N	9750	EX	M
PV	N	5200	PV	N
EX	N	9750	EX	N
F	N	15870	F	N
EX	N	7050	EX	N
EX	N	5010	EX	N
EX	N	3750	EX	N
EX	N	9750	EX	N

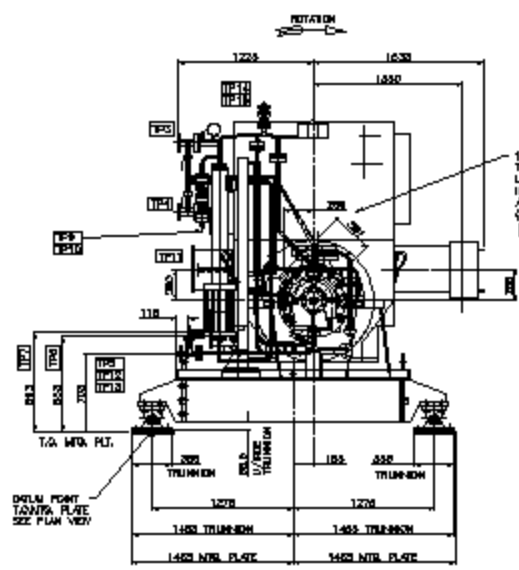
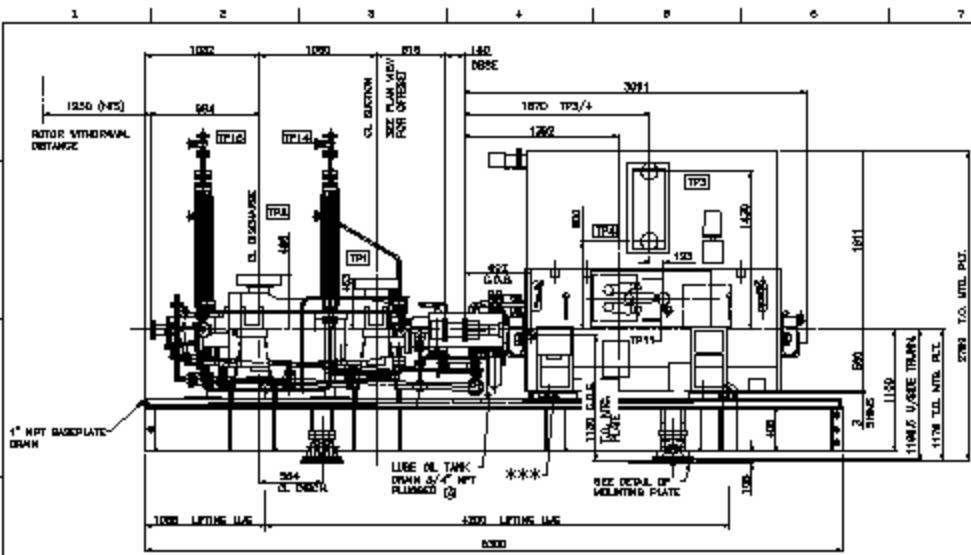
F=FORCE IN NEWTONS R=RESULTANT N=NOMENTS IN NEWTON METRES.



