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Paper

OFFSHORE WASHDOWN PUMP UNIT

A MANUFACTURING CASE STUDY

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ABSTRACT

The paper is a case study of a pump package built as part of a washdown system to be used on an offshore platform. The new way of doing business with this major oil company includes an increase in the scope of engineering and the amount of documentation required to complete the job. This is a trend that has received more attention recently and was mandated for the 2nd washdown unit by the same end customer. Other oil companies are demanding similar specifications and equipment requirements. The paper will discuss information that a pump supplier / package builder needs to know to participate in bids to major oil companies. The lessons learned on the first pump unit that were applied to the second identical unit and how to avoid mistakes, will also be discussed. Photos, diagrams and drawings will be used to illustrate the subject of the paper.

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1.0 INTRODUCTION TO THE CASE STUDY

In July 2001, a high-pressure Hot Water Washdown unit for a Major Oil Company's offshore platform was in the quote/bidding phase and in October 2001, Weatherford was formally awarded the contract. Weatherford finished and shipped the unit in February 2003 but requests for documents and manuals continued until the last piece of documentation was submitted and approved in November 2003. Weatherford submitted about 100 requested documents and eight volumes of Mechanical Catalogues and Manufacturing Records books. The initial award money was $165,000 and the change orders brought the total to $240,000.

Weatherford received the second order for the almost identical unit in June 2003 and manufactured and shipped the 2nd unit in March 2004 but the documents requests/submits ended in December 2004. This paper will mainly discuss the 2nd unit.

2.0 DESCRIPTION OF THE UNIT

Figure 1 is the P&ID drawing for the scope of the unit. The unit is designed to deliver a maximum of 9000kg/hour (40 GPM) water at maximum discharge pressure 90 barg (1300 PSIG) and heated maximum temperature of 60 °C (140 °F) to four work stations through four water guns. A water jet type eductor was used to mix liquid soap with the incoming fresh water at an approximate proportion of 1 part soap to 20 parts water. The main components include: one high pressure wash down surge tank, one detergent tank, one high pressure triplex pump with suction and discharge dampeners, three feed mechanical packing lubricator and a 40 HP TEFC motor with a T3 operation temperature code, one 480V, 390 KW 5-3PH heater, one NEMA 4X heater control panel and mounted on a structure skid of estimate total weight of 10,000 lbs and 3300mm x 2500mm x 2500mm LWH.

