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Newfoundland & Labrador Hydro

Hydro Plant Corrosion / Fouling Study 2002

Upper Salmon Generating Station

SERVICE WATER SYSTEM

Newfoundland & Labrador Hydro

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SERVICE WATER SYSTEM

Piping
Strainer
Supply Pump
Control Valves
Heat Exchangers

Prepared for: Newfoundland & Labrador Hydro
Hydro Generation

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Date: November 23, 2001

SUMMARY

It was determined that a hydro plant cooling water study was needed to determine the most effective solution to the cooling water fouling that is plaguing our hydro plants. The methodology for this study was planned out to include the following: prioritize plants and systems for review, review drawings, inspect coolers for extent of fouling, calculate actual flow rates, and determine the best solution for each hydro plant.

It was determined that Upper Salmon, Cat Arm, and Hinds Lake had the most problems with regards to cooling water.

In order to first determine which plant had the worse problems an in-depth analysis of each plants cooling water system had to be undertaken. Next a complete review of the plants work history had to be done. This was accomplished by reviewing all work orders related to the plants cooling water system in the J.D.Edwards. From this it can be determined which plant had the worse problems.

What was needed next was a review of how the plant's cooling water system has been operating. This was accomplished by using the Trend Monitoring Program that I designed. From the trend graphs one could see just how efficiently the plant has been operating and how the work on the cooling water system affects it. This gives us a time frame for cleaning components of the system so that we could set up a maintenance program for the cooling water system.

A cost analysis was done to determine the amount of money being spent on the current cooling water system in each plant. Also a cost analysis for replacing the piping was done using RSMeans Mechanical Cost Data for each plant.

Several solutions were presented to combat the fouling problem and they are; chemical cleaning of the system, replace the piping with corrosion resistant pipe, add a corrosion inhibitor to the water, use organic filters, or convert to a closed cooling water system.

From these solutions four were chosen for further investigation and they are; replace piping with corrosion resistant pipe, add a corrosion inhibitor to the water, convert the system to a closed system, and continue to operate as we have. Each solution was researched and a Net Present Worth calculation was done to determine the most economical solution. It was determine that replacing the piping with corrosion resistant pipe is the best solution, considering that the pipe has to be replaced in the next few years the other solutions did not seem economical.

The NPW of this solution for Upper Salmon is $73,806 over the pipe life of 20 years. The NPW of continuing to operate as we have is $86,210 and this does not include replacing the existing piping, which labour alone is $26,000. The closed loop solution has a NPW of $98,075 but the existing piping has to be replaced for this solution to be affective. The closed loop solution can always be added on after the piping is replaced.

TABLE OF CONTENTS

SERVICE WATER SYSTEM

The service water system in Upper Salmon has had fouling problems since it's opening in 1983. At first this was though to be caused by the unsettled organic materials within the water reservoir and should be 'washed' through the system in three to four years. Since the plants first opening the strainer had to be cleaned twice a year. Every two or three years since the early 90's a scheduled outage is preformed on the unit to clean the strainer and surface air coolers that become clogged with debris. This maintenance is required to prevent the unit from over heating during the summer months. The service water system pipe becomes clogged with organic 'slim' and hardened organics that attach themselves to the corroded pipe walls.

The purpose of this report is to provide the reader with a complete review of the service water system along with an analysis of how the system has been operated. In conclusion to this information recommendations are provide that will help to improve the reliability and service of the cooling water system.

General Information

The cooling water supply is gravity fed art full head pressure from the spiral case at the draft tube gallery using a common header with the fire protection water and domestic water supply. System water is provided via a six-inch supply header and passed through an automatic strainer (ME-11). The water is then distributed to the generator coolers, thrust bearing, turbine shaft seal and low pressure air compressors.

As the station is unmanned, the six –inch Adams strainer is provided with an automatic backwash cycle controlled by pressure differential and a timed cycle. The strainer is designed to remove particles larger than 250 Um (0.010 in).

There is a by-pass line around the automatic strainer, with an in-line basket type strainer (St-11), to permit maintenance and servicing to the automatic strainer without requiring shutdown of the unit.

When the unit is shutdown for servicing and the penstock drained, the fire protection water will be prevented from draining to the spiral case or the generator cooling water system by a check valve (FW-4V).

Generator coolers

The generator is self-ventilating, normally forcing the enclosed air over the field poles, stator iron and windings, and pushing it through cooling coils of heat exchangers, located within the generator housing, to be recirculated.

For powerhouse heating, generator cooling air is drawn in through air-operated louvers at the turbine floor. The air will leave the generator enclosure, at a temperature controlled by the cooling coils, through air-operated discharge louvers in the generator top covers.

The generator air coolers are arranged into two separately piped banks of four coolers. The system has sufficient capacity to permit continuous operation at 155 percent rated output with any one cooler out of service.

The following instrumentation and control are provided for the generator air coolers:

- Individual flow balancing valves in the discharge line of each of the generator coolers.
- Flow sensing orifices installed in the supply headers of the two cooler banks. Each orifice is supplied with transmitters and two indicators, one on the turbine gauge panel and the other at the automatic flow control valve.
- An automatic flow control valve (FCV-1) in the common discharge from the two banks of generator coolers to modulate the cooling water flow to maintain a constant generator pit temperature sensing element at the discharge side of one cooler.

Generator Cooling Water Control

For control of the generator cooling water an AUTO-OFF-HAND control switch (43-WG) is located on the turbine gauge panel. Under normal operation the switch will be in the auto position to energize solenoid A of air switching valve VS-22, which allows cooling water modulating control from the temperature controller (TIC).

On unit start up however, a circuit which is independent of control switch position de-energizes solenoid A and energizes solenoid B to fully open water flow control valve FCV-1. The water flow indicator on the turbine gauge panel will signal that flow exists and the unit start sequence will continue. At 90% full load speed this circuit de-energizes and returns the system to normal temperature control.

If during unit operation a stator high temperature alarm occurs, this circuit will again energize and the flow control valve will fully open to allow maximum water flow through the surface air coolers. This full flow condition will exist until the temperature drops below the alarm point.

When control switch 43-WG is switched to the hand position, the flow control valve is fully opened by operation of VS-22 solenoid B.

An indicator light on the turbine gauge panel is turned on when control switch 43-WG is in the auto position and the unit is started or when in the hand position.

Surface Air Coolers Flow Rate:

Flow Rate	Set Point
Left Cooler Bank	15 L/sec
Right Cooler Bank	15 L/sec

Table 1

Turbine Shaft Seal

Turbine shaft seal water is taken from the generator cooling water supply line. A cyclone separator has been provided to meet shaft seal water quality requirements. An orifice type flow meter (F1-5) with low flow alarm contacts in the turbine shaft seal cooling water supply line measures the cooling water flow rate.

Turbine Shaft Seal Flow Rate:

Flow Rate	Set Point
Shaft Seal	10 – 20 L/min @ 50 KPa

Table 2

Thrust Bearing Oil Coolers

The generator thrust bearing oil is cooled by heat exchangers located between the trust bearing and the outer wall of the reservoir within the generator pit. The thrust bearing oil cooling water flow is controlled by control switch 43-WB, operating solenoid valve (VS-14). In the auto position the solenoid valve is held closed until the unit starts, when it is de-energized and allows full water flow to the coolers. Are indicating light immediately above the control switch operates to indicate that the solenoid valve is open and the bearing coolers are in operation. With the control switch in the hand position, the solenoid valve is permanently open, resulting in full water flow to the coolers.

An orifice type flow indictor with transmitter is provided at the thrust bearing cooling water discharge line. Two indicators are provided: one on the turbine gauge panel and the other at the automatic flow control valve.

Thrust Bearing Cooler Flow Rate:

Flow Rate	Set Point
Thrust Bearing Coolers	4.5 L/sec

Table 3

You can find the flow diagrams for the Upper Salmon cooling water system in Appendix A.

HISTORY OF SERVICE WATER SYSTEM

General Information

All work orders that are in the J.D.Edwards system since fall 1994 pertaining to the service water pumps, strainers, and heat exchangers have been reviewed to piece together an overview of the major work done on the service water system. All of the major work done on this system is listed below in the following table. It can be seen from table 4 that the SAC's have been cleaned every year since 1993. It can also be seen that the SAC piping has been replaced in 2000. The rotary strainer is cleaned approximately every three years. The generator coolers have been cleaned only once since 1993, but from the amount of build up found within these coolers this cleaning frequency should have been more then what it was.

USI - Work Order History

	January	February	March	April	May	June	July	August	Septembe	October	November	December
1993										Cleaned 8 - SAC		
1994											Cleaned 8 - SAC	
1995					Cleaned 8 - SAC				Cleaned R.Strainer			
1996				Cleaned R.Strainer	Cleaned 8 - SAC				Cleaned 8 - SAC R.Strainer			Cleaned Y-Strainer
1997				Cleaned 8 - SAC				Cleaned R.Strainer			Modified & Cleaned 1 - SAC	
1998										Modified & Cleaned 8 - SAC		
1999								Cleaned 8 - SAC	Replaced part of shaft seal piping			
2000									Replaced 3" & 4" SAC Piping	Cleaned 8 - SAC		
2001								Cleaned R.Strainer	Cleaned 8 - SAC 4- G.Cooler			

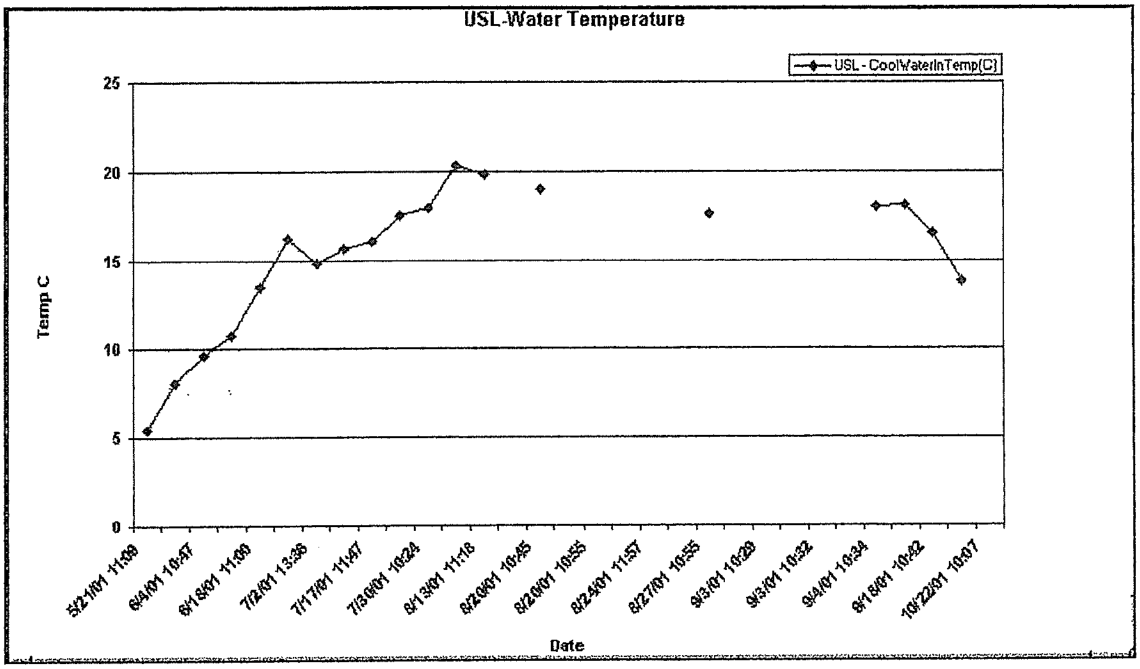
Table 4

Review of Trend Monitoring Readings

Trend Monitoring readings are taken weekly by operations for all hydro generating stations except Snooks Arm and Venams Bight. With knowledge of the work history performed on the generating station coupled with the trend monitoring readings one can develop a picture of how the generating station has operated over the last few years.

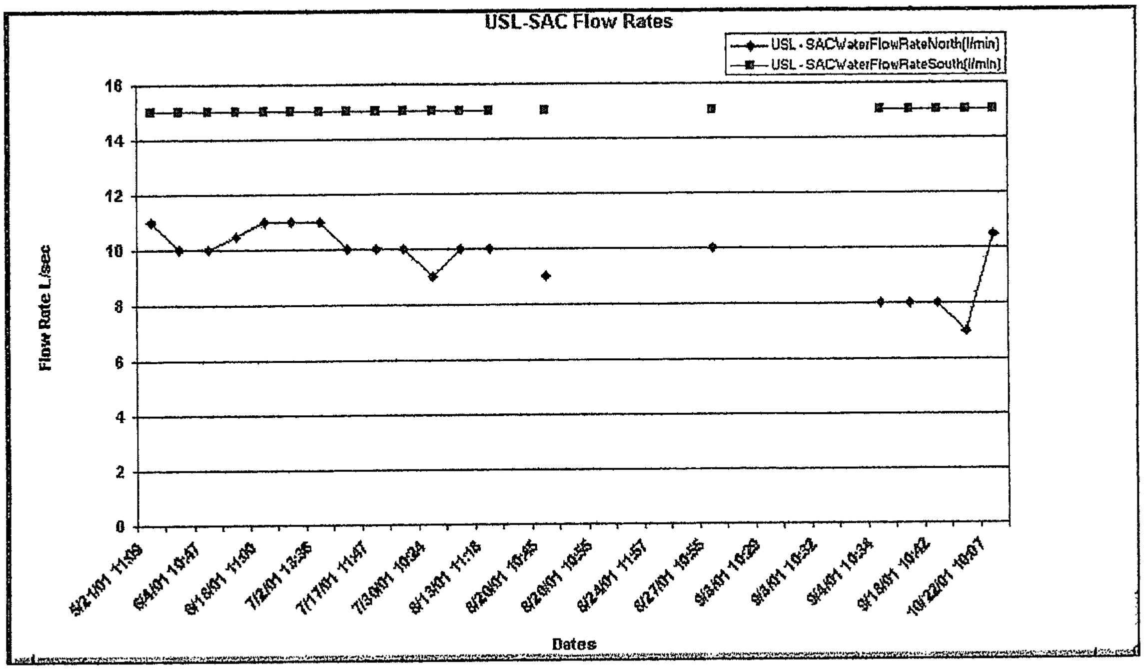
The Trend monitoring readings are now being stored into a database using Microsoft Access. A hard copy of the weekly readings is being kept on site for backup. The Microsoft Access Trend Monitoring program now allows quick graphing of operating parameters to help us determine the efficiency of the unit. The program is user friendly and allows operations to view the units operating parameters over an extended period of time.