Images of Re-Engineered Pumps

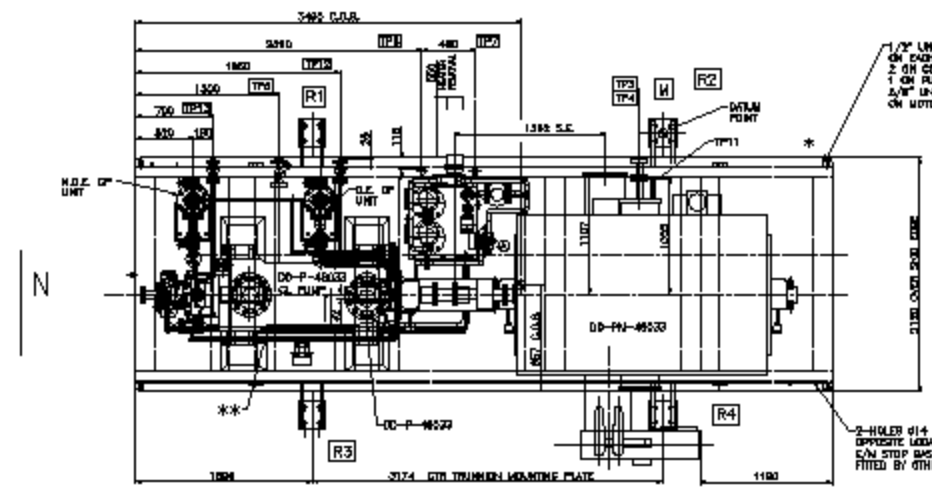


OH2 Booster

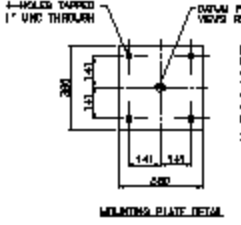
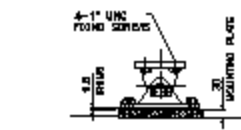


1" 160MP RTJ FLANGE TO BE USED TO SECTION LINE BY CLIENT.
INCREASE TO 1 1/2" NB AFTER FIRST CONNECTION (BALANCE LINE)
(SEE)

ITEM	DESCRIPTION	UNIT	VALUE
1	ROTOR FLANGE	"	2.50
2	ROTOR FLANGE	"	3.00
3	ROTOR FLANGE	"	3.50
4	ROTOR FLANGE	"	4.00
5	ROTOR FLANGE	"	4.50
6	ROTOR FLANGE	"	5.00
7	ROTOR FLANGE	"	5.50
8	ROTOR FLANGE	"	6.00
9	ROTOR FLANGE	"	6.50
10	ROTOR FLANGE	"	7.00
11	ROTOR FLANGE	"	7.50
12	ROTOR FLANGE	"	8.00
13	ROTOR FLANGE	"	8.50
14	ROTOR FLANGE	"	9.00
15	ROTOR FLANGE	"	9.50
16	ROTOR FLANGE	"	10.00
17	ROTOR FLANGE	"	10.50
18	ROTOR FLANGE	"	11.00
19	ROTOR FLANGE	"	11.50
20	ROTOR FLANGE	"	12.00
21	ROTOR FLANGE	"	12.50
22	ROTOR FLANGE	"	13.00
23	ROTOR FLANGE	"	13.50
24	ROTOR FLANGE	"	14.00
25	ROTOR FLANGE	"	14.50
26	ROTOR FLANGE	"	15.00
27	ROTOR FLANGE	"	15.50
28	ROTOR FLANGE	"	16.00
29	ROTOR FLANGE	"	16.50
30	ROTOR FLANGE	"	17.00
31	ROTOR FLANGE	"	17.50
32	ROTOR FLANGE	"	18.00
33	ROTOR FLANGE	"	18.50
34	ROTOR FLANGE	"	19.00
35	ROTOR FLANGE	"	19.50
36	ROTOR FLANGE	"	20.00
37	ROTOR FLANGE	"	20.50
38	ROTOR FLANGE	"	21.00
39	ROTOR FLANGE	"	21.50
40	ROTOR FLANGE	"	22.00
41	ROTOR FLANGE	"	22.50
42	ROTOR FLANGE	"	23.00
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44	ROTOR FLANGE	"	24.00
45	ROTOR FLANGE	"	24.50
46	ROTOR FLANGE	"	25.00
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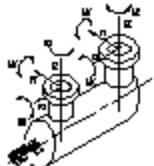


1/2" WIRE BOSSING BOSS
ON EACH CORNER
2 ON CORNER MARKED A
1 ON PUMP AND MARKED P.
2 1/2" WIRE BOSSING BOSS
ON MOTOR P.D. MARKED PP.



NOTES

- ALLOW ± .005 IN. FOR VARIATION OF NEEDLE FLANGE PAGES AND ALL OTHER CRITICAL DIMENSIONS UNLESS SPECIFICALLY TOLERANCED.
- WORKER HORIZONTAL AND VERTICAL ALIGNMENT SCREWS PROVIDED.
- FOR BRAKT ALIGNMENT DETAILS SEE SPEC. NO. 004-10884.