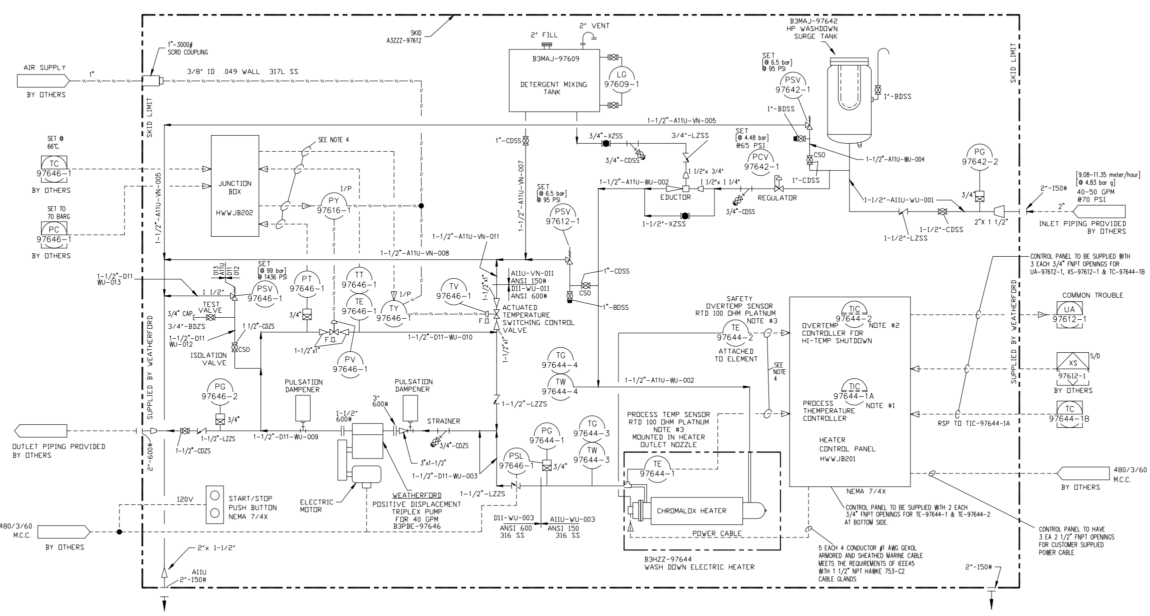


FIGURE 1 --- P&ID DRAWING OF HP HOT WATER PRESSURE WASHER

3.0 DOCUMENTATION REQUIREMENTS

By the contract agreement, Weatherford, the seller shall submit to the buyer, those documents and drawings for project owner's and buyer's approval listed in the general terms of technical specification and /or the technical meeting memorandum attached hereto by the date as specified and then the buyer shall return one copy of them to Weatherford within thirty days after the receipt of such drawings. Should the buyer neither have returned the drawings within the said period as specified above, nor have advised the seller within the period as above of any counter proposal in writing to the seller. The seller shall send the buyer a telefax or email reminding the buyer that the same has not been returned and in the event that the buyer shall fail to notify the seller by telefax of any remarks within five days from the date of receipt by the buyer of such telefax or email, then upon the expiration of such period, the drawings concerned shall be deemed to have been approved automatically by the buyer. Seller will not proceed with order until buyer returns approved copy of drawings.

Figure 2 is an example of 7 pages of the Supplier Data Requirement List (SDRL) and Figure 3 SDRL shows the workflow.

PROJECT OWNER BUYER			Purchase Order Number **AO02-DS-WR-136**	
SUPPLIER DOCUMENT REGISTER (SDR), G1			**PAGE 1 OF 7**	
SDRL CODE	**SUPPLIER DOCUMENT NUMBER**	**DOCUMENT TITLE**	**REV**	**SUBMISSION DATE**
R52	WR-136-R52	CERTIFICATE OF MATERIAL CONFORMANCE		Nov 21, 03
R57	WR-136-R57	REDUCED SECTION TENSILE TEST RESULTS		Nov 21, 03
R58	WR-136-R58	IN-PROCESS MATERIAL TEST RESULTS		Nov 21, 03
R62	WR-136-R62	RADIOGRAPHIC TEST REPORTS		Nov 21, 03
R63	WR-136-R63	NON - DESTRUCTIVE INSPECTION RESULTS AND CALIBRATION RECORDS		Nov 21, 03
R64	WR-136-R64	DESTRUCTIVE TEST RESULTS / CERTIFICATES		Nov 21, 03

FIGURE 2 --- SUPPLIER DATA REQUIREMENT LIST

PROJECT OWNER BUYER	Purchase Order Number **AO02-DS-WR-136**
SUPPLIER DOCUMENT REGISTER (SDR), G1	**Page 1 of 7**

SDRL CODE	SUPPLIER DOCUMENT NUMBER	DOCUMENT TITLE	REV	SUBMISSION DATE
G1	WR-136-G1	SUPPLIER DATA SCHEDULE		Jul 31, 03
C3	WR-136-C3	STRUCTURAL STEEL CALCULATIONS		Aug 15, 03
C10	WR-136-C10	WIND LOAD CALCULATIONS		Aug 15, 03
C13	WR-136-C13	PROCESS/UTILITY CALCULATIONS		Aug 15, 03
D1	WR-136-63908-D1	OUTLINE DRAWINGS		Aug 15, 03
D2	WR-136-63928-D2	SHOP DETAIL DRAWINGS		Aug 15, 03
D3	WR-136-63908-D3	EQUIPMENT ARRANGEMENT DRAWINGS		Aug 15, 03
D4	WR-136-63909-D4	ASSEMBLY DRAWINGS		Aug 15, 03
D8	WR-136-D8	INSTRUMENT SCHEMATICS & CONTROL DIAGRAMS		Aug 22, 03
D10	WR-136-D10	PIPING & INSTRUMENTATION DIAGRAMS		Aug 22, 03
D15	WR-136-0118-D15	ELECTRICAL INTERNAL CONNECTION DIAGRAM		Aug 22, 03
D16	WR-136-0118-D16	ELECTRICAL SCHEMATICS & WIRING DIAGRAM		Aug 22, 03
D20	WR-136-XXX-D20	DETAIL VESSEL OR TANK FABRICATION DRAWINGS		Aug 22, 03