The trend monitor readings for Upper Salmon were lost when the computer systems where updated in the spring 2001. Since the implementation of the Trend Monitoring Program using Microsoft Access the trend monitoring readings are once again being recorded. This database only has data since May 2001. Analysis of this short amount of data only gives us a snap shot of how the plant operated over the past summer.



Graph 1 - Water Temperature

Graph 1 shows the water temperature differential for the cooling water system since May 2001. One can see how the water temperature fluctuates through out the year, with increased temperatures during the summer months and decreased temperatures during the winter months.



Graph 2 - SAC Flow Rates

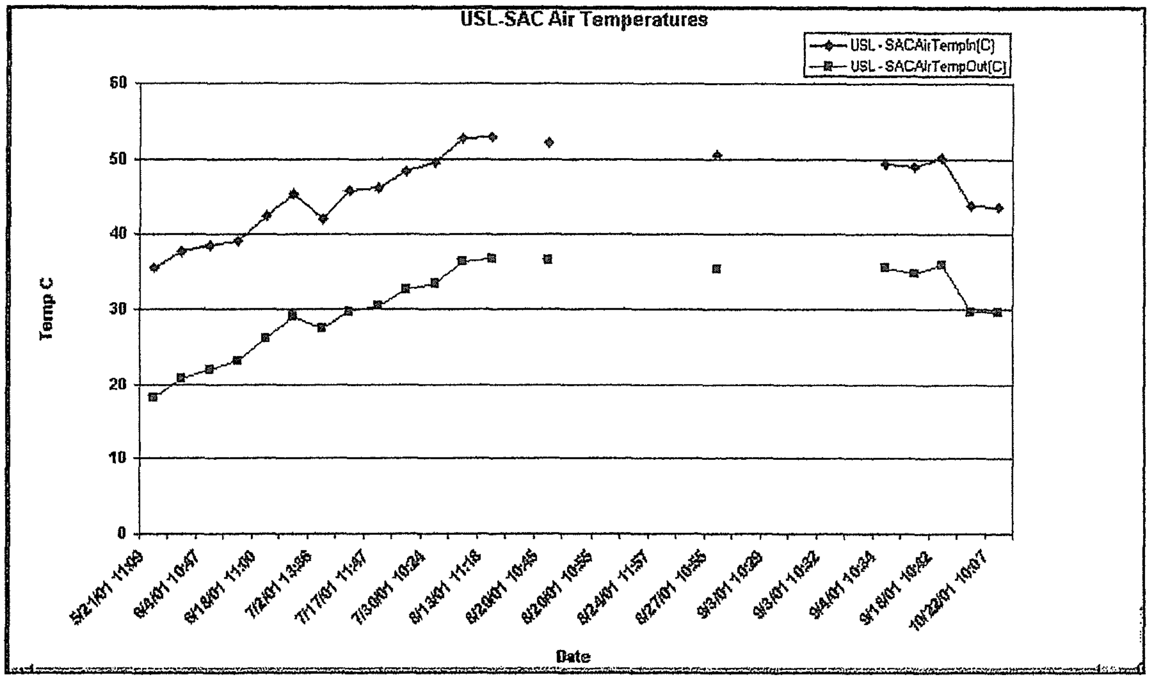
Graph 2 shows the SAC flow rates since May 2001. The recommended flow rates are 15 L/sec for each inlet header bank, with 3 L/sec considered low flow. The South bank flow meter has been reading 15 + L/sec since it was commissioned. The increase in the North bank flow rate from 7 L/sec to 10.5 L/sec was due to the coolers being cleaned in September 2001.

Actual Velocity Calculations:

Flow rate per tube $Q_t = 0.1875$ L/sec
Area of tube $A_t = 0.334$ in^2

Velocity per Tube $V_t = {}^{Qt}\!/_{At} = 2.86$ ft/sec

On the Fall 2001 outage inspection of the North bank discharge six-inch line resulted in the finding that the piping is clogged with debris. This would explain the lower flow rates 10 L/min through the north bank header. This piping is scheduled for replace since it has been in service since 1983. The piping will be replaced with six-inch sch 80 PVC.

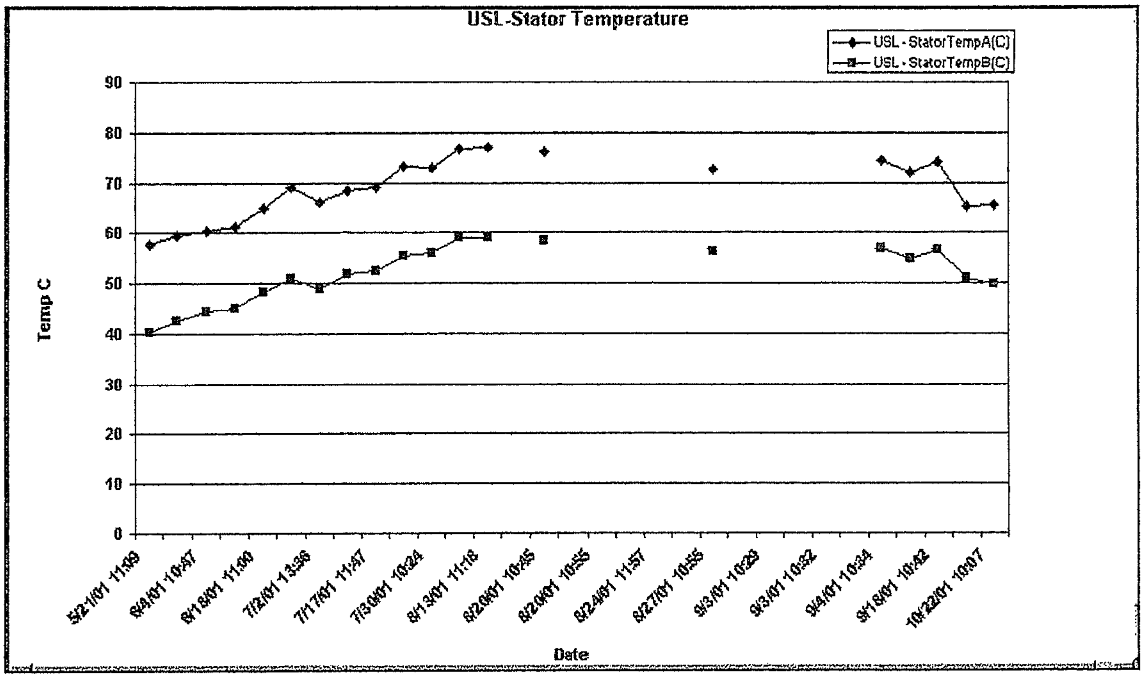


Graph 3 - SAC Air Temperatures

Graph 3 shows the SAC air temperature differential since May 2001. The air temperature into the SAC is measured inside the stator frame and the air temperature out of the SAC is measured inside the generator housing. One can see how the air temperature fluctuates through out the year, with increased temperatures during the summer months and decreased temperatures during the winter months. Even though the temperature fluctuates the temperature differential between the inlet and outlet remains constant around an average of 18 °C.

	Cold Air	Warm Air
Alarm	40 °C	°C
Trip Unit off Line	°C	°C

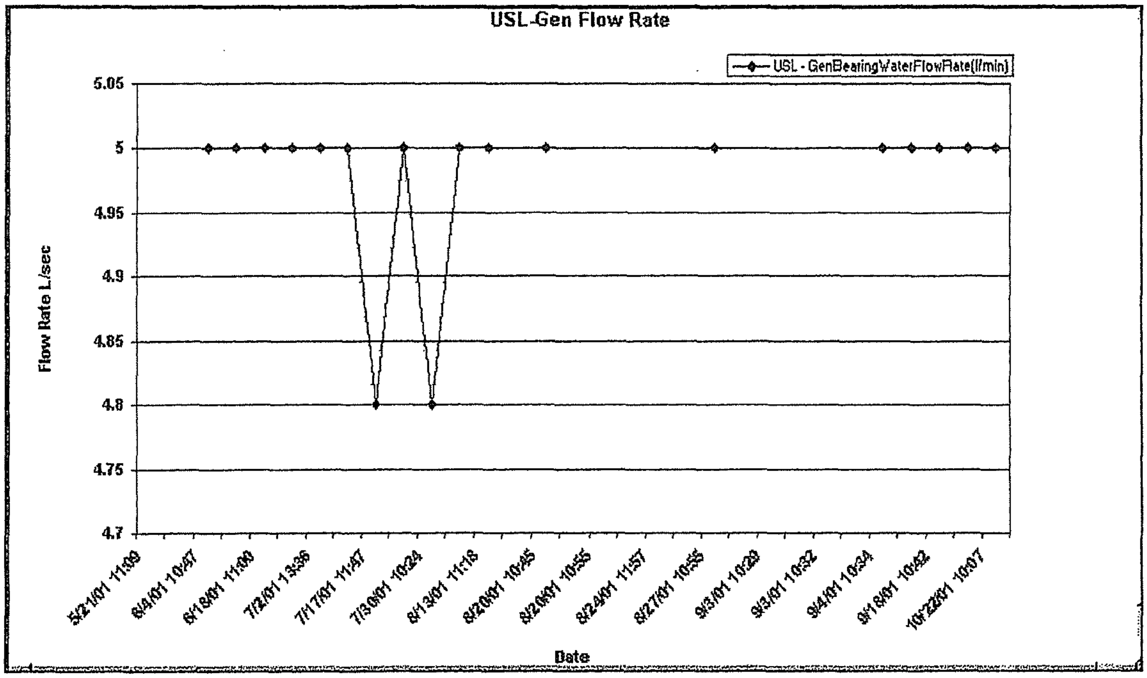
The temperatures recorder this pass summer shows that the SAC outlet temperature climbed to 38 °C almost reaching the alarm temperature set point of 40 °C.



Graph 4 - Stator Temperatures

Graph 4 shows the stator temperature since May 2001. One can see how the stator temperature fluctuates through out the year, with increased temperatures during the summer months and decreased temperatures during the winter months.

Core Alarm	
Iron Alarm	



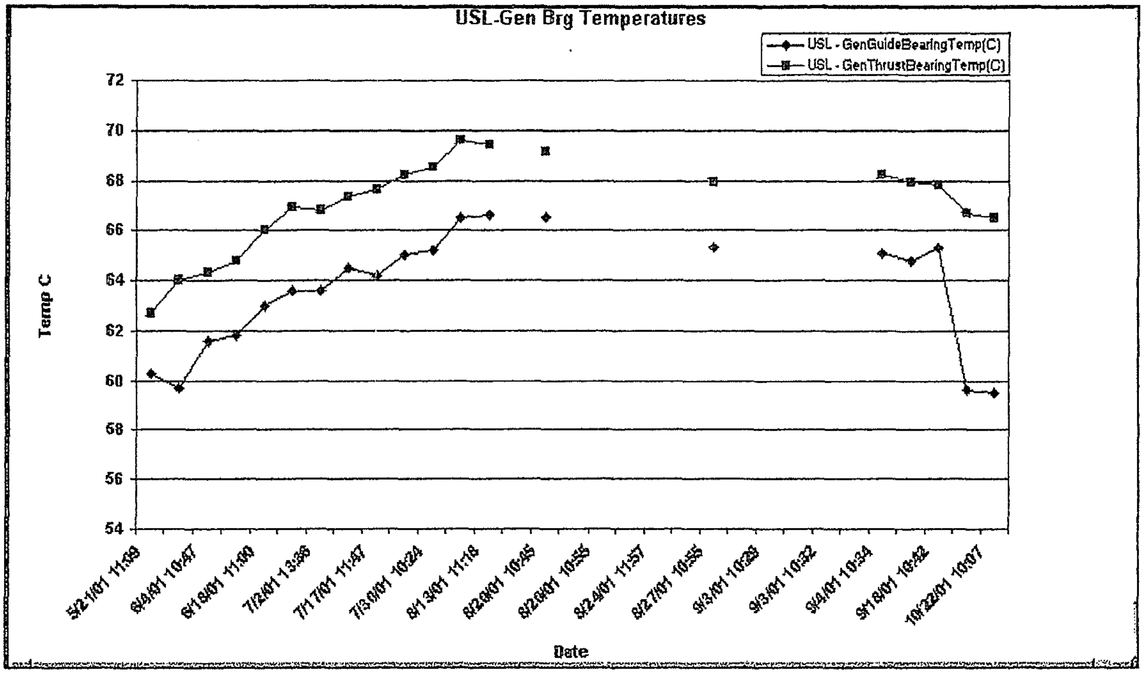
Graph 5 - Generator Flow Rate

Graph 5 shows the generator cooling water flow rate since May 2001. The recommended flow rate is 4.6 L/sec, with 5 L/sec considered high. The generator flow meter has been reading 5 + L/sec since commissioning.