NOZZLE	ALLOWABLE COMPONENTS & RESERVANTS
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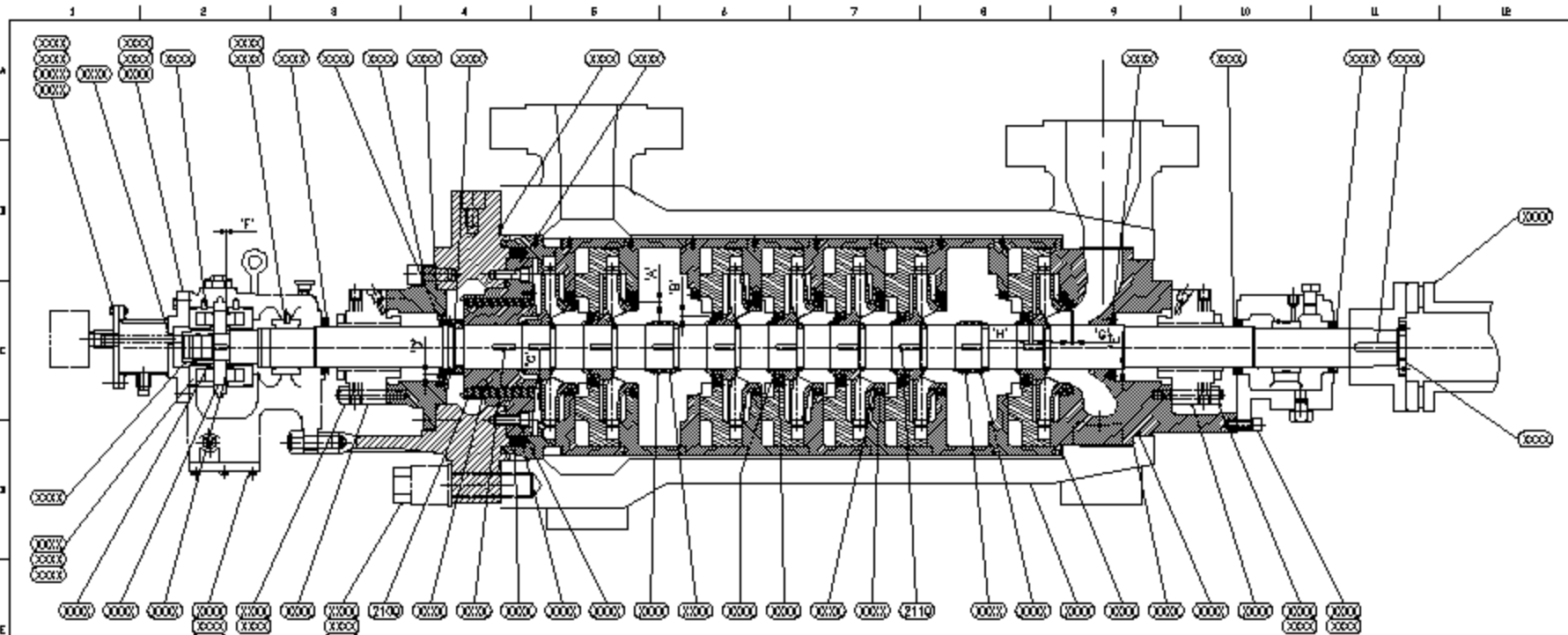
ALL LOADS ARE MAXIMA AND DO NOT OCCUR SIMULTANEOUSLY.