FIGURE 2 (Continue) --- SUPPLIER DATA REQUIREMENT LIST

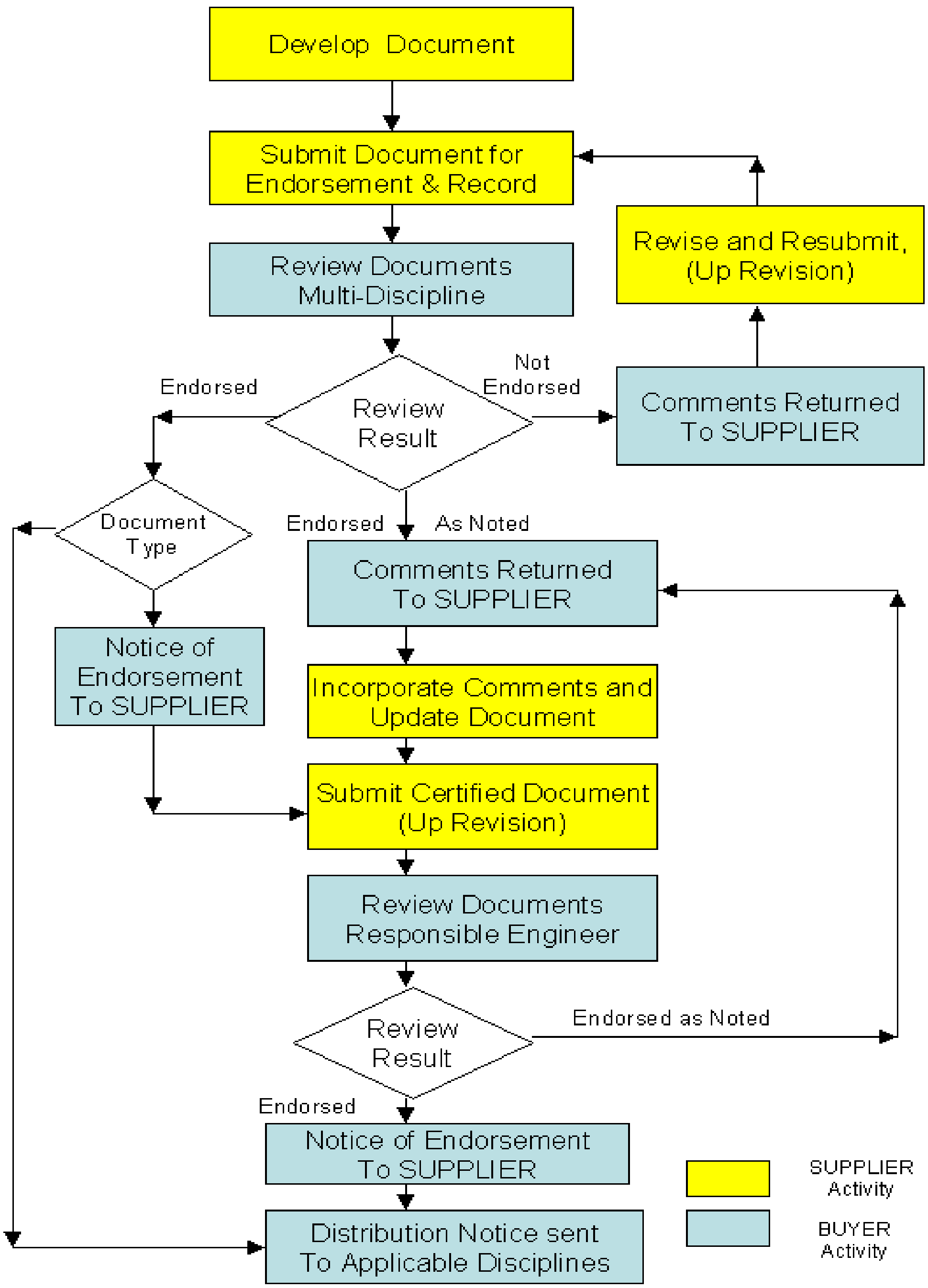


FIGURE 3 --- SDRL WORK FLOW

All of the documents required can be grouped as (1) specifications (2) procedures (3) reports (4) calculations (5) drawings (6) vendor documents (7) information documents and (8) others. For every item submitted, we would received a return for each item, marked as “A”---approved or “B”---approved provided changes noted are incorporated and “C”---to be corrected and resubmitted for approval, do not proceed with construction and finally “D”---receipt noted, for reference. Normally, for the reports and information documents, in the two or three circles (submit-return-submit), would get a rating “A”, engineering drawings, usually would take five to six circles to get an “A”. Because this was the 2nd unit, most engineering work was done and only minor changes were needed, so after three to four circles we would get an “A” rating. Vendor documents turned out to be hardest in terms of “paper work” to get. Sometimes after dozens of email exchanges and numerous calls, we still could not get what the customer needed and we had to “make up” something as an alternative.