Actual Velocity Calculations:

Flow rate per tube $Q_t = 1.25$ L/sec
Area of tube $A_t = 0.864\ in^2$

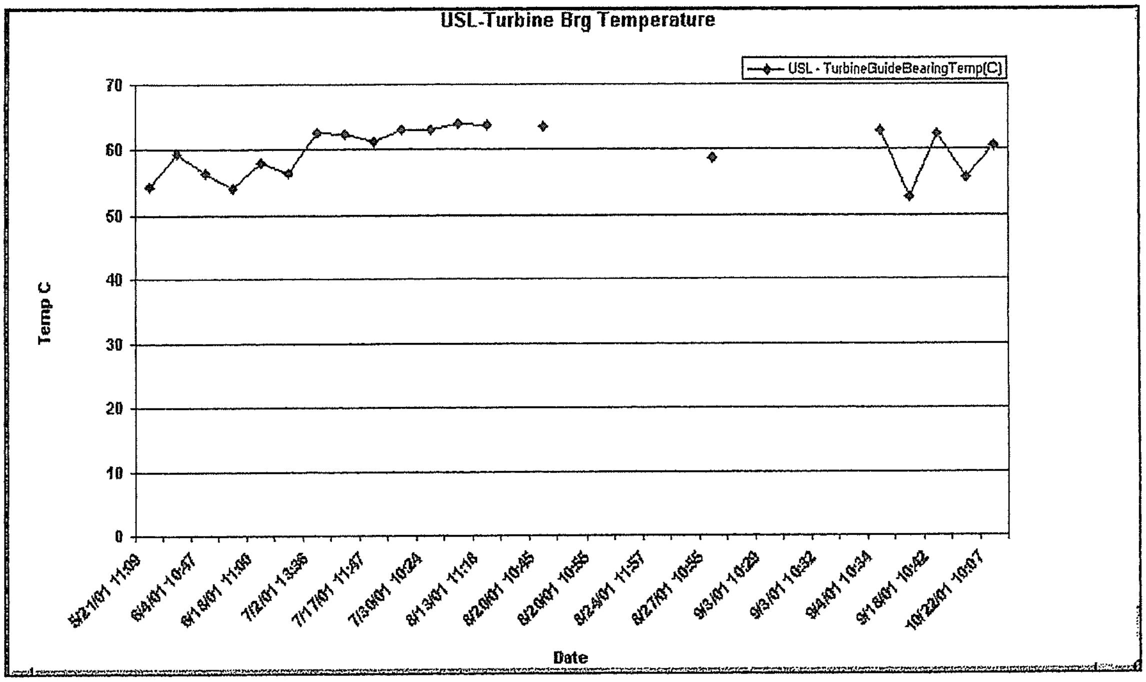
Velocity per Tube $V_t = Qt/At = 7.36$ ft/sec



Graph 6 - Generator Bearing Temperatures

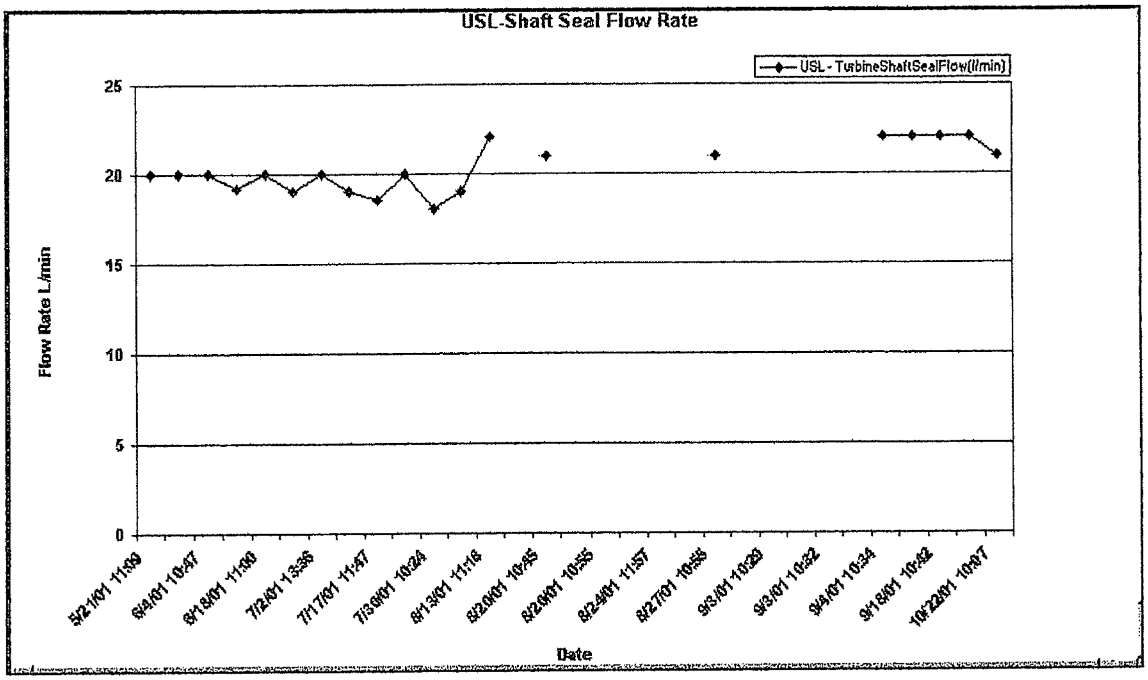
Graph 6 shows the generator thrust/guide bearing temperatures since May 2001. One can see the temperature drop in the guide bearing from 65 °C to 59 °C after the generator coolers were flushed in September 2001. One can see how the bearing temperature fluctuates through out the year, with increased temperatures during the summer months and decreased temperatures during the winter months.

	Guide Bearing	Thrust Bearing
Alarm		
Trip Unit off Line		



Graph 7 - Turbine Bearing Temperature

Graph 7 shows the turbine guide bearing temperatures since May 2001. One can see that there is a small temperature fluctuation between the summer months and the winter months with regard to the bearing temperature. The turbine bearing has no coolers for temperature control.



Graph 8 - Shaft Seal Flow Rate

Graph 8 shows the shaft seal flow rate since May 2001. The recommended flow rate is 20 L/min, with 30 L/min considered high and 10L/min considered low.

The shaft seal piping inside the turbine pit was replaced with copper tubing during the summer 1999. The piping outside of the turbine pit ahs not been replaced.

Test Samples

In August 2001 water samples from the Upper Salmon plant were sent to BetzDearborn for analysis. The water sample is directly from the penstock supply. Table **XX** shows the composition of the water sample.

Composition	Sample #1
pH	5.1
Specific Conductance @ 25C, umhos	24
Alkalinity "P" as $CaCO_3$, ppm	0
Alkalinity "M" as $CaCO_3$, ppm	< 2
Sulfur Total as SO_4, ppm	< 5
Chloride as CL, ppm	4.4
Hardness Total as $CaCO_3$, ppm	3.4
Calcium Hardness Total as $CaCO_3$, ppm	2.0
Magnesium Hardness Total as $CaCO_3$, ppm	1.4
Copper Total as Cu, ppm	0.06
Iron Total as Fe, ppm	0.17
Sodium as Na, ppm	1.2
Phosphate Total Inorganic as Po_4, ppm	< 0.2
Carbon Total Organic as C, ppm	5.1
Silica Total as SiO_2, ppm	0.8

Table

No pipe sample deposits have been taken for analysis as of October 2001. It is highly recommended that some sample deposits from the SAC coolers and supply piping be taken.

From the test samples one can see that the water is acidic with a pH level of 5.1. The acidic water is causing the service water piping to corrode. The corroded pipe is then able to retain more organics due to its ruff inner surface. It is recommended that another water sample be taken during the spring run off to determine the amount of organics present in the water.

The BetzDearborn analysis of the water sample can be found in Appendix B.

Cost Analysis

Maintenance Cost for Cleaning

In order to clean the service water coolers and piping in Upper Salmon, a maintenance crew has to be assembled in Bay D'Espoir and drive to Upper Salmon. Travel time to Upper salmon from Bay D'Espoir is normally two hours.

Travel Arrangements (normal workweek)

Monday: Leave Bay D'Espoir in the morning and drive to Upper Salmon. Work 6.0 hours upon arriving on site.
Tuesday to Thursday: Regular workweek 8.0 hours per day.
Friday: Work 6.0 hours and then drive back to Bay D'Espoir for the weekend.

Hours of actually work performed on site for one workweek is 36.0 hours.

Perdiem Expenses ($9 Breakfast, $11 Dinner, $18 Supper, $6 Incidentals (over night))

Monday: $34 (no breakfast)
Tuesday to Thursday: $43 per day
Friday: $20 (no supper or incidentals)

Total Perdiem charge per person per week: $183

Having a work crew of more than 4 workers will require the services of a cook and perdiem will not be paid while the services of a cook is provided on site.

All workers will receive perdiem for the purpose of this study.

Minimum Work Crew and Wages

1 Worker at $21.56 hr
1 Supervisor at $23.72 hr (10% more than the worker)

Total over head costs = salary x 1.63

Travel to site will be by fleet vehicles, 2 required, one supervisor vehicle and one work crew truck. Tools and cleaning equipment will be transported to the site with these vehicles.

The supervisor is usually over seeing two or three jobs while on site. For this cost analysis 1/3 of the supervisors wage will be allocated to the job.

Required gas for travel is $20 to site and $20 return from site for one work truck.

Total Cost to Clean SAC

Time required to clean eight SAC's for one work crew is seven days (56.0 hrs); this includes removal, cleaning, and reinstallation of coolers.

Labour: 2 (workers) x 64.0 hrs (56.0 cleaning, 8.0 driving) x $21.56 = $2,759.68
1 (supervisor) x 21.3 hrs (1/3 x 64.0 hrs) x $23.72 = $505.24

Total Over Head Costs: $3,264.92 x 1.63 = $5,321.82

Perdiem: 3 (work crew) x 2 weeks x $183 = $1098
(Monday $34, Tuesday to Thursday $129, Friday $20)

Gas: 4 Trips (2 vehicles) x 2 weeks x $20 = $160

Total cost: $6,579.82

Total Cost to Clean SAC Piping

Time required to clean SAC piping inside of generator housing for one work crew is four and half days (36.0 hrs); this includes removal, cleaning, and reinstallation of piping.

Labour: 3 (workers) x 40.0 hrs (36.0 cleaning, 4.0 driving) x $21.56 = $2,587.20
1 (supervisor) x 13.3 hrs (1/3 x 40.0 hrs) x $23.72 = $315.48

Total Over Head Costs: $2,902.68 x 1.63 = $4,731.37

Perdiem: 4 (work crew) x $183 = $732
(Monday $34, Tuesday to Thursday $129, Friday $20)

Gas: 4 Trips (2 vehicles) x $20 = $80

Total cost: $5,543.37

Total Cost to Clean Generator Coolers

Time required to clean four generator coolers for one work crew is four days (32.0hrs); this involves cleaning the coolers in place by flushing.

Labour: 3 (workers) x 36.0 hrs (32.0 cleaning, 4.0 driving) x $21.56 = $2,328.48
1 (supervisor) x 12.0 hrs (1/3 x 36.0 hrs) x $23.72 = $284.64

Total Over Head Costs: $2,613.12 x 1.63 = $4,259.39

Perdiem: 4 (work crew) x $171 = $684
(Monday $34, Tuesday to Thursday $129, Friday $8)

Gas: 4 Trips (2 vehicles) x $20 = $80

Total cost: $5,023.39

Total Cost to Clean Generator Cooler Piping

Time required to clean generator piping inside of generator housing for one work crew is three days (28.0 hrs); this includes removal, cleaning, and reinstallation of piping.

Labour: 3 (workers) x 32.0 hrs (28.0 cleaning, 4.0 driving) x $21.56 = $2,069.76
1 (supervisor) x 10.7 hrs (1/3 x 32.0 hrs) x $23.72 = $253.80

Total Over Head Costs: $2,323.56 x 1.63 = $3,787.40

Perdiem: 4 (work crew) x $120 = $480
(Monday $34, Tuesday to Wednesday $86)

Gas: 4 Trips (2 vehicles) x $20 = $80

Total cost: $4,347.40

ALTERNATIVE SOLUTIONS

General Information

The fouling problem with regard to the cooling water system is being caused by two problems. The first problem is corrosion of the piping system and the second problem is organic build up. The acidic water supply is causing the piping system to corrode and the organics are then attaching themselves to the corroded pipe. Over time the organics build up and are able to clog the pipe. The heat transferred into the cooling water from the heat exchangers cause the suspended organics in the water to participate out. This then causes the discharge piping to become clogged with organics and choke off the flow rate. A decreased flow rate allows for more organics to settle within the cooling water system. Eventually the entire cooling water system will become clogged with organics.

The following is a list of solutions that can be used to combat this problem.

1. Mechanical cleaning of the system.
2. Chemical cleaning of the system.
3. Replace the piping with corrosion resistant pipe.
4. Chemically treat the water.
5. Develop a flushing maintenance program.
6. Incorporate organic filters.
7. Convert the system to a closed loop operation.

A brief description of each proposed solution is discussed below.

Mechanical Cleaning

Mechanical cleaning of the cooling water system will require a maintenance cleaning program if this solution is going to be considered. Without maintenance cleaning program the reliability of the service water system will be compromised and forced unit outages will happen.

Mechanically cleaning the service water system will require a cleaning maintenance crew and scheduled plant outages to perform the work. The piping and heat exchangers have to be removed from service and physically cleaned by hand. This hand cleaning decreases the life expectancy of both the piping and heat exchangers. The hand cleaning of piping and cooler tubes is done with rotating nylon brushes that physically scrape the pipe walls of organic build up. Also the possibility of mechanical damage is increased when man handling the piping and heat exchangers.

Chemical Cleaning

Chemical cleaning of the service water system requires a maintenance cleaning program to be established. Without a maintenance cleaning program the reliability of the service water system will be compromised and forced unit outages will happen.

Chemically cleaning the service water system will require a cleaning maintenance crew and scheduled plant outages to perform the work. The piping and heat exchangers don't have to be removed from the system. Instead isolation valves upstream and downstream are closed and mechanical branch connections are attached to the piping system in both upstream and downstream locations. The chemical mixture is then pumped through the system to dissolve any organic build up.

Chemical treatment is harsh on the piping and heat exchangers and decreases their life expectancy. The chemical leaves the metal in an unpassivated state and corrosion will occur very rapidly after returning the system to service.

Replace Piping

Currently the piping material is mild steel schedule 40. Two different piping materials have been considered for replacement of the mild steel pipe, they are 316 stainless steel pipe schedule 10 and polyvinyl chloride (PVC) pipe schedule 80.

The 316 stainless steel schedule 10 pipe is considered because of its corrosion resistance and mechanical properties. The stainless steel pipe will be placed in high traffic areas or in areas where the piping is likely to be hit to prevent damage.

The PVC schedule 80 pipe is considered because of its corrosion resistance, mechanical properties, and thermal properties. Schedule 80 will be more durable when compared with schedule 40. Due to PVC's excellent thermal properties there will be no need to insulate the pipe as compared to stainless steel. The PVC pipe will be placed in low traffic areas where the probability of the pipe being damaged is remote.

Chemical Treatment of the Water

The water can be chemically treated to reduce the acidity of the water by raising the ph level and also help keep all organic materials in a suspended state. The existing service water system is a once through operation and will require large amounts of chemical. BetzDearborn purposed a chemical treatment solution, which can be found in Appendix C. It is estimated to cost $5,000 to set up this system and $30,000 per year for chemical usage.