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MAINT. WEIGHT	UNIT	NO.
280	LB	280
320	LB	320
360	LB	360
400	LB	400
440	LB	440
480	LB	480
520	LB	520
560	LB	560
600	LB	600
640	LB	640
680	LB	680
720	LB	720
760	LB	760
800	LB	800
840	LB	840
880	LB	880
920	LB	920
960	LB	960
1000	LB	1000

ITEM	DESCRIPTION	UNIT	NO.
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PART NO.	DESCRIPTION	MATERIAL	MATL ID	QTY.
20	WATER PLATE	STEEL	A203C0000	2
30	ROTOR, IMPL. TIE	IMP-ROTOR	A203A144	1
31	KEY TO SHFT	KEY-IMP	41400000	2
32	IMPELLER THIRST BEARING	STEEL	A0203A000	2
33	THIRST BEARING SHAFT END	STEEL	A0203A000	1
34	IMPELLER IMPL. MOUNT	STEEL	A0203A00	1
35	IMPL. IMPL. IMPELLER IMPELLER	STEEL	A0203A00	1
36	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
37	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
38	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
39	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
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44	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
45	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
46	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
47	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
48	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
49	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
50	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1

PART NO.	DESCRIPTION	MATERIAL	MATL ID	QTY.
51	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
52	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
53	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
54	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
55	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
56	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
57	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
58	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
59	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
60	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
61	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
62	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
63	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
64	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
65	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
66	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
67	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
68	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
69	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
70	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1

PART NO.	DESCRIPTION	MATERIAL	MATL ID	QTY.
71	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
72	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
73	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
74	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
75	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
76	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
77	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
78	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
79	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
80	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
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84	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
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86	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
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88	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
89	IMPELLER IMPL. IMPELLER IMPELLER	IMP-IMPELLER	A0203A00	1
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REF.	MDL	INCL	VERN
A	0.005	0.002	0.001
B	0.002	0.001	0.001
C	0.001	0.001	0.001
D	0.001	0.001	0.001
E	0.001	0.001	0.001
F	0.001	0.001	0.001

REF.	MDL	INCL	VERN
F	0.002	0.001	0.001
G	0.001	0.001	0.001
H	0.001	0.001	0.001

PARTS LIST FOR REPLACEMENT ITEMS ONLY, EXCEPT ITEM No. 4000.
FOR DETAILS OF MAIN COMPONENTS SEE SPARE CARTRIDGE SECTION
DWG. NO. DBE 13371.

CUSTOMER INTX
USER: RHP, BULLTON
PURCHASER: BIP, TULLOCH
SUPPLIER: DAVID BROWN UNION PUMPS
3D CAD MODEL PROVIDED UNDER
PUMP SERIAL NO. 2003244



Approved By:

DATE: 20030610

PROJECT: DOUBLE PUMP

DRAWING NO.: DBE-13371

REVISION: 0

DATE: 20030610

SCALE: 1:1

BY: RHP

CHECKED: BIP

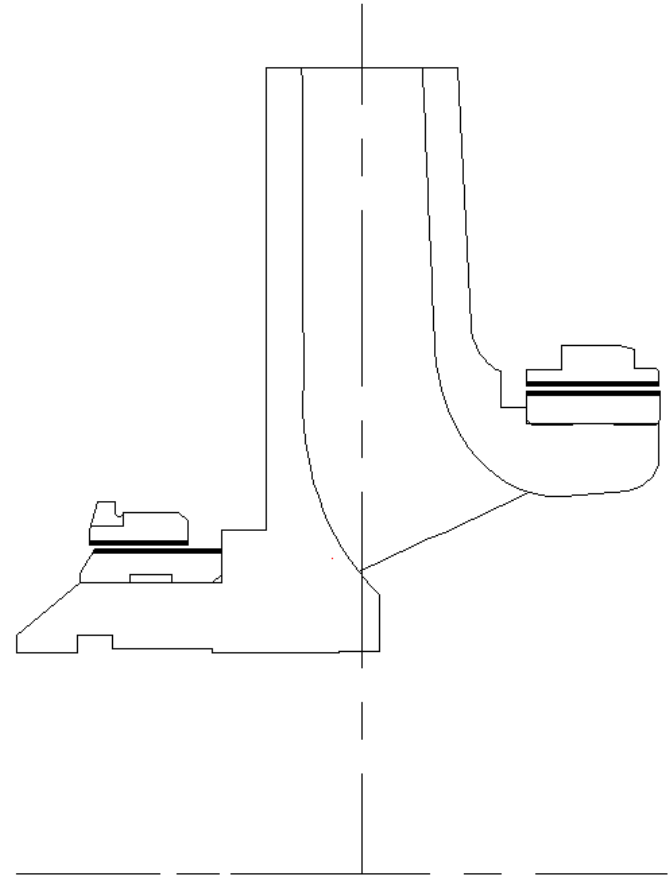
APPROVED: BIP

DATE: 20030610

TITLE SECTIONAL ARRANGEMENT - MAIN PUMP
REV 0
DBE-13371

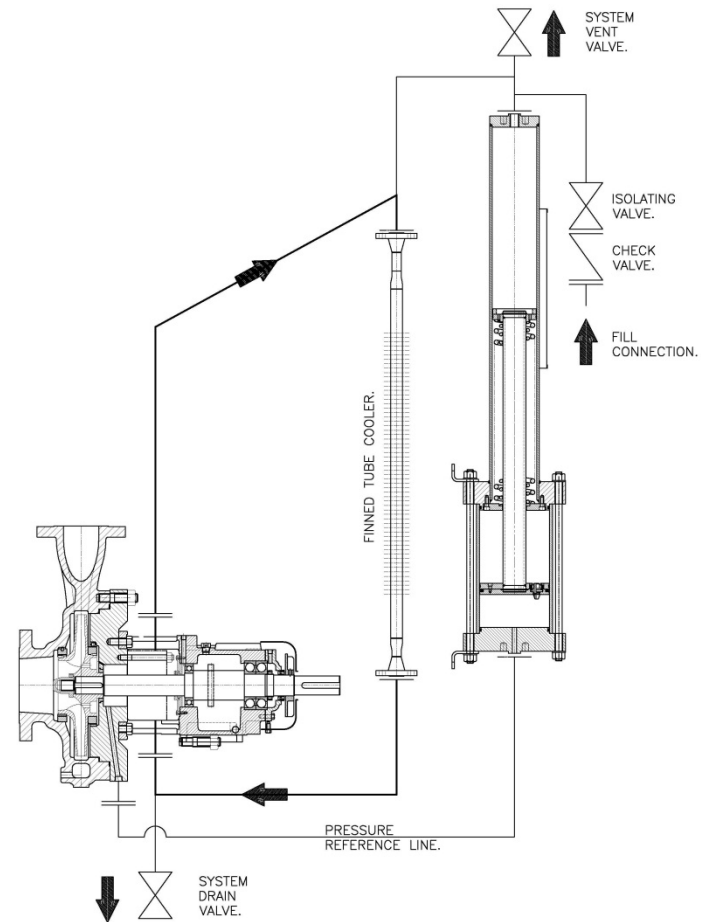
Wear Ring Modifications

- **Case and Hub Rings Modified**
- **Resistance to Particulate damage Required**
- **Silicon Carbide Coating applied to Wear ring surfaces**
- **HVOF application with pulling resistance of greater than 1000psi**
- **Coating hardness 1000 BNH**

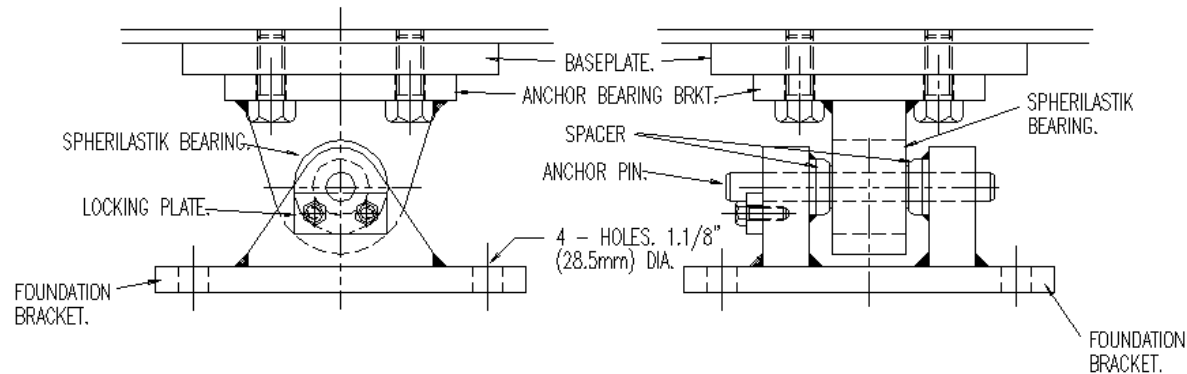


Sealing Modifications

- **Pressurised Sealing System – Constant Delta Pressure**
- **1-2 bar above product sealing pressure**
- **Tracks the product sealing pressure**
- **SS construction**
- **Requires no nitrogen**
- **Plan 53C**