To the engineering calculations, the customer demanded a redo of all the items involved even very small changes. For example, the customer required new engineering structural steel calculation for the skid due to change from tubing to angles and 2” dimension difference. Some calculations for the Figure 4, skid structure steel calculation are list below:

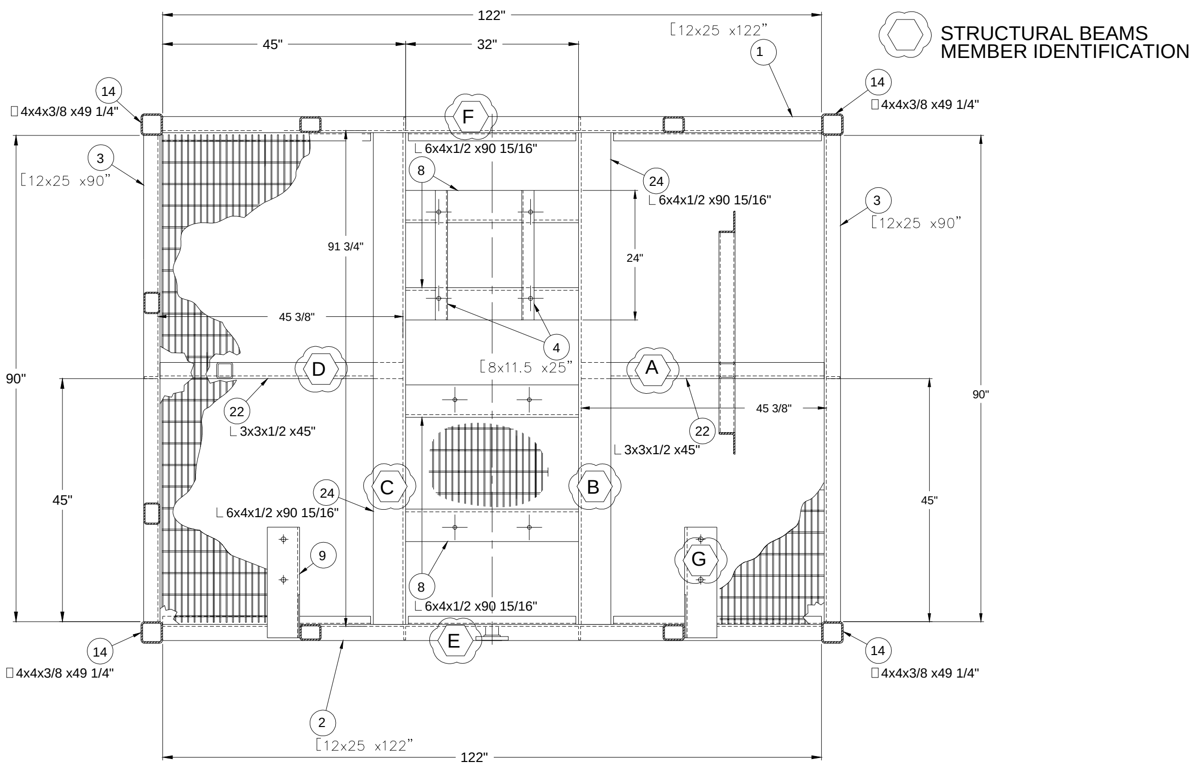
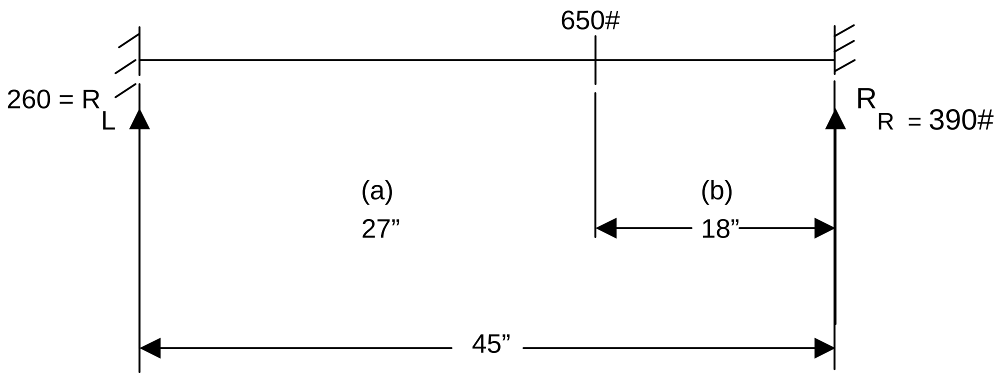


FIGURE 4 --- SKID STRUCTUAL STEEL CALCULATION

Angle ⟨A⟩ L3X3X1/2, $S = 1.1\ in^3$ $I = 2.22\ in^4$

W = 1300 # / 2 = 650 #



Max. negative stress is at load.