Flushing Maintenance Program

Flushing each cooler individually to remove any organic build up will help keep the service water system clear. Flushing is performed when all water flow is directed through one particular cooler for a predetermined amount of time. Any lose organic material will be forced out of the cooler and washed away.

If a flushing program was implemented it would reduce the amount of lose organic build up within the service water system. The program would consist of flushing the coolers every four weeks starting in the spring and continuing over the summer.

Organic Filters

Organic filters can be incorporated at the beginning of the service water system to remove the organics from the water. Sand filters are an effective method of removing organics from water. Typical flow rates for sizing a sand filter are 3-6 gpm for every square foot of surface area. The smallest sand filter for Upper Salmon would be around 10.5 ft in diameter to allow for 530 gpm. Space would then become a problem with this solution.

Closed System Operation

By adding another heat exchanger to the existing service water system one can create a closed system. There are various heat exchangers that can be implemented into the system such as water-to-water, air-to-water, or chemical-to-water.

Water-to-water would be the most practical in this situation due to the amount of heat that is being transferred through the exchanger. An air-to-water heat exchanger would have a very large surface area in order to remove the quantity of heat within the system, making this solution not practical. Using a chemical within the closed circuit system is not necessary considering the temperatures that we are dealing with.

This additional heat exchanger will require pumps, piping and valves in order to be incorporated into the service water system. In addition the style and location of this new heat exchanger will be incorporated into the design of the new system so that maintenance will be easier. Also this system will have 100% capacity back up so that cleaning of the heat exchanger will not require any unit outages.

The use of a cooling pond to supply water to the service water system can be considered a closed loop system because you are reusing the existing water that is in the cooling pond. The water in the cooling pond can be chemically treated to ensure that it remains neutral and does not become acidic. Again space would be a restriction with this type of solution.

VIABLE SOLUTIONS

In order to compare the viable solutions the Net Present Worth (NPW) method will be used to determine which solution is most feasibly from a financial point of view. The NPW method will only take into account the investment dollars needed to bring the solution to life. Other benefits to each solution is not taken into account using the NPW method because of the many variables involved in placing a dollar sign on there worth.

In the conclusions and recommendations section each solution will be discussed including all of the advantages and disadvantages associated with that solution.

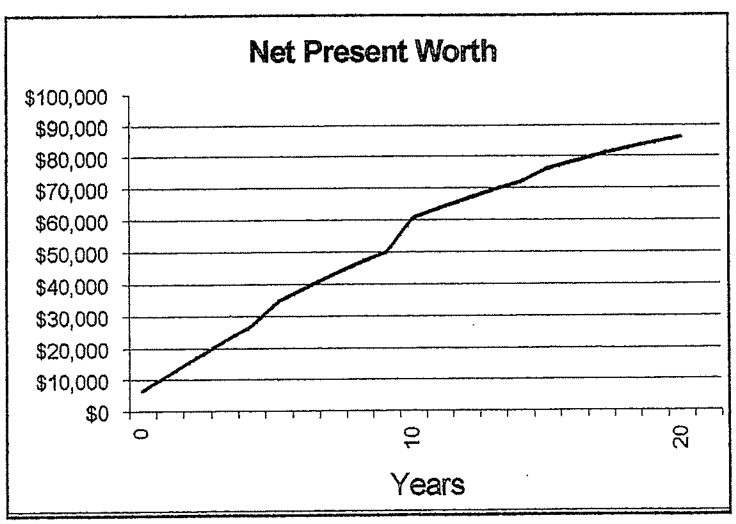
Continue to Maintain Current Operation

The "do nothing" approach is to continue operating the plant as we have in the past. This means mechanically cleaning the SAC's every year, generator bearing coolers every five years, SAC piping every ten years, and generator bearing cooler piping every ten years. This solution will require high maintenance and unit outages so that the work can be performed.

NPW Analysis

Below is the NPW analysis of the "do nothing" solution. There is no capital expenditures related to this solution only yearly operating costs as can be seen below.

Graph 9 is the NPW analyse of "do nothing" solution:



Graph 9

Table 7 shows the costs associated with this solution:

Capital Cost	
Total	0

Operating Cost	
Clean SAC (every yr)	$6,580
Clean SAC Piping (10 yr)	$5,543
Clean Gen Brg Coolers (5 yr)	$5,023
Clean Gen Brg Cooler Piping (10 yr)	$4,347

Table 5

The NPW is calculated over the life span of the piping, which is 20 years. The inflation rate used is 2%, the power rate used for the pump is $0.05 kWh, and the rate of return for Hydro is 8.5%.

The total NPW of this solution is $86,210.

The spreadsheet for the NPW graph showing the yearly increases can be found in Appendix D.

Replace Piping Inside of Generator Housing

Stainless Steel is recommended as the ideal piping material to be used inside of the generator housing due to its corrosion resistance and mechanical properties. The generator cooler piping is carbon steel and should be replaced with stainless steel. The shaft seal piping that extends through the generator housing wall and down into the turbine pit is copper. From the turbine pit wall over to the shaft seal the piping was replaced with stainless steel tubing. The shaft seal piping will not be replaced because it is already a non corrosive material.

Generator Bearing Cooler Water Piping

The generator cooler water piping is currently carbon steel. It is recommended to replace the carbon steel with stainless steel sch 10 inside the generator housing. The following table is a list of parts needed to replace the piping with stainless steel. The price quote is from EMCO Distribution Ltd.

Parts Table:

Item #	Part Description	Quantity	Price	Total
1	2" Pipe s.s sch 10	120	$7.51	$901.20
2	2" Elbow s.s Vic 90 degrees	14	$70.15	$982.10
3	2" Elbow s.s Vic 45 degrees	12	$70.15	$841.80
4	2"x2"x2" Tee s.s Vic	10	$154.92	$1,549.20
5	2" Coupling c.s Vic style 77 (E gasket)	74	$11.50	$851.00
6	2" Vic-Flange Adapters style 741 c.s	2	$36.30	$72.60
7	2" Pressure Tap Orifice Flanges s.s (1set)	1	$479.75	$479.75
8	2" Ball Valves c.s Vic Series 721	4	$121.45	$485.80
9	2" Nipple #40 Grv x Thd c.s Vic	4	$9.00	$36.00
10	2" x 3/4" Reducer Bushing c.s	4	$4.60	$18.40
11	3/4" Automatic Air Vent Valve (MAWP 150 psig)	4	$113.18	$452.72

The total cost for parts is $6,670.57

Cost Analysis to Replace Generator Bearing Cooler Water Piping

The labour time required for a crew to replace the piping was calculated using RS Means Mechanical Cost Data 2000. An additional 25% labour time was added to the RS Means calculation for pipe location and restrictions. An additional 15% labour time was added to the RS Means calculation for removal of old piping system. RS Means calculations can be found in Appendix E. The costs break down associated with travel, perdiem, and minimum work crew can be found under the Cost Analysis section on page 18.

Labour time for work crew of two: 43.8 hrs
Added labour due to pipe location and space restrictions: 43.8 x 25% = 11.0 hrs
Labour time for work crew to remove old piping: 54.8 x 15% = 8.2 hrs
Total labour time required to complete job = 63.0 hrs

In order to complete this job within the two week scheduled outage all work has to be done within 72.0 hours, leaving 8.0 hours for travel. The supervisor is usually over seeing two or three jobs while on site; therefore only 1/3 of the supervisors wage will be allocated to this particular job.

Labour: 2 (workers) x 71.0 hrs (63.0 installation + 8.0 driving) x $21.56 = $3,061.52
1 (supervisor) x 23.7 hrs (1/3 x 71.0 hrs) x $23.72 ($21.56 x 10%) = $561.37

Total Over Head Costs: $3,622.89 x 1.63 = $5,905.31

Perdiem: 3 (work crew) x $183 = $549
(Monday $34, Tuesday to Thursday $129, Friday $20)
3 (work crew) x $140 = $420
(Monday $34, Tuesday to Wednesday $86, Thursday $20)

Gas: 4 Trips (2 vehicles) x 2 weeks x $20 = $160

Total Cost: $7,034.31

Replace Piping Outside of Generator Housing

Polyvinyl chloride (PVC) is recommended as the ideal piping material to be used outside of the generator housing due to its corrosion resistance, mechanical properties, thermal properties, and cost. The inlet header, auxiliary header, and discharge piping should be replaced with PVC.

Inlet Header Piping

The inlet header piping is supplied with water directly from the penstock. From the penstock the piping runs along the wall down to the strainer located on the floor then back up the wall through the ceiling and exits on the generator floor. From here it runs up the generator wall to the ceiling where it then runs along the ceiling and branches off to supply the SAC, generator coolers, and shaft seal. Damage caused by accidental impact should not be of any concern due to this piping arrangement. The inlet header piping will be replaced starting from the penstock supply line and continue to the entrance of the generator housing. The following table is the list of parts needed to replace the inlet piping with PVC. The price quote is from EMCO Distribution Ltd.

Parts table:

Item #	Part Description	Quantity	Price	Total
1	6" Pipe PVC Sch 80	100	$7.80	$780.00
2	6" Elbows 90 PVC Socket Sch 80	5	$26.96	$134.80
3	6" Flange PVC Socket Sch 80	13	$48.10	$625.30
4	6"x6"x6" Tee PVC Socket Sch 80	3	$46.31	$138.93
5	6"x6"x3" Reducing Tee PVC Socket Sch 80	2	$36.30	$72.60
6	6"x6"x2" Reducing Tee PVC Socket Sch 80	1	$63.88	$63.88
7	6" Butterfly Valve PVC Flanged	5	$362.01	$1,810.05
8	6" Check Valve PVC Flanged	1	$1,669.01	$1,669.01
9	6" Pressure Tap Orifice Flanges s.s socket (1 set)	1	$1,630.00	$1,630.00
10	6" Flange steel socket	1	$16.68	$16.68
11	**2" Air Vent Valve PVC Socket**	1		**$0.00**
12	3" Pipe PVC Sch 80	60	$2.86	$171.60
13	3" Elbows 90 PVC Socket Sch 80	4	$6.38	$25.52
14	3"x3"x1 1/2" Reducing Tee PVC Socket Sch 80	2	$14.87	$29.74
15	3"x2" Reducer Coupling PVC Socket Sch 80	1	$12.88	$12.88
16	2" Pipe PVC Sch 80	10	$1.32	$13.20
17	2" Elbows 90 PVC Socket Sch 80	1	$2.54	$2.54
18	2" Ball Valve PVC Socket	1	$55.00	$55.00
19	2" Flange PVC Socket Sch 80	1	$6.07	$6.07
20	2"x2"x2" Tee PVC Socket Sch 80	2	$8.61	$17.22
21	2"x1 1/2" Reducer Bushing PVC Socket Sch 80	2	$3.45	$6.90
22	2"x1 1/2" Reducer Coupling PVC Socket Sch 80	2	$5.25	$10.50
23	1 1/2" Pipe PVC Sch 80	10	$1.00	$10.00
24	1 1/2" Elbows 90 PVC Socket Sch 80	6	$2.00	$12.00
25	1 1/2" Ball Valve PVC Socket	4	$41.24	$164.96
26	1.5"x1.5"x1.5" Tee PVC Socket Sch 80	1	$6.88	$6.88
27	1.5"x1.5"x1/2" Reducing Tee PVC Socket Sch 80	2	$5.26	$10.52
28	1 1/2" Y-Strainer PVC Socket	1	$120.26	$120.26

The total cost for parts is $7,617.04

Total cost with reusing existing pressure tap orifice flanges is $5,987.04

Cost Analysis to Replace Inlet Header Piping

The labour time required for a crew to replace the piping was calculated using RS Means Mechanical Cost Data 2000. An additional 25% labour time was added to the RS Means calculation for pipe location and space restrictions. Also an additional 15% labour time was added to the RS Means calculation for removal of old piping system. Two additional worker will be placed on this job, shortening the labour time by 50%. RS Means calculations can be found in Appendix E. The costs break down associated with travel, perdiem, and minimum work crew can be found under the Cost Analysis section on page 18.

Total labour time required for work crew of four: 40.2 hrs
Added labour due to pipe location and space restrictions: 40.2 x 25% = 10.0 hrs
Labour time for work crew to remove old piping: 50.2 x 15% = 7.5 hrs
Total labour time required to complete job = 57.7 hrs

In order to complete this job within the two week scheduled outage all work has to be done within 72.0 hours, leaving 8.0 hours for travel. The supervisor is usually over seeing two or three jobs while on site; therefore only 1/3 of the supervisors wage will be allocated to this particular job. For this cost estimate the supervisor will stay in the nearest hotel.

Labour: 4 (workers) x 65.7 hrs (57.7 installation + 8.0 driving) x $21.56 = $5,665.97
1 (supervisor) x 21.9 hrs (1/3 x 65.7 hrs) x $23.72 ($21.56 x 10%) = $519.47

Total Over Head Costs: $6,185.44 x 1.63 = $10,082.27

Perdiem: 5 (work crew) x $183 = $915
(Monday $34, Tuesday to Thursday $129, Friday $20)
5 (work crew) x $128 = $640
(Monday $34, Tuesday to Wednesday $86, Thursday $8)

Hotel (1 supervisor): 6 (nights) x $80 = $480

Gas - work crew: 2 Trips (1 vehicle) x 2 weeks x $20 = $80
- supervisor: 16 Trips (1 vehicle) x $20 = $320

Total Cost: $12,517.27

Discharge Header Piping

The discharge piping descends down the outside of the generator wall to the floor. Damage caused by accidental impact should not be of any concern due to the location of the piping on the concrete wall. The discharge piping will be replaced from where the stainless steel exits the generator housing and will continue until it meets the piping embedded in the floor. The following table is the list of parts needed to replace the piping with PVC. The price quote is from EMCO Distribution Ltd.