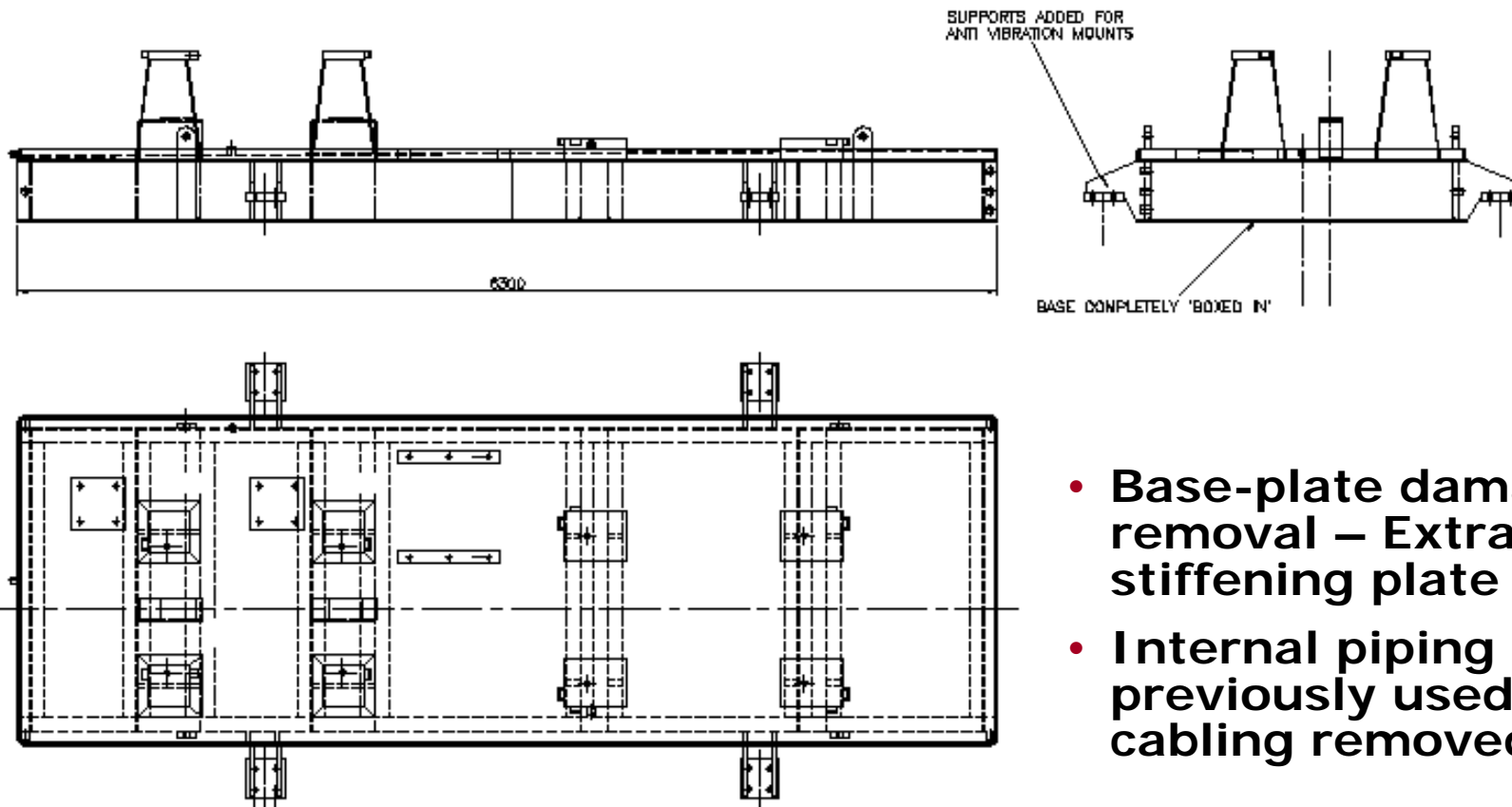


Base-plate Modifications



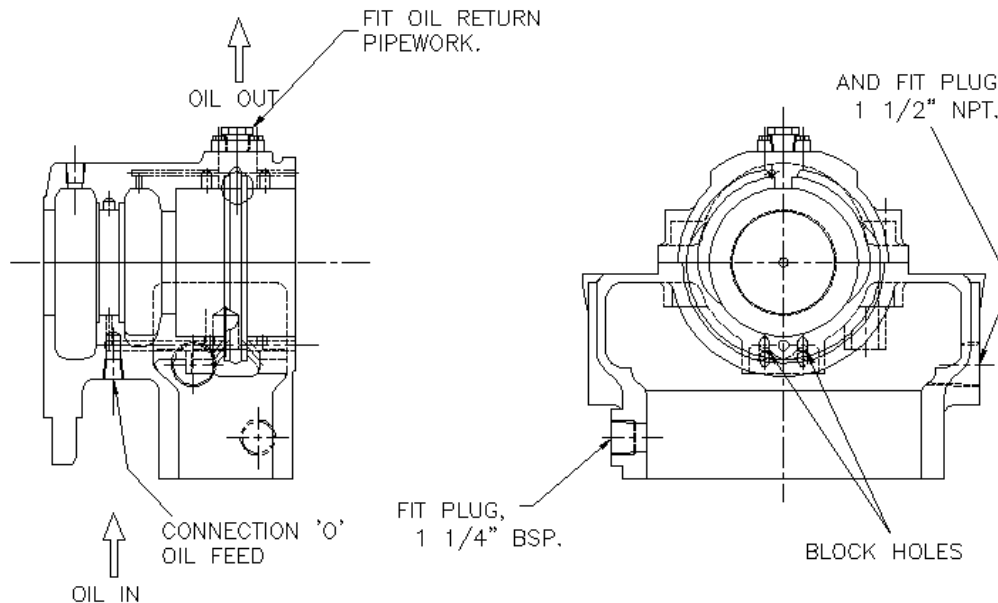
- **Flexible Deck on platform requires Anti-vibration Mountings**
- **Base-plate damaged on removal – Extra stiffening plate added**