$$\frac{-2W \times 18^2 \times 27^2}{S \quad 45^3} = \frac{-2x650 \times 18^2 \times 27^2}{1.1x45^3} = -3063 \qquad \text{(Ref. 3, P242)}$$

$3063 < 20{,}000\ lbf/in^2$

Max. stress is at end next shorter segment.

$$\frac{650 \times 27^2 \times 18}{45^2 \times 1.1} = 3829 < 20{,}000 \qquad \text{(Ref. 3, P242)}$$

Max. deflection is in the longer segment

$E = 29{,}000{,}000\ lb_F\ /in^2$

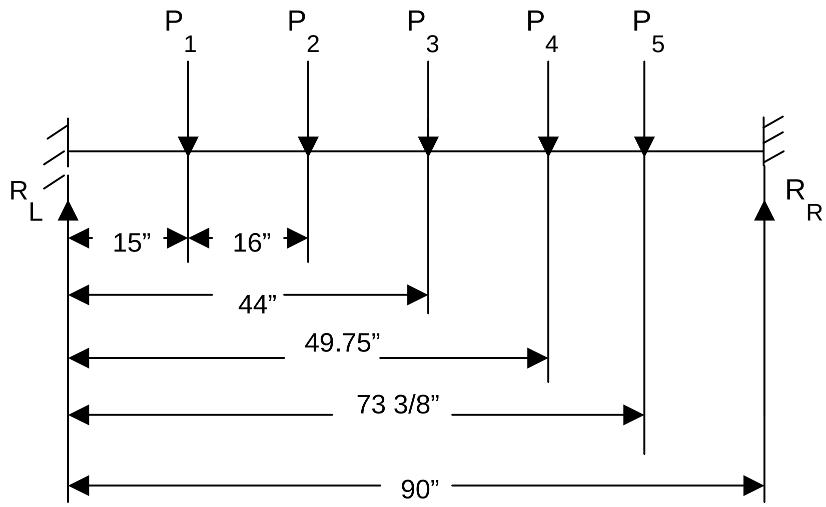
L / 720 = 45 / 720 = .0625 in

$$\triangle = \frac{2W \times b^2 \times a^3}{3\ EI\ (L + 2a)^2} \qquad \text{(Ref. 3, P243)}$$

$$= \frac{2 \times 650 \times 18^2 \times 27^3}{3 \times 29{,}000{,}000 \times 2.22\ (45 + 2 \times 27)^2} = .004\ in. < .0625\ in.$$

SO ANGLE A 3 x 3 x ½ IS OK

Angle ⟨B⟩ 6 / 4 L 6x4x1/2, $I = 6.27\ in^4$, $S = 2.08\ in^3$



$$P_1 = \frac{\text{PUMP}}{4} + \text{DIAMPER \& PIPE} = \frac{772}{4} + 275 = 468\#$$

$$P_2 = \frac{\text{PUMP}}{4} = 193\#$$

P_3 @ 44”= 260# (SEE CALCULATION FOR ANGLE A)

$$P_4 \text{ @ } 49.75” = P_5 \text{ @ } 73\ 3/8” = \frac{\text{MOTOR}}{4} = \frac{596}{4} = 149\#$$

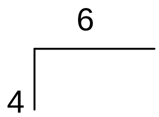
$$R_R = \frac{15}{90}468 + \frac{31}{90}193 + \frac{44}{90}260 + \frac{49.75}{90}149 + \frac{73.375}{90}149 = 475\#$$

$$R_L = 468 + 193 + 260 + 149 + 149 - 516 = 703\#$$

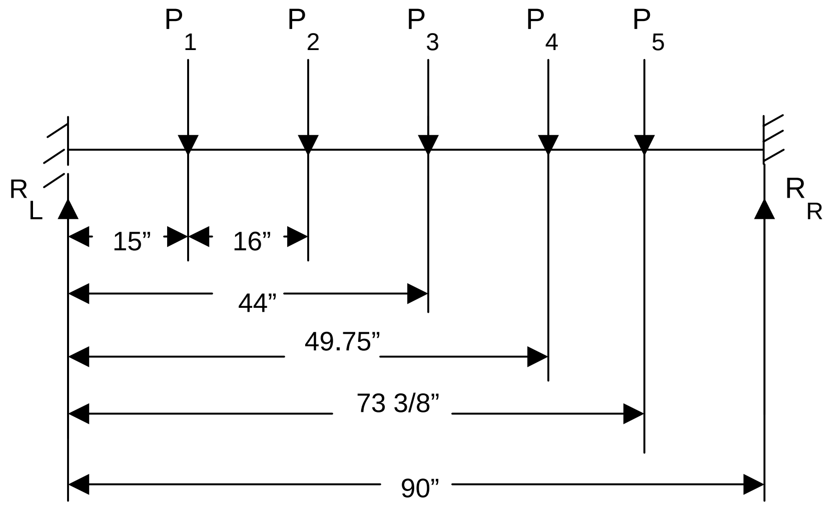
SINCE THE LOAD OF ANGLE B IS SMALLER THAN THAT OF ANGLE C
PLEASE REFERENCE THE CALCULATION FOR ANGLE C