Parts Table:

Item #	Part Description	Quantity	Price	Total
1	6" Pipe PVC Sch 80	60	$7.80	$468.00
2	6" Elbows 90 PVC Socket Sch 80	4	$26.96	$107.84
3	6" Elbows 45 PVC Socket Sch 80	5	$34.84	$174.20
4	6" Flange PVC Socket Sch 80	6	$48.10	$288.60
5	6"x4" Reducer Coupling PVC Socket Sch 80	2	$48.49	$96.98
6	6"x3" Reducer Coupling PVC Socket Sch 80	2	$61.65	$123.30
7	6"x6"x6" Tee PVC Socket Sch 80	3	$46.31	$138.93
8	6"x6"x2" ReducingTee PVC Socket Sch 80	1	$63.88	$63.88
9	6" Butterfly Valve PVC Flanged	2	$362.01	$724.02
10	6" Pressure Tap Orifice Flanges s.s socket (1 set)	1	$1,630.00	$1,630.00
11	4" Pipe PVC Sch 80	10	$4.17	$41.70
12	4" Elbows 90 PVC Socket Sch 80	1	$9.47	$9.47
13	4" Butterfly Valve PVC Flanged	1	$239.91	$239.91
14	4" Flange PVC Socket Sch 80	2	$13.09	$26.18
15	3" Flange PVC Socket Sch 80	2	$11.12	$22.24
16	2" Pipe PVC Sch 80	10	$1.32	$13.20
17	2" Elbows 90 PVC Socket Sch 80	2	$2.54	$5.08
18	2" Ball Valve PVC Socket	1	$184.85	$184.85
19	2" Flange PVC Socket Sch 80	1	$6.07	$6.07

The total cost for parts is $4,364.45

Total cost with reusing existing pressure tap orifice flanges is $2,734.45

Cost Analysis to Replace Discharge Header Piping

The labour time required for a crew to replace the piping was calculated using RS Means Mechanical Cost Data 2000. An additional 25% labour time was added to the RS Means calculation for pipe location and space restrictions. Also an additional 15% labour time was added to the RS Means calculation for removal of old piping system. RS Means calculations can be found in Appendix E. The costs break down associated with travel, perdiem, and minimum work crew can be found under the Cost Analysis section on page 18.

Total labour time required for work crew of two: 36.2 hrs
Added labour due to pipe location and space restrictions: 36.2 x 25% = 9.0 hrs
Labour time for work crew to remove old piping: 45.2 x 15% = 6.8 hrs
Total labour time required to complete job = 52.0 hrs

In order to complete this job within the two week scheduled outage all work has to be done within 72.0 hours, leaving 8.0 hours for travel. The supervisor is usually over seeing two or three jobs while on site; therefore only 1/3 of the supervisors wage will be allocated to this particular job.

Labour: 2 (workers) x 60 hrs (52.0 installation + 8.0 driving) x $21.56 = $2,587.20
1 (supervisor) x 20.0 hrs (1/3 x 60.0 hrs) x $23.72 ($21.56 x 10%) = $474.40

Total Over Head Costs: $3,061.60 x 1.63 = $4,990.41

Perdiem: 3 (work crew) x $183 = $549
(Monday $34, Tuesday to Thursday $129, Friday $20)
3 (work crew) x $97 = $291
(Monday $34, Tuesday $43, Wednesday $20)

Gas: 4 Trips (2 vehicles) x 2 weeks x $20 = $160

Total Cost: $5,990.41

Auxiliary Header Piping

The auxiliary header piping runs along the ceiling to supply water to the domestic water and compressor after coolers. Damage caused by accidental impact should not be of any concern due to the location of the piping on the concrete wall. The auxiliary header piping will be replaced with stainless steel. The following table is the list of parts needed to replace the piping with PVC. The price quote is from EMCO Distribution Ltd.

Parts Table:

Item#	Part Description	Quantity	Price	Total
1	3" Pipe PVC Sch 80	60	$2.86	$171.60
2	3" Elbows 90 PVC Socket Sch 80	10	$6.38	$63.80
3	3"x3"x3" Tee PVC Socket Sch 80	1	$11.71	$11.71
4	3"x2 1/2" Reducer Coupling PVC Socket Sch 80	1	$15.33	$15.33
5	3"x1" Reducer Coupling PVC Socket Sch 80	1	$15.33	$15.33
6	2 1/2" Pipe PVC Sch 80	10	$2.12	$21.20
7	2 1/2" Elbows 90 PVC Socket Sch 80	2	$5.96	$11.92
8	2 1/2" Flange PVC Socket Sch 80	1	$10.06	$10.06
9	1" Pipe PVC Sch 80	40	$0.71	$28.40
10	1" Elbows 90 PVC Socket Sch 80	3	$1.40	$4.20
11	1" Ball Valve PVC Socket	1	$24.47	$24.47
12	1"x1"x1" Tee PVC Socket Sch 80	2	$2.51	$5.02
13	1" Check Valve PVC Socket	1		$0.00

The total cost for parts is $383.04

Cost Analysis to Replace Auxiliary Header Piping

The labour time required for a crew to replace the piping was calculated using RS Means Mechanical Cost Data 2000. An additional 25% labour time was added to the RS Means calculation for pipe location and space restrictions. Also an additional 15% labour time was added to the RS Means calculation for removal of old piping system. One additional worker will be placed on this job, shortening the labour time by 25%. RS Means calculations can be found in Appendix E. The costs break down associated with travel, perdiem, and minimum work crew can be found under the Cost Analysis section on page 18.

Total labour time required for work crew of three: 20.0 hrs
Added labour due to pipe location and space restrictions: 20.0 x 25% = 5.0 hrs
Labour time for work crew to remove old piping: 25.0 x 15% = 3.8 hrs
Total labour time required to complete job = 28.8 hrs

In order to complete this job within the one week scheduled outage all work has to be done within 36.0 hours, leaving 4.0 hours for travel. The supervisor is usually over seeing two or three jobs while on site; therefore only 1/3 of the supervisors wage will be allocated to this particular job.

Labour: 3 (workers) x 32.8 hrs (28.8 installation + 4.0 driving) x $21.56 = $2121.50
1 (supervisor) x 10.9 hrs (1/3 x 32.8 hrs) x $23.72 ($21.56 x 10%) = $258.55

Total Over Head Costs: $2380.05 x 1.63 = $3879.48

Perdiem: 3 (work crew) x $ 171 = $513
(Monday $34, Tuesday to Thursday $129, Friday $8)

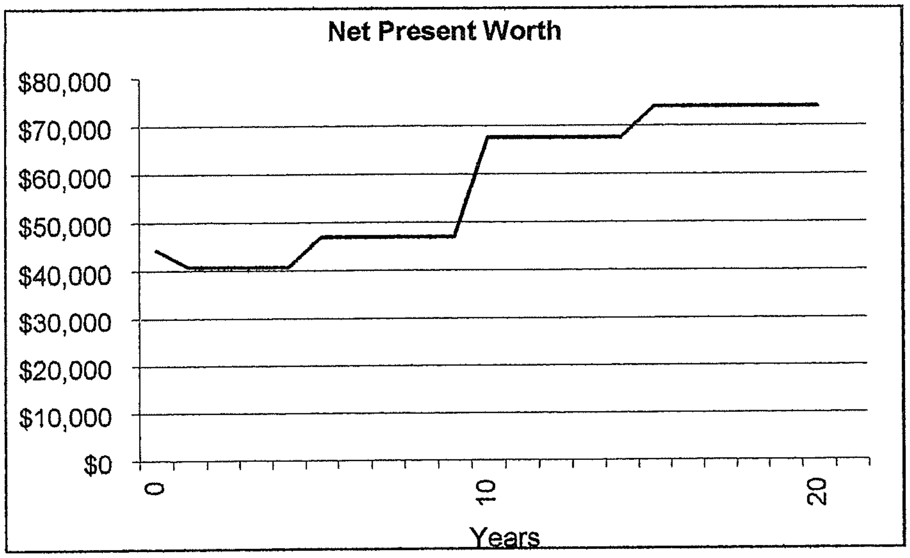
Gas: 4 Trips (2 vehicles) $20 = $80

Total Cost: $4,472.48

NPW Analysis

Below is the NPW analysis of the replace piping solution. There are capital expenditures with this solution along with operating expenditures. The capital is for replacing the existing generator bearing cooler piping inside the generator housing with stainless steel and replace the inlet and discharge header piping outside of the generator housing with PVC.

Graph 10 is the NPW analyse of replacing the pipe solution:



Graph 10

Table 5 shows the costs associated with this solution:

Capital Cost	
Gen Brg Piping (Parts & Installation)	$13,705
Inlet Piping (Parts & Installation)	$20,134
Discharge Piping (Parts & Installation)	$10,355
Total	$44,194

Operating Cost	
Clean SAC (5yr)	$6,580
Clean SAC Piping (10 yr)	$5,543
Clean Gen Brg Coolers (10 yr)	$5,023
Clean Gen Brg Cooler Piping (10 yr)	$4,347

Table 6

The NPW is calculated over the life span of the piping, which is 20 years. The inflation rate used is 2%, the power rate used for the pump is $0.05 kWh, and the rate of return for Hydro is 8.5%.

The total NPW of this solution is $73,806.

The spreadsheet for the NPW graph showing the yearly increases can be found in Appendix D.

Closed System Operation

Heat Exchanger Selection

The style of heat exchanger that needed to be selected would have to meet the following criteria:

1. Compact design
2. Easy to maintain and clean
3. Will not clog
4. Capacity of 630 Usgpm

It was determined that a plate and frame heat exchanger would meet all of these requirements. Due to it's construction the exchanger can be expanded to meet future cooling requirements by adding more plates and this design also allows for easy access for cleaning.

Tom Furlong of Maynard Reece was contacted for a price estimate on this type of heat exchanger. A quoted price of $17, 500 per unit was established for this cost feasibility study.

Pump Selection

In order to select a pump for this system the pressure drop across the entire cooling water system including the new heat exchanger would have to be known. Using Design Flow Solutions one can enter the entire cooling water system (all known parameters) into the program and determine the pressure drop at the desired flow rate.

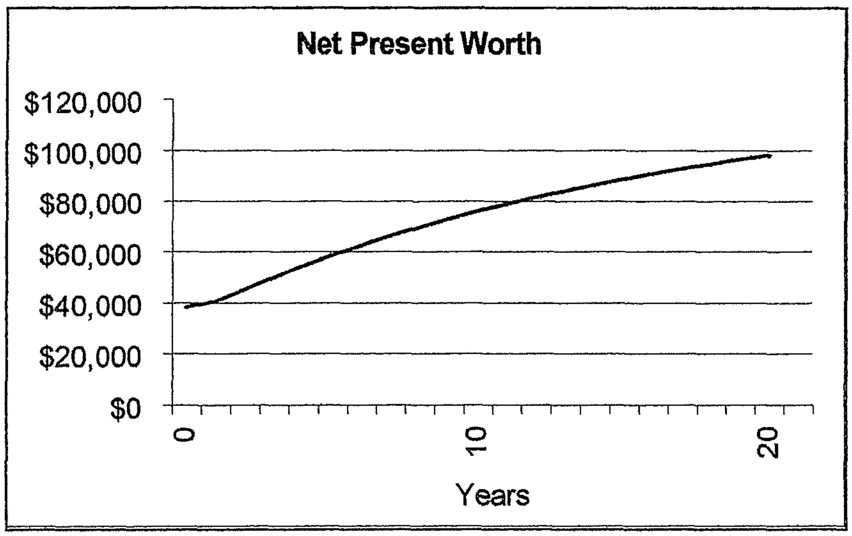
It was determined that the pressure drop for Upper Salmon at 630 Usgpm was 26 psia. A print out of the calculation can be found in Appendix F.

The pump selected for this application is a Goulds centrifugal pump 3196 (4 x 6 – 10G, 9.5" impeller). This pump is capable of 630 Usgpm @ 77 ft head using water as the medium. The pumps specification sheet can be found in Appendix G.

NPW Analysis

The closed loop solution has capital and operating expenditures associated with it. The capital expenditure is for purchasing the heat exchanger, recirculation pump, and associated piping and hardware for the installation. This solution will require 100% capacity back up so two heat exchangers and recirculation pumps will have to be purchased.

Graph 11 is the NPW analyse for the closed loop solution:



Graph 11

Table 6 shows the costs associated with this solution:

Capital Cost	
Pump	$6,514
Heat Exchanger	$17,500
Installation Piping & Hardware	$8,000
Total	$32,014

Operating Cost	
Recir Pump Consumption (49 weeks)	$6,133

Table 7

The NPW is calculated over the life span of the piping, which is 20 years. The inflation rate used is 2%, the power rate used for the pump is $0.05 kWh, and the rate of return for Hydro is 8.5%.

The total NPW of this solution is $98,075.

The spreadsheet for the NPW graph showing the yearly increases can be found in Appendix D.

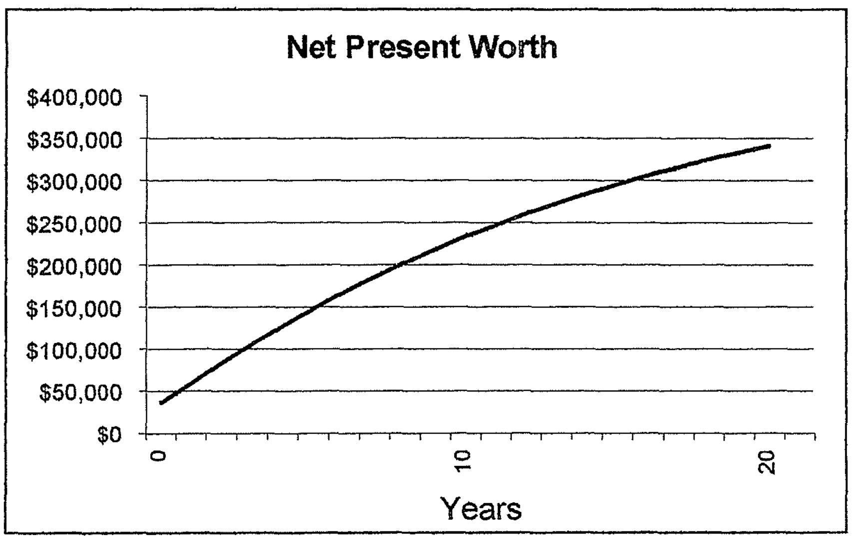
Chemical Injection

The chemical injection solution is based on injecting a chemical known as FLOGARD POT6101 into the cooling water system. This chemical has both cathodic and anodic inhibitors that react with the water to prevent corrosion of the piping and organic build up within the piping. The concentrations are very low 4 ppm and the impact on the environment would be very low considering the chemical is being discharged into the tailrace with the rest of the discharged water.

NPW Analysis

This solution has both capital and operating expenditures. The operating expenditures are very high due to the continuous replacement of the FLOGARD POT6101 chemical.