- **Internal piping previously used for cabling removed**

Base-plate Modifications



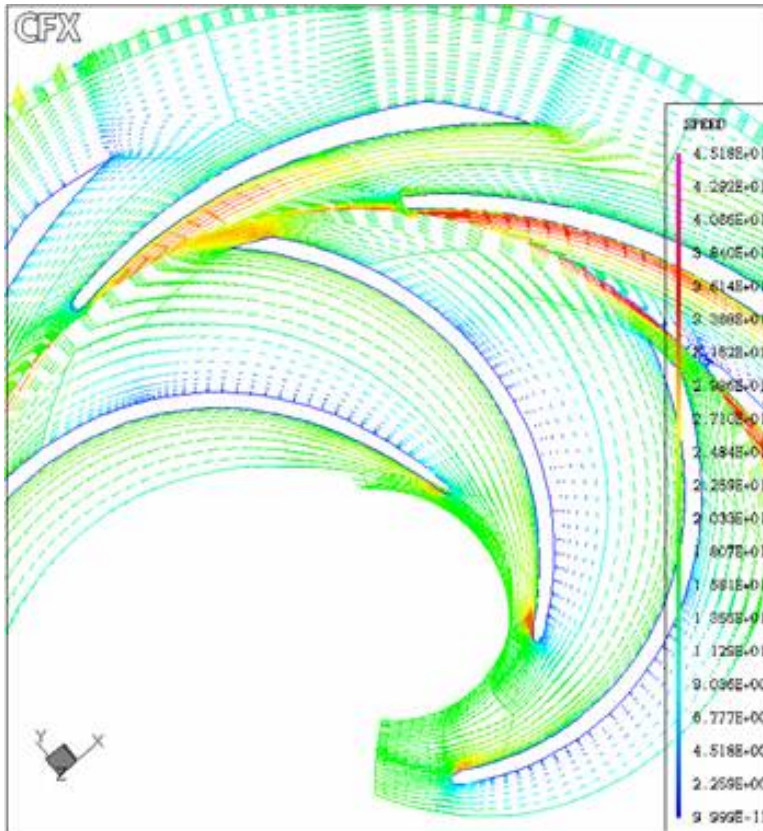
- Base-plate damaged on removal – Extra stiffening plate added
- Internal piping previously used for cabling removed