SO ANGLE B 6x4x1/2 is OK

Angle (C)



L 6x4x1/2, $I = 6.27\ in^4$, $S = 2.08\ in^3$



$P_1 = \frac{PUMP}{4} + \text{DAMPENER \& PIPE} = \frac{772}{4} + 275 = 468\#$

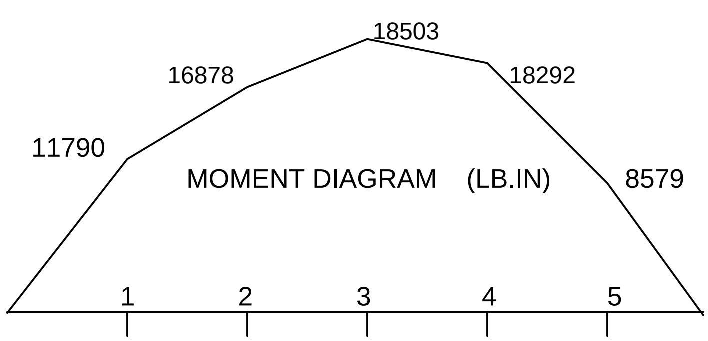
$P_2 = \frac{PUMP}{4} = 193\#$

P_3 @ 44”= 343# (SEE CALCULATION FOR ANGLE D)

P_4 @ 49.75” = P_5 @ 73 3/8” = $\frac{MOTOR}{4} = \frac{596}{4} = 149\#$

$$R_R = \frac{15}{90} 468 + \frac{31}{90} 193 + \frac{44}{90} 343 + \frac{49.75}{90} 149 + \frac{73.375}{90} 149 = 516\#$$

R_L = 468 + 193 + 343 + 149 + 149 - 516 = 786#



$M_{max@P3}$ = 18503 lb.in

$$S_{RQD} = \frac{18503}{20000} = .925\ in^3 < S = 2.08\ in^3$$

ACTUAL Deflection $$\triangle < \frac{W \times L^3}{192\ EI} = \frac{1302 \times 90^3}{192 \times 29{,}000{,}000 \times 6.27} = 0.027\ in \quad \text{(Ref. 3, P243)}$$

$$\triangle < 0.027\ in < L / 720 = 90 / 720 = 0.125\ in \qquad \text{(customer spec.)}$$

SO ANGLE C 6x4x1/2 is OK

Etc.

4.0 MANUFACTURING PROBLEMS

Originally, the unit soap tank was quoted as stainless steel, but the customer wanted Fiberglass Reinforced Plastic (FRP). During testing, water was dripping at the flange connection of the Soap Tank (see Figure 5). Cracks were visible to the naked eye and appeared to have traveled into the neck of the FRP flange (see Figure 6). Cracks were visible on both flange connections. It was determined that incorrect tightening of the flange bolts was the main cause of the leakage and low strength FRP itself (compared to steel tank) also contributed to the failure. The FRP Soap Tank was then removed from the skid and sent back to the tank vendor to repair. The Raised face flange was then changed to a flat-faced flange and rubber gaskets were used. Inner tubing of the neck/flange was replaced and remolded into the tank body. After repairing, the FRP soap tank was hydrostatically tested for four hours. The support for the FRP tank on the skid was also redesigned. No more leakage was found during subsequent tests.

The same problem was encountered in the first unit (FRP tank broken) and why it happened to the second unit. The change of vendor and project team contributes to a repeat of the problem encountered on the first unit.