Graph 12 is the NPW analyse of the chemical injection solution:



Graph 12

Table 7 shows the costs associated with this solution:

Capital Cost	
Injection System	$5,000
Test Coupon Rack	$515
Total	$5,515

Operating Cost	
Chemical (49 weeks)	$30,000

Table 8

The NPW is calculated over the life span of the piping, which is 20 years. The inflation rate used is 2%, the power rate used for the pump is $0.05 kWh, and the rate of return for Hydro is 8.5%.

The total NPW of this solution is $340,501.

The spreadsheet for the NPW graph showing the yearly increases can be found in Appendix D.

CONCULSIONS AND RECOMMENDATIONS

From the material presented there were four different solutions that could be taken to resolve the problem. To recap the four alternative solutions were to continue to operate as we have "do nothing approach", replace the piping with corrosion resistant material, inject chemical into the service water for treatment, or install a closed loop system with treated water to cool the units. Each solution has it's benefits and draw backs.

The NPW analysis calculated the following dollar figures for each solution;

Do Nothing	$86,210
Replace the Piping with s.s & PVC	$73,806
Closed Loop System	$98,075
Chemical Injection	$340,501

Table 9

The "continue to operate as we have" will mean scheduled outages for cooler and pipe cleaning. There is an uncertainty with this solution when it comes to forced outages due to cooling problems during the summer months. If a maintenance program for cleaning and maintaining the cooling water system is not implemented forced outages due to cooling problems during the summer months, in the height of the maintenance season, will occur. In order to prevent this a fouling monitoring program for the cooling water system has to be put in place.

The service water system currently has all of its original piping that was installed when the plant was first came on-line in 1983. This life expectancy of this pipe is near its end. The cooling water pipe will have to be replaced in the near future. Already the SAC piping inside the generator housing has been replaced with stainless steel sch 10 pipe. Also the shaft seal piping inside the turbine pit has been replaced with copper pipe. The SAC discharge six-inch line outside the generator housing is scheduled for replacement with PVC pipe before the end of 2001.

The other alternative of replacing the piping with corrosion resistant pipe has an initial capital investment with a low operating cost associated with it. The labour cost of replacing the pipe in the cooling water system is going to be the same regardless of what type of pipe you use to replace it.

One of the benefits of having the corrosion resistant pipe like stainless steel and PVC is lower maintenance. Unit outages for cleaning service water piping will be less frequent, hence will free up more manpower for other tasks during the maintenance season.

Another benefit to corrosion resistant piping is the reduced likely hood of the pipe becoming clogged with debris. Since the pipe is resistant to corrosion from the service water it is not likely that enough organic material will be able to adhere to the pipe wall to impend flow to the point of stagnation. It is believed that only a small layer of organics will adhere to the inner pipe wall and once that layer is in place the rest of the organics will be washed through the system. Cleaning of the coolers and piping will still have to be done to optimize the efficiency of the system but the frequency of cleanings will be drastically reduced from the current operation.

Another benefit to the replace piping with corrosion resistant pipe solution is that no new equipment or design changes have to be made to the existing system, just replace the existing pipe.

As can be seen from the NPW analysis replacing the piping with corrosion resistant pipe has a NPW of $73,806 and the other solution of continuing to operate like we have in the past has a NPW of $86,210. The NPW of the solution to replace the piping with corrosion resistant pipe has a lower NPW.

The closed loop system has a NPW of $98,075. The problem with this solution is that it is add on to the existing cooling water system. Seeing that the service water piping is almost at its life expectancy the cost of replacing that piping has to also be considered. A quick calculation of labour costs just to replace the piping not including the pipe is around $26,000.

With the closed loop solution the piping inside of the generator housing can be mild steel sch 40 pipe and the piping outside of the generator housing can be PVC to help reduce costs. The SAC piping inside of the generator housing has already been replaced with stainless steel. This solution will use treated water for recirculating through the unit and use the existing service water to cool the heat exchangers.

The closed loop solution will have more components with the extra two recirculating pumps and heat exchangers. This increases the chances of more problems within the system.

The maintenance of the unit's coolers and piping will be non-existent but the outside heat exchanger will have to be cleaned. The frequency of this clean will have to be determined from operating the system. These outside heat exchangers should be positioned for easy cleaning.

The chemical injection solution has a NPW of $340,501 which makes this solution not feasible compared to the other alternative solutions. Also any solution that doesn't impact the environment is always a better alternative.

It is recommended that we go with the solution of "replacing the piping with corrosion resistant pipe" for Upper Salmon. The pipe's life expectancy within the service water system is coming to an end and will need to be replaced in the near future. Also the SAC piping inside of the generator housing has already been replaced and this section of piping is the most costly. With this alternative we still have the ability of replacing sections of the existing system year by year until it is all changed over, reducing the over all capital expenditure for that year. Also this solution will result in lower maintenance costs for the system. Another benefit is that no new design work has to be done in order for this solution to be implemented.

HYDRO

ENGINEERING DESIGN

Subject: USC - Temp Alarms

Made By: Ray Snook Date: Nov. 28, 01 Page 1 of 1

USC

* Stator

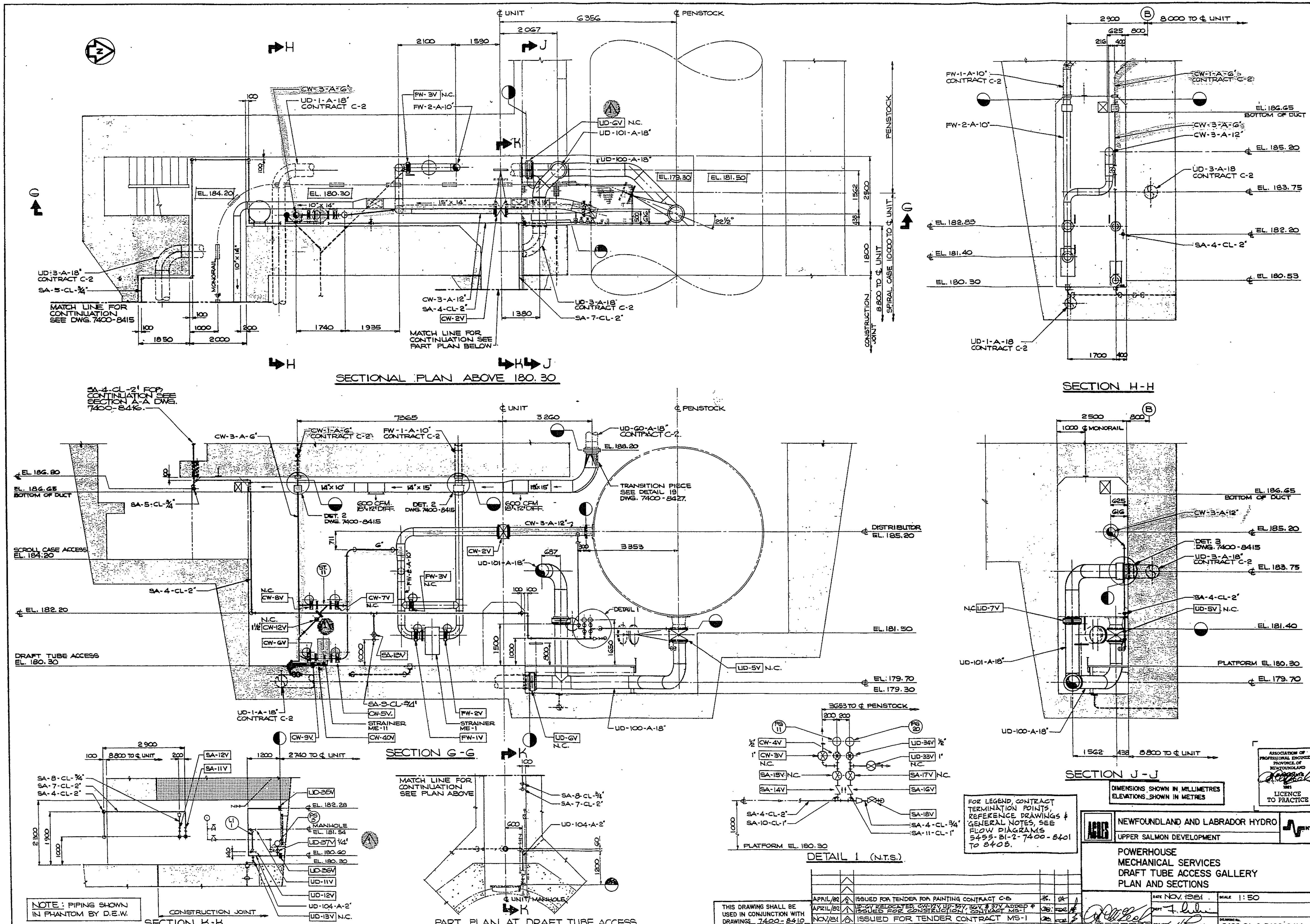
	72°C
Windings	90°C

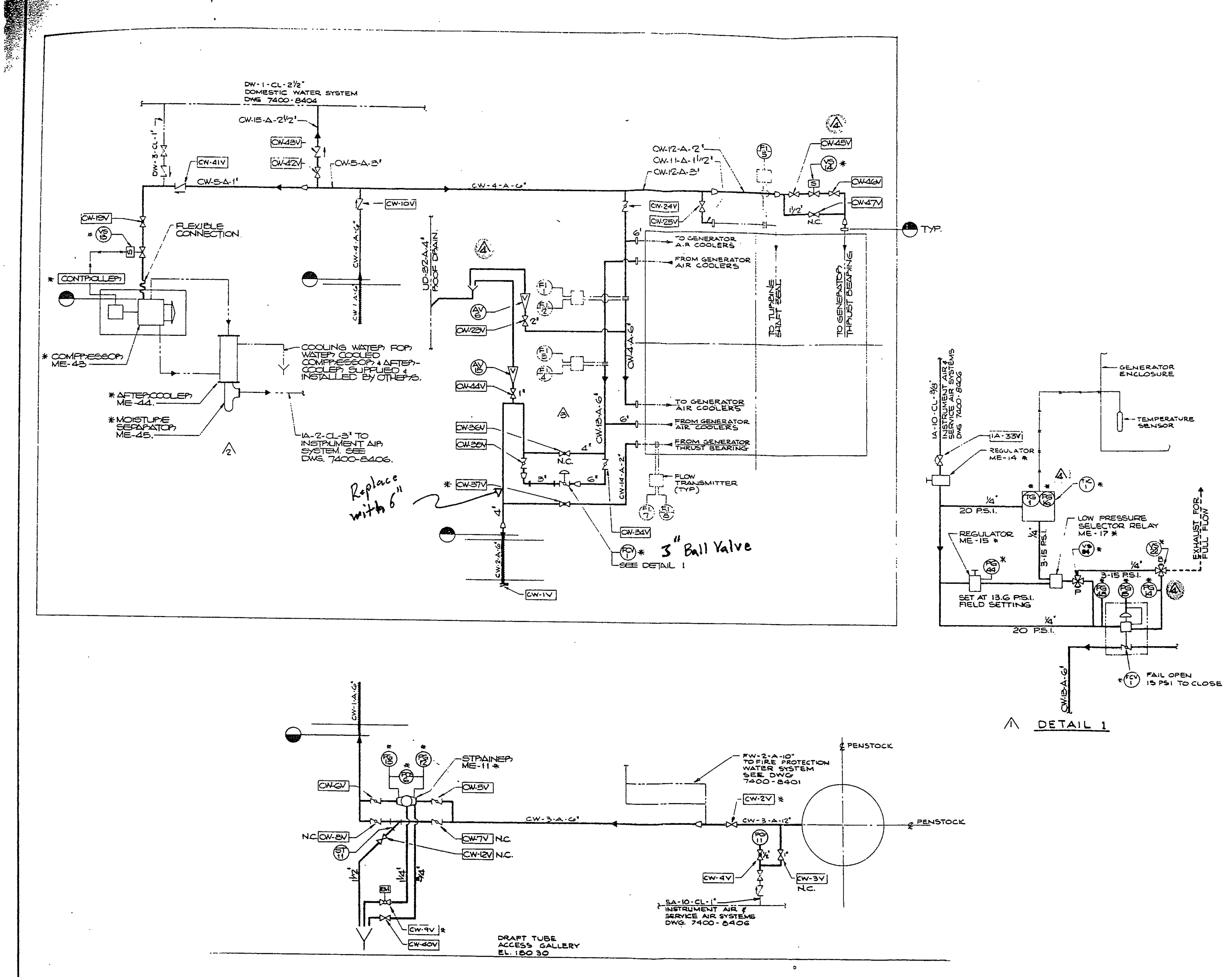
* SAC

IN	65°C
OUT	50°C

* Turbine Metal 70°C
* Thrust brg. Metal 83°C
* Guide brg. Metal 80°C

APPENDIX A


SECTIONAL PLAN ABOVE 180.30
SECTION H-H
SECTION G-G
SECTION J-J
SECTION K-K
PART PLAN AT DRAFT TUBE ACCESS
DETAIL 1 (N.T.S.)
℄ UNIT
℄ PENSTOCK
PENSTOCK
CONSTRUCTION JOINT
8800 TO ℄ UNIT
SPIRAL CASE 10000 TO ℄ UNIT
MATCH LINE FOR CONTINUATION SEE DWG. 7400-8415
MATCH LINE FOR CONTINUATION SEE PART PLAN BELOW
MATCH LINE FOR CONTINUATION SEE PLAN ABOVE
SA-4-CL-2" FOR CONTINUATION SEE SECTION A-A DWG. 7400-8416.
CW-3-A-6"
UD-1-A-18" CONTRACT C-2
FW-2-A-10"
FW-1-A-10" CONTRACT C-2
UD-101-A-18"
UD-100-A-18"
UD-3-A-18" CONTRACT C-2
SA-5-CL-3/4"
CW-3-A-12"
SA-4-CL-2"
SA-7-CL-2"
SA-8-CL-3/4"
SA-10-CL-1"
SA-11-CL-1"
UD-104-A-2"
UD-60-A-18" CONTRACT C-2
TRANSITION PIECE SEE DETAIL 19 DWG. 7400-8427.
600 CFM 18"x12" DIFF.
DET. 2 DWG. 7400-8415
DET. 2 DWG. 7400-8416
DET. 3 DWG. 7400-8415
DISTRIBUTOR EL. 185.20
SCROLL CASE ACCESS EL. 184.20
DRAFT TUBE ACCESS EL. 180.30
EL. 186.80
EL. 186.65 BOTTOM OF DUCT
EL. 185.20
EL. 183.75
EL. 182.83
EL. 182.20
EL. 181.50
EL. 181.40
EL. 180.53
EL. 180.30
EL. 179.70
EL. 179.30
EL. 188.20
PLATFORM EL. 180.30
MANHOLE EL. 181.54
MONORAIL
1000 ℄ MONORAIL
STRAINER ME-11
STRAINER ME-1
N.C.
FOR LEGEND, CONTRACT TERMINATION POINTS, REFERENCE DRAWINGS & GENERAL NOTES, SEE FLOW DIAGRAMS 5455-B1-2-7400-8401 TO 8408.
DIMENSIONS SHOWN IN MILLIMETRES
ELEVATIONS SHOWN IN METRES
NOTE: PIPING SHOWN IN PHANTOM BY D.E.W.
THIS DRAWING SHALL BE USED IN CONJUNCTION WITH DRAWINGS 7400-8410 TO 7400-8427
APRIL/82 ISSUED FOR TENDER FOR PAINTING CONTRACT C-8
APRIL/82 UD-GV RELOCATED, CW-17V, UD-35V, 36V & 37V ADDED & ISSUED FOR CONSTRUCTION, CONTRACT MS-1
NOV/81 ISSUED FOR TENDER CONTRACT MS-1
DATE No REVISIONS
LICENCE TO PRACTICE
NEWFOUNDLAND AND LABRADOR HYDRO
UPPER SALMON DEVELOPMENT
POWERHOUSE
MECHANICAL SERVICES
DRAFT TUBE ACCESS GALLERY
PLAN AND SECTIONS
DATE NOV. 1981
SCALE 1:50
5455-B1-2-7400-8414