Bearing Modifications



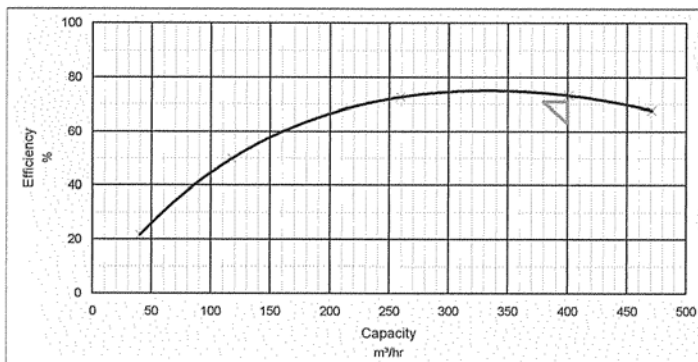
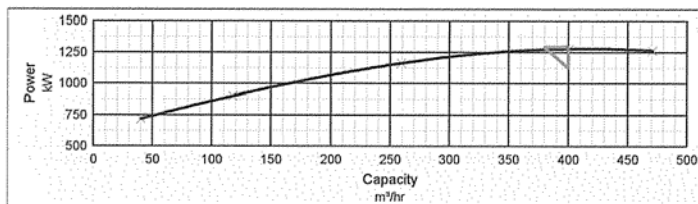
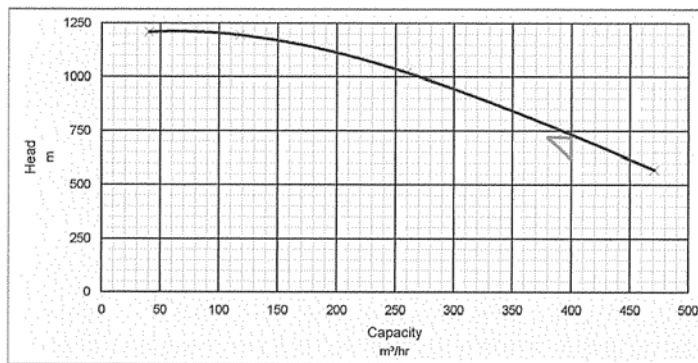
- **Poor reliability of existing equipment reported.**
- **Self contained lubrication system within the bearing was prone to failure.**
- **Preference for Lube-oil system expressed after contact finalised – late modification.**
- **Bearing modifications required to facilitate LO system**

Discharge Pressure Re-Rate



- Benchmark testing
- CFD Evaluation of Existing Geometry
- De-Staging to 7 stages from 9 stages
- New trim levels established after benchmark testing
- CFD re-design to improve efficiency.

Barrel Pump Performance Curve – After Re-rate



Lessons/Problems

- **Re-engineering is technically more time consuming than engineering a new piece of equipment for the same service**
- **Frank and open discussion at weekly progress meetings benefited both sides**
- **Scope of supply - creep accommodated within project timeline as a result of early identification and acceptance. No concessions sought!**
- **Shipment of pump skid to site prior to pump test allowed site work schedule to be kept on track.**
- **Unconventional approach from both sides.**

Conclusion/Recapitulation

- **Hydraulic modification of SWI and Booster Performance for Produced water re-injection Service**
- **Bearing Modifications to improve reliability**
- **Seals modified for zero Emissions with Plan 53C**
- **Base plate modified for Anti-Vibration mounting**
- **Close working relationship between contactor and manufacturer key to achieving project timeline**

Questions