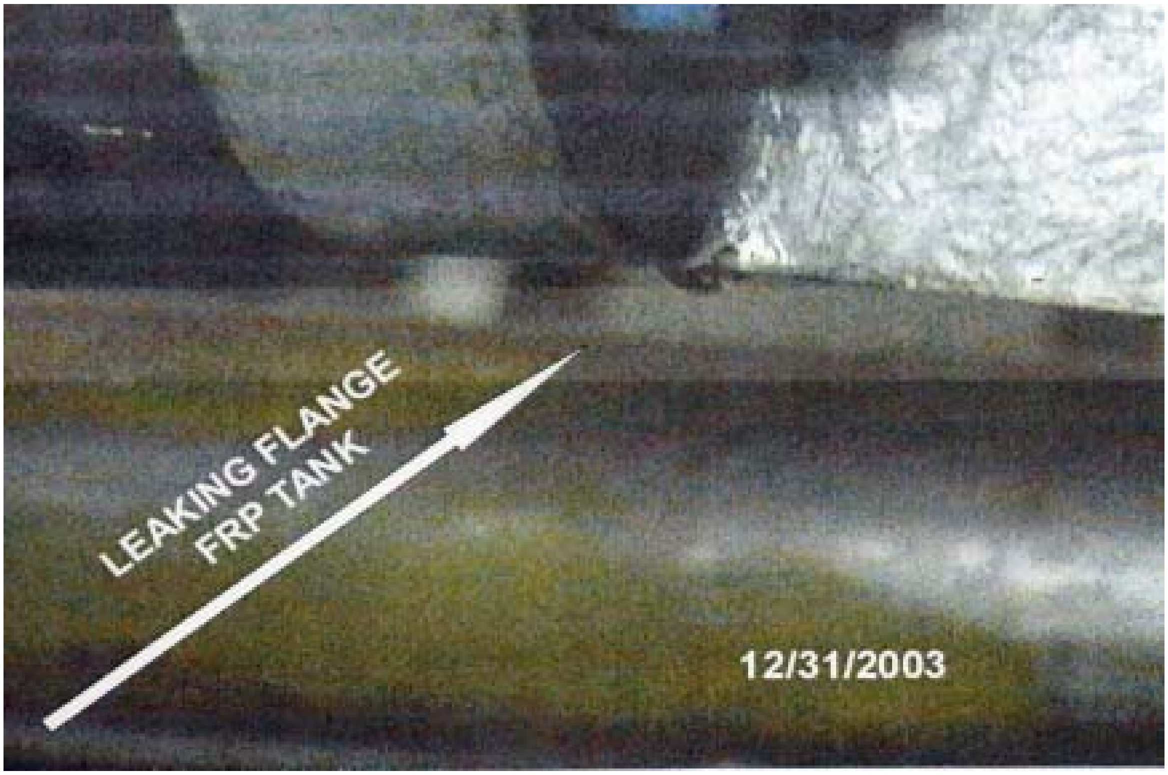


FIGURE 5 --- FRP Soap Tank Leakage

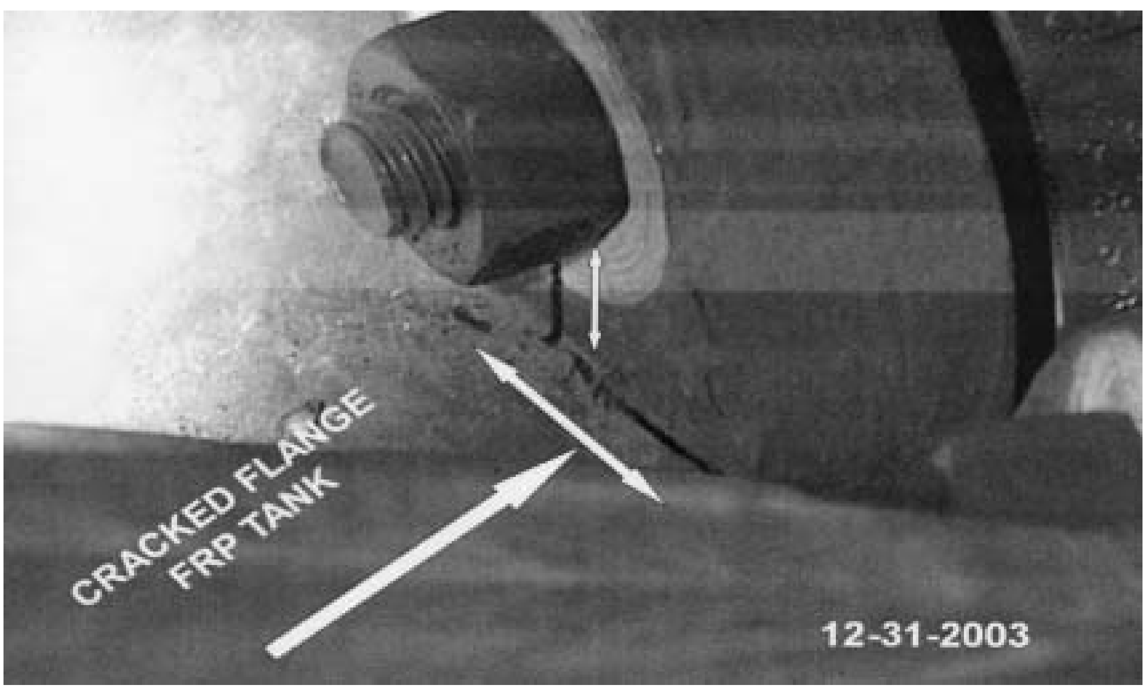


FIGURE 6 --- FRP SOAP TANK CRACKS

5.0 FINAL ACCEPTANCE TEST

During the final acceptance test (FAT), the first High Pressure Hot Water Washdown Unit performed as expected when tested in Houston. It was assembled in Texas and delivered the 40 GPM at 1300 PSIG as required and delivered hot water to four shut-off style guns during FAT. The second unit in the series, which is the subject of this paper, was assembled in Louisiana, but when it came time for the FAT, the pump did not perform well and it was suspected that there was not enough water reaching the suction side of the pump. The project manager, the customer's inspector and the shop people were waiting for a reason that the pump was not performing. A simple and fast method to analyze the pressure drop from the 70-psi inlet pressure through the piping, valves and tanks was used for a quick check. The resistance of valves and fittings to flow of fluids seemed to be the quickest way to get a handle on the problem. From the P&ID of the system shown in Figure 1, a list was made of the elements in the plumbing leading to the positive displacement triplex pump using Reference 2. We adopted the general formula:

$$H = K\frac{V^2}{2g}$$

Where K = Experimental coefficient
V = Velocity of water
g = 32.2 feet per second per second
H = Effective head pressure, feet of water

To estimate the Resistance to Flow in Terms of Equivalent Pipe Length

Element in the System	Quantity	Equivalent Pipe Length
Pipe, Schedule 80, 1-1/2”	45.5 feet	45.5
Elbow, 1-1/2”	17 x 4’ of pipe	68
Valve, check, 1-1/2”	2 x 40’ of pipe	80
Valve, globe 1-1/2”	1 x 40’ of pipe	40
Thermoweld probe	2 x 40’ of pipe	80
Eductor, 1-1/2”	1 when in by-pass	0
Y-strainer, 1-1/2”	2 when clean	80
Union, 1-1/2”	7 full bore	0
Flange 1-1/2”	6 full bore	0
Swage 2” x 1-1/2”	1	2.5
Tee, 1-1/2”	9	81
Valve, 1-1/2” ball	1	1
Swage 1-1/2” x 1-1/4”	1	2.5
Pressure regulator, 1-1/2”	1 adjusts supply	0
Cross, 1-1/2”	1	9
Elbow, 45 deg.	2	6
Swage, 1-1/2” x 3	1	1.5
Total Equivalent Feet of Pipe		497