LEGEND

- GATE VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- DIAPHRAGM VALVE
- ANGLE VALVE
- PRESSURE SAFETY VALVE
- DIAPHRAGM OPERATED VALVE
- SOLENOID VALVE
- 4-WAY SOLENOID VALVE
- FLAP VALVE
- Y-TYPE STRAINER
- CAP
- REDUCER
- HOSE CONNECTION
- HOSE ADAPTER C/W CAP AND CHAIN
- FLOOR DRAIN
- PUMP STRAINER
- VENT FILTER
- AIR RELEASE AND VACUUM BREAKER VALVE
- EMBEDDED PIPING (CONTRACT C-2)
- ELECTRIC MOTOR OPERATED BALL VALVE.

PG	PRESSURE GAUGE	TIC	TEMPERATURE INDICATING CONTROLLER
PSV	PRESSURE SAFETY VALVE	FS	FLOW SWITCH
PDS	PRESSURE DIFFERENTIAL SWITCH	ST	STRAINER
PS	PRESSURE SWITCH	PDI	PRESSURE DIFFERENTIAL INDICATOR
AV	AIR RELEASE AND VACUUM BREAKER VALVE	LI	LEVEL INDICATOR
VS	SOLENOID VALVE	PRV	PRESSURE REGULATING VALVE
FA	FLOW ALARM	HL	HIGH LEVEL SWITCH
FCV	FLOW CONTROL VALVE	WM	WATER METER
TS	TEMPERATURE SWITCH	TW	THERMOWELL
TR	TRAP	MS-1 / OTHERS	TERMINATION OF CONTRACT
FW	FIRE WATER	ME	MECHANICAL EQUIPMENT
CW	COOLING WATER	TK	TANK
UD	UNWATERING AND DRAINAGE	P	PUMP
DW	DOMESTIC WATER	PF	PLUMBING FIXTURE
ST	SANITARY DRAINS AND VENTS	FHC	FIRE HOSE CABINET
GA	GOVERNOR AIR		PANEL MOUNTED INSTRUMENT
BA	BRAKE AIR		LOCAL MOUNTED INSTRUMENT
IA	INSTRUMENT AIR	F.I.	FLOW INDICATOR
SA	SERVICE AIR	TG	TEMPERATURE GAUGE.
DO	DIESEL OIL		

REFERENCE DRAWINGS

1. PIPE LINE LISTS 7400-8501 TO 8509.
2. VALVE LISTS 7400-8521 TO 8536.
3. INSTRUMENT LISTS 7400-8551 TO 8568.
4. EQUIPMENT LISTS 7400-8581 TO 8589.

NOTES

1. ITEMS MARKED THUS * SUPPLIED BY MANAGER.
2. PIPE LINES CW-1 & CW-2 SUPPLIED & INSTALLED UNDER CONTRACT C-2.
3. VALVE CW-1V SUPPLIED & INSTALLED UNDER CONTRACT C-2.

NEWFOUNDLAND AND LABRADOR HYDRO
UPPER SALMON DEVELOPMENT

POWERHOUSE COOLING WATER SYSTEM FLOW DIAGRAM

DATE	No	REVISIONS
MAR/83	4	REVISED AS BUILT.
AUG/82	3	LINE No CW-13-A-6" & 4" WAS 6" VALVE No CW-35V & 36V WERE 6" VALVE No CW-44V & AV-15 ADDED
JUNE/82	2	PIPE LINE CW-13-A-1½" VALVES CW-23V & 26V DELETED, COOLING WATER PIPING TO COMPRESSOR REVISED
APRIL/82	1	AV-6 WAS 3", DETAIL 1 REVISED & ISSUED FOR CONSTRUCTION CONTRACT MS-1
NOV/81	0	ISSUED FOR TENDER CONTRACT MS-1

ASSOCIATION OF PROFESSIONAL ENGINEERS PROVINCE OF NEWFOUNDLAND — 1981 LICENCE TO PRACTICE

DATE NOV. 1981 — SCALE NOT TO SCALE

DRAWING No. 5455-81-2-7400-8402 — REV 4

APPENDIX B

USL

BetzDearborn

WATER ANALYSIS REPORT

4000018855
NEWFOUNDLAND & LABRADOR HYDRO
HOLYROOD GENERATING STATION
Holyrood, NF
Canada A0A 2-R0

Sampled: 21-AUG-2001
Reported: 28-AUG-2001
Field Rep: Finn, Edward
91000078

	JMO/USL
	L0823126
pH	5.1
Specific Conductance, at 25°C, µmhos	24
Alkalinity, "P" as $CaCO_3$, ppm	0
Alkalinity, "M" as $CaCO_3$, ppm	< 2
Sulfur, Total, as SO_4, ppm	< 5
Chloride, as Cl, ppm	4.4
Hardness, Total, as $CaCO_3$, ppm	3.4
Calcium Hardness, Total, as $CaCO_3$, ppm	2.0
Magnesium Hardness, Total, as $CaCO_3$, ppm	1.4
Copper, Total, as Cu, ppm	0.06
Iron, Total, as Fe, ppm	0.17
Sodium, as Na, ppm	1.2
Phosphate, Total Inorganic, as PO_4, ppm	< 0.2
Phosphate, Ortho-, as PO_4, ppm	I
Phosphate, Filtered Ortho-, as PO_4, ppm	< 0.2
Silica, Total, as SiO_2, ppm	0.8

USL

BetzDearborn

WATER ANALYSIS REPORT

4000018855
NEWFOUNDLAND & LABRADOR HYDRO
HOLYROOD GENERATING STATION
Holyrood, NF
Canada A0A 2-R0

Sampled: 21-AUG-2001
Reported: 28-AUG-2001
Field Rep: Finn, Edward
91000078

	JMO/USL
	L0823126
Carbon, Total Organic, as C, ppm	5.1
Color, Apparent, Color Units (APHA)	20

VSL

BetzDearborn

WATER ANALYSIS REPORT

4000018855
NEWFOUNDLAND & LABRADOR HYDRO
HOLYROOD GENERATING STATION
Holyrood, NF
Canada A0A 2-R0

Sampled: 21-AUG-2001
Reported: 28-AUG-2001
Field Rep: Finn, Edward
91000078

Result Legend

I - A chemical or physical interference prevented the labs ability to perform this test.

APPENDIX C

Corrosion Inhibitor Program
FLOGARD POT6101

Newfoundland Hydro
St. John's, Newfoundland

October 10, 2001

Edward Finn
District Representative

BetzDearborn Canada Inc.
P.O. Box 1048
Carbonear. Newfoundland
A1Y 1C5
Tel: 709-596-3100
Fax: 709-596-1332

October 18, 2001

Newfoundland Hydro
P.O. Box 12400
St. Johns, NF
A1B 4K7

Attention: **John Mallam**

SUBJECT : **Cooling Water Inhibitor Proposal**

John,

Please find below our proposal to treat the once-thru cooling water systems in your Hydroelectric Station with our corrosion inhibitor – **Flogard POT6101**.

In short, we propose that you install a chemical injection and monitoring system to dose the system with 4 ppm of Flogard POT6101.

The annual cost of the chemical treatment, based on continuous operation, would be $30,000.

We suggest, you monitor the effectiveness of the program by using corrosion coupons that simulate the corrosion in the system and are analyzed in our lab.

THEORY:

The recent set of water samples, taken by yourselves, were tested by our analytical lab in the USA. A short table comparing the important parameters in these tests is below. These have been communicated to you previously, but we show them here for completeness.

As well, we have calculated the Langelier index, which is calculated by a nomagraph and is used in the water treatment industry as an overall indication of the scaling or corrosion tendency of any particular water.

Your waters all had a Langelier's index below –5.0, so these waters would be described as "Very Corrosive". Therefore, the problems you have been experiencing with rust and corrosion are predictable and understandable. Fortunately, they are also preventable with proper chemical treatment.

TABLE 1

	HINDS LAKE	CAT ARM	UPPER SALMON	BAIE D'ESPOIR
Date	08/21/2001	08/04/2000	08/2001	08/2001
pH	5.9	5.1	5.1	6.2
Conductivity (mmhos)	25	91	24	13.7
'M' alkalinity (ppm)	0.7	< 2	< 2	2.1
Total Hardness (ppm)	6.5	6.5	3.4	3.8
Copper (ppm)	0.05	0.05	0.06	< 0.05
Iron (ppm)	4.3	0.79	0.17	0.08
TOC (ppm)	2.4	--	5.1	4.7
Langelier Index	- 5.1	- 5	- 5.3	- 5.5

The deposits that we analysed were also reported to you by e-mail. These deposits proved to be high in iron and manganese. The iron is from the rusted piping, while the manganese is chemically associated with the organic matter in the surface water supply. This manganese is noteworthy because it is found in deposits where the surface water is high in organics like these. Manganese does foul piping by depositing on the pipe wall rather than corrode. Fortunately, it is a problem that can be treated chemcially.

In its simplest terms, corrosion is a reaction like the reactions that occur in a conventional lead - acid battery.

The Cathodic reaction is:

$$2H^+ + 2e^- \rightarrow H_2$$

This reaction occurs in a low pH – acidic environment because of the relative abundance of H^+.

The Anodic reaction is:

$$Fe \rightarrow Fe^{2+} + 2e^-$$

This reaction results in the loss of metal from the piping.

If you can stop these reactions from occurring, by stopping the flow of electrons, then the corrosion is stopped .

Chemical corrosion inhibitors basically fall into two broad classes: Anodic and Cathodic, depending on how they act. The product we propose, Flogard POT6101, contains both a Cathodic and an Anodic inhibitor. The phosphate in the product acts as a weak anodic inhibitor, by forming a loosely adhered film of iron phosphate - $FePO_4$. The Cathodic inhibitor is zinc - Zn. As well, the zinc will sequester the manganese, which is currently causing fouling problems, so the problems with the manganese deposition will be significantly reduced.

PRODUCT:

Please see the Product Bulletin attached for the Inhibitor, which describes the inhibitor in detail. The product is available in both drums and 1136 kg semi - bulk tanks. I suggest, you obtain the product in these semi-bulk tanks. We have also attached product facts and its MSDS for your review.

PRICING:

The dosage is 4 ppm, based on the flow of the water. At an estimated flow rate of 600 imperial gallons per minute for 24 hrs per day, 365 days per year, the consumption of the Flogard POT6101 is 7970 kgs per year.

The price of the Flogard POT6101 in these semi-bulk tanks is $3.85/ kg FOB Pointe Claire, QC. Freight and taxes extra. Therefore, the annual cost of the chemical would be $30,685. If the facility is run less than 100% of the time, then the consumption will be less - directly proportional to operating hours.

REFERENCES:

BetzDearborn currently treats many similar applications to yours in Atlantic Canada. References include:

Contacts:

Mr. Bob Cass
Manager of Water and Wastewater
City of Port Hawkesbury
Phone: 902-435-1494

Mr. Pat Bellemare
Senior Operator
City of Dartmouth
Phone: 902-435-8300

Mr. Herve Richard
Chief Engineer
Noranda Inc.
Brunswick Mines
Phone: 506-546-6671

WORK PLAN / SERVICE:

You should have on-site help from your chemical supplier to implement and monitor this chemical program, particularly since the references above needed to have the chemical introduced at a low concentration, which was gradually increased over several months.

As part of this proposal, we are offering as part of our service, 2-3 days of on-site service during start-up, followed by monthly visits for the first six months of the program and then twice yearly visits thereafter. This service is important. If the program is to succeed, operators need to be familiarized with testing procedures, corrosion coupon installation / changeout, the associated piping racks, chemical dosing pumps and chemical injection procedures and drawdowns. Site visits will be followed up by a written service report by BetzDearborn.

CHEMICAL FEED EQUIPMENT:

We have identified a chemical injection system, with a remote start / stop that would be suitable for this application (see the diagram attached). Prominant Fluid Controls can supply a dual metering pump skid, which can be automized to operate according to our needs. Options include:

- Duty and standby injection pumps.
- Flow switch to provide alarm if there is loss of chemical injection.
- Automatic switch over to stand-by pump in the event of duty pump failure.

The attached literature describes the Prominent options and provides a discussion matrix to select the chemical injection system to meet your application needs. We would be pleased to assist in selecting this system with Prominent. Budgetary cost for such a system would be $5000.

CHEMICAL TESTING:

We suggest, you obtain a simple chemical test so that the operators can check the chemcial concentration of PO_4 injected into the water. These chemical tests are straight forward and easy to use. Hach sells a simple PO_4 test (catalogue No. 2248-00), they are available from Atlantic Purification systems at 902-469-2806 and cost $141.33 for a kit with 100 tests.