The pressure drop for 1-1/2” pipe is around 4.78 psi per 100’. Multiplying 4.97 x 4.78 = 23.76 psi pressure drop in the water inlet side of the plumbing system. If the incoming water is adjusted to 70 psi at 40 gpm, then 70 psi – 23.76 psi pressure drop = 46.24 psi should be measurable at the pump inlet. Gauges were placed at the pump and various places in the plumbing system until the item, which caused the most pressure drop, was located. The check valves were specified as API #12 Ball Lift Type, but plug type, standard port check valves were purchased and installed in the system. When the check valves were replaced, the pressure drop problem was eliminated.

Where K valves and equivalents were gotten from charts/graphs in reference 2, P530-532.

6.0 CONCLUSIONS

The new way of doing business for some of the major oil companies increases the scope of engineering and documentation. A product such as a High Pressure Hot Water Washdown Unit may be fairly simple, but the purchase order could include specifications that must be fully understood before acceptance of the project. Some engineering companies and their customers, the major oil companies, for reasons such as liability or safety, are now enforcing what was once “boiler plate”. This may deter many small companies, who are otherwise technically capable of handling the project, but do not have the personnel needed to comply with the project documentation requirements. It may be better for large companies like Weatherford, to take-on such projects. Although the first unit was not very profitable, the second unit showed a better return due to the major engineering work had already been done for the first unit. Even the documentation part of the project was easier because of a similar format/method for document requirements. In general, time was saved and being up on the learning curve increased profit. It is understood that similar units will be ordered for future offshore platforms.

7.0 REFERENCES

1) Michael T. Gracey, Manufacturing case study involving major oil company--- WJTA 2003 American Waterjet Conference, August 17-19, 2003
2) Crane Co., Valves Fittings Pipe Fabricated Piping--- CRANE 1952
3) Machinery’s Handbook, Twenty-Fifth Edition, 1996