We will provide any instructions necessary for the operators to run this test. By using this test, we will unsure that the correct concentration of inhibitor is injected into the water.

CORROSION COUPONS:

As you are probably aware, corrosion coupons offer a method to quantitatively measure any reduction in the rate of corrosion over time. Coupons consist of a small strip of metal (either copper or mild steel) that measures approximately 50 x 10 x 5 mm and is inserted directly into the cooling water and left there for some time - typically 100 days. The coupons are then replaced and sent to the lab, where surface corrosion is noted. The weights before and after the in-service period are used to calculate a rate of corrosion in mil/year or g/ft^2 removed per year. Thus, the effectiveness of any corrosion reduction program can be evaluated quantitatively.

To ensure the results are reliable, the coupons must be installed properly and exposed to the correct flow rate. We recommend installation of a 1" diameter, iron corrision rack, with flow control valve, Part No. 2029978. The cost of this unit is $515.

Do not hesitate to contact me at 709-596-3100, if you would like to discuss our proposal.

Yours truly,
BetzDearborn

Edward Finn

Edward Finn
District Representative

Cc: Shane White
Phil Millard
Yves Lefebvre

Enc.

Product Facts

FLOGARD™ POT6101
Potable Water Treatment

- NSF Approved for potable water
- Single-product liquid treatment
- Highly effective inhibitor

DESCRIPTION AND USE

FLOGARD™ POT6101 is a liquid blend of phosphate and zinc designed to inhibit corrosion of mild steel in mill supply water systems and once-through cooling systems. Corrosion control is accomplished by two mechanisms. At typical use levels, the major protection is due to the formation of a zinc-phosphate barrier film at the cathodic site of the corrosion cell. Phosphate also provides some additional corrosion protection by promoting the formation of a protective film at the anodic sites.

TREATMENT AND FEEDING REQUIREMENTS

The optimum dosage of FLOGARD POT6101 is a function of the corrosivity of the water to be treated and other conditions particular to a given installation. For best performance, this product should be fed continuously. While the typical feedrate is 4 - 20 ppm, this product is to be used in accordance with control procedures BetzDearborn establishes for a specific application and local potable water guidelines.

FLOGARD POT6101 may be fed directly from the shipping container or diluted to any convenient strength.

Tanks, pumps, piping and valves may be made of 316 stainless steel or most common plastics. Avoid the use of mild steel and copper alloys.

GENERAL PROPERTIES

Physical properties of FLOGARD POT6101 are shown on the Material Safety Data Sheet, a copy of which is available upon request.

PACKAGING INFORMATION

FLOGARD POT6101 is a liquid blend available in a variety of containers and delivery methods. Contact your BetzDearborn representative for details.

STORAGE

Protect from freezing. If this product is frozen during shipment or storage, slight mixing may be required to ensure homogeneity.

SAFETY PRECAUTIONS

A Material Safety Data Sheet containing detailed information about this product is available upon request.

BetzDearborn
Shaping the Future of Water & Process Treatment

www.betzdearborn.com

BetzDearborn

ISSUE DATE: 16-JAN-2001

MATERIAL SAFETY DATA SHEET

BetzDearborn Canada, Inc.*
3451 Erindale Station Road
Mississauga, ON L5C 2S9
Business telephone: (905) 279-2222

EMERGENCY TELEPHONE (HEALTH/ACCIDENT)
(800) 963-5222 (Canada)

HMIS RATINGS
(See Section 16 for additional information)

HEALTH:	3
FLAMMABILITY:	0
REACTIVITY:	0

*Hercules Canada, Inc. and BetzDearborn Canada, Inc. carrying on business as Hercules Canada

1 PRODUCT IDENTIFICATION

PRODUCT NAME:

FLOGARD POT6101

PRODUCT APPLICATION AREA:

CORROSION INHIBITOR.

2 COMPOSITION / INFORMATION ON INGREDIENTS

Information for specific product ingredients as required by the WHMIS Regulations is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
7664-38-2	PHOSPHORIC ACID Corrosive ORAL LD50-RAT: 1,530 MG/KG DERMAL LD50-RABBIT: 2,740 MG/KG INHL. LC50: NO DATA.	15-40
7733-02-0	ZINC SULFATE Severe irritant; potential reproductive toxin ORAL LD50-RAT: 2,949 MG/KG DERMAL LD50: NO DATA. INHL. LC50: NO DATA.	15-40

No component is considered to be a carcinogen by the U.S. National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC) or under WHMIS.

3 HAZARDS IDENTIFICATION

****

EMERGENCY OVERVIEW

Severe irritant to the skin. Corrosive to the eyes. Mists/aerosols cause irritation to the upper respiratory tract.

Odor: None; Appearance: Colorless, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; Severe irritant to the skin.

ACUTE EYE EFFECTS:
Corrosive to the eyes.

ACUTE RESPIRATORY EFFECTS:
Primary route of exposure;Mists/aerosols cause irritation to the upper respiratory tract.

INGESTION EFFECTS:
May cause severe gastrointestinal irritation.

TARGET ORGANS:
Prolonged or repeated exposures may cause tissue necrosis. Product or product component may cause reproductive toxicity at maternal toxic levels (based on animal testing).

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
Inhalation of vapors/mists/aerosols may cause eye, nose, throat and lung irritation. Skin contact may cause severe irritation or burns.

4 FIRST AID MEASURES

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Thoroughly wash clothing before reuse. Get medical attention if irritation develops or persists.

EYE CONTACT:
URGENT! Immediately flush eyes with plenty of low-pressure water for at least 20 minutes while removing contact lenses. Hold eyelids apart. Get immediate medical attention.

INHALATION:
Remove to fresh air. If breathing is difficult, give oxygen. If breathing has stopped, give artificial respiration. Get immediate

medical attention.

INGESTION:

Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 3-4 glasses milk or water.

NOTES TO PHYSICIANS:

No special instructions

5 FIRE FIGHTING MEASURES

FIRE FIGHTING INSTRUCTIONS:

Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).

EXTINGUISHING MEDIA:

dry chemical, carbon dioxide, foam or water

HAZARDOUS DECOMPOSITION PRODUCTS:

Thermal decomposition (destructive fires) yields elemental oxides.

FLASH POINT:

> 200F   > 93C P-M(CC)

6 ACCIDENTAL RELEASE MEASURES

PROTECTION AND SPILL CONTAINMENT:

Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.

DISPOSAL INSTRUCTIONS:

The waste characteristics of the absorbed material, or any contaminated soil, should be determined in accordance with provincial regulations. Water contaminated with this product may be sent to a sanitary sewer treatment facility, in accordance with any local agreement or discharged under provincial regulations.
Incinerate or land dispose in an approved landfill.

7 HANDLING & STORAGE

HANDLING:

Acidic. Corrosive(Metal). Do not mix with alkaline material.

STORAGE:

Keep containers closed when not in use. Use approved containers only. Store in cool, well-vented area. Contact with metals may release flammable hydrogen gas.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE LIMITS

Consult local authorities for acceptable provincial values.

CHEMICAL NAME

PHOSPHORIC ACID
PEL (OSHA): 1 MG/M3
TLV (ACGIH): 1 MG/M3

ZINC SULFATE
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

ENGINEERING CONTROLS:
Adequate ventilation to maintain air contaminants below exposure limits.
RESPIRATORY PROTECTION:
If air-purifying respirator use is appropriate, use a respirator with dust/mist filters.
SKIN PROTECTION:
rubber gloves-- Wash off after each use. Replace as necessary.
EYE PROTECTION:
splash proof chemical goggles

9 PHYSICAL & CHEMICAL PROPERTIES

Specific Grav.(70F,21C)	1.398	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	-13	Vapor Density (air=1)	< 1.00
Freeze Point (C)	-25		
Viscosity(cps 70F,21C)	10	% Solubility (water)	100.0

Odor		None
Appearance		Colorless
Physical State		Liquid
Flash Point	P-M(CC)	> 200F > 93C
pH As Is (approx.)		1.4
Evaporation Rate (Ether=1)		< 1.00

NA = not applicable ND = not determined

10 STABILITY & REACTIVITY

STABILITY:
Stable under normal storage conditions.
HAZARDOUS POLYMERIZATION:
Will not occur.
INCOMPATIBILITIES:
May react with strong oxidizers.
DECOMPOSITION PRODUCTS:
Thermal decomposition (destructive fires) yields elemental oxides.
BETZDEARBORN INTERNAL PUMPOUT/CLEANOUT CATEGORIES:
"B"

11 TOXICOLOGICAL INFORMATION

Oral LD50 RAT:	>2,000 mg/kg
NOTE - Estimated value	
Dermal LD50 RABBIT:	>2,000 mg/kg
NOTE - Estimated value	

12 ECOLOGICAL INFORMATION

AQUATIC TOXICOLOGY

Rainbow Trout 96 Hour Static Acute Bioassay

LC50: 21.3 mg/L

No Effect Level: 15.5 mg/L

Daphnia magna 48 Hour Static Acute Bioassay phyto plankton

LC50: 3.8 mg/L
No Effect Level: 3.2 mg/L

Fathead Minnow 96 Hour Acute Toxicity
Product toxicity determined from bioassays conducted on individual components.

LC50: 16 mg/L
No Effect Level: 6.3 mg/L

BIODEGRADATION
No Data Available.

13 DISPOSAL CONSIDERATIONS

Incinerate or bury in approved landfill. Please be advised that there may be additional local or provincial requirements relating to the disposal of waste. Consult provincial and local regulations regarding the proper disposal of this material.

14 TRANSPORT INFORMATION

Transportation of Dangerous Goods:
Proper Shipping Name: Corrosive Liquids, n.o.s. (Phosphoric Acid)
PIN: UN1760; Classification: 8(9.2); Packing Group: III

15 REGULATORY INFORMATION

This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

CEPA:
All components of this product comply with substance notification requirements under CEPA.

WHMIS CLASSIFICATION:
D2A D2B E

FOOD AND DRUG ADMINISTRATION:
The ingredients in this product are Generally Recognized As Safe by FDA for direct addition to human food.

16 OTHER INFORMATION

NFPA/HMIS		CODE TRANSLATION
Health	3	Serious Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	B	Goggles,Gloves

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	22-MAY-1998		** NEW **
	09-DEC-1998	15	22-MAY-1998
	23-MAR-2000	15	09-DEC-1998
	07-APR-2000	4	23-MAR-2000
	14-JUL-2000	15	07-APR-2000
	16-JAN-2001	14	14-JUL-2000

Prepared by the Regulatory Affairs Group, BetzDearborn Canada, Inc.
Telephone: 1(905)279-2222   Date of preparation: 16-JAN-2001

BetzDearborn

Shaping the Future of Water & Process Treatment

A DIVISION OF HERCULES INCORPORATED

Corrosion Test Coupon Racks

BetzDearborn Corrosion Test Coupon Racks provide a convenient means of monitoring the progress of corrosion in systems such as boilers, condensate lines, open recirculating cooling water, closed circulating hot or chilled water systems, etc. The corrosion test rack creates a side stream off the main system in which corrosion test coupons can be exposed to system water under controlled and reproducible conditions.

The corrosion coupons can be periodically removed and either visually examined or returned to the laboratory for determination of weight loss, corrosion rate, and pitting severity.

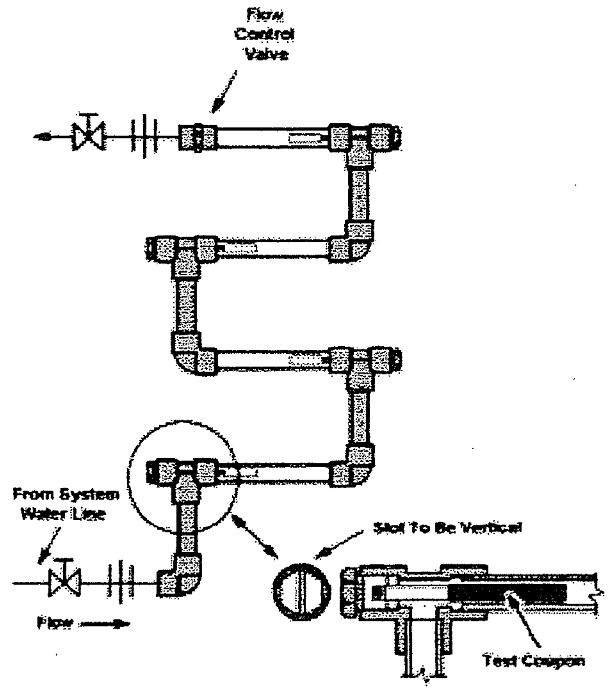


Figure 1

BLACK IRON CORROSION RACK

The Black Iron Corrosion Rack is recommended for corrosion monitoring in high temperature and/or high-pressure installations such as steam condensate, high temperature water, hydronic heating, recirculating process systems, etc. The Black Iron Rack is constructed of 1" threaded black iron pipe. It is supplied with four 1" MNPT steel mounting plugs, and one 10 gpm Dole™ flow control valve. Caution: Maximum pressure & temperature are limited by the Dole flow control valve.

Maximum Pressure: 200 psig (13.8 bar)

Maximum Temperature: 160° F (71° C)

PVC CORROSION RACK

The PVC Corrosion Rack is recommended for corrosion monitoring in low temperature systems such as open recirculating cooling water systems, chilled water, process water systems, etc. The PVC Rack is constructed of 1" threaded Sched. 80 PVC pipe. It is supplied with four 1" PVC mounting plugs and an 8 gpm Dole™ flow control valve. Two designs are available. One is constructed of all gray, opaque PVC. The other features transparent pipe sections for viewing the test coupons in place. See Figures 1 & 2. To discourage algae growth in the transparent sections, opaque snap-on pipe covering is supplied with this corrosion rack.

FLOW RATE	VELOCITY	
	1" PVC Rack	1" Black Iron Rack
5 gpm	2.2 ft/sec (0.67 m/sec)	1.9 ft/sec (0.58 m/sec)
8 gpm	**3.6 ft/sec (1.1 m/sec)**	**3.0 ft/sec (0.91 m/sec)**
10 gpm	4.5 ft/sec (1.4 m/sec)	3.7 ft/sec (1.3 m/sec)
12 gpm	5.4 ft/sec (1.6 m/sec)	4.4 ft/sec (1.4 m/sec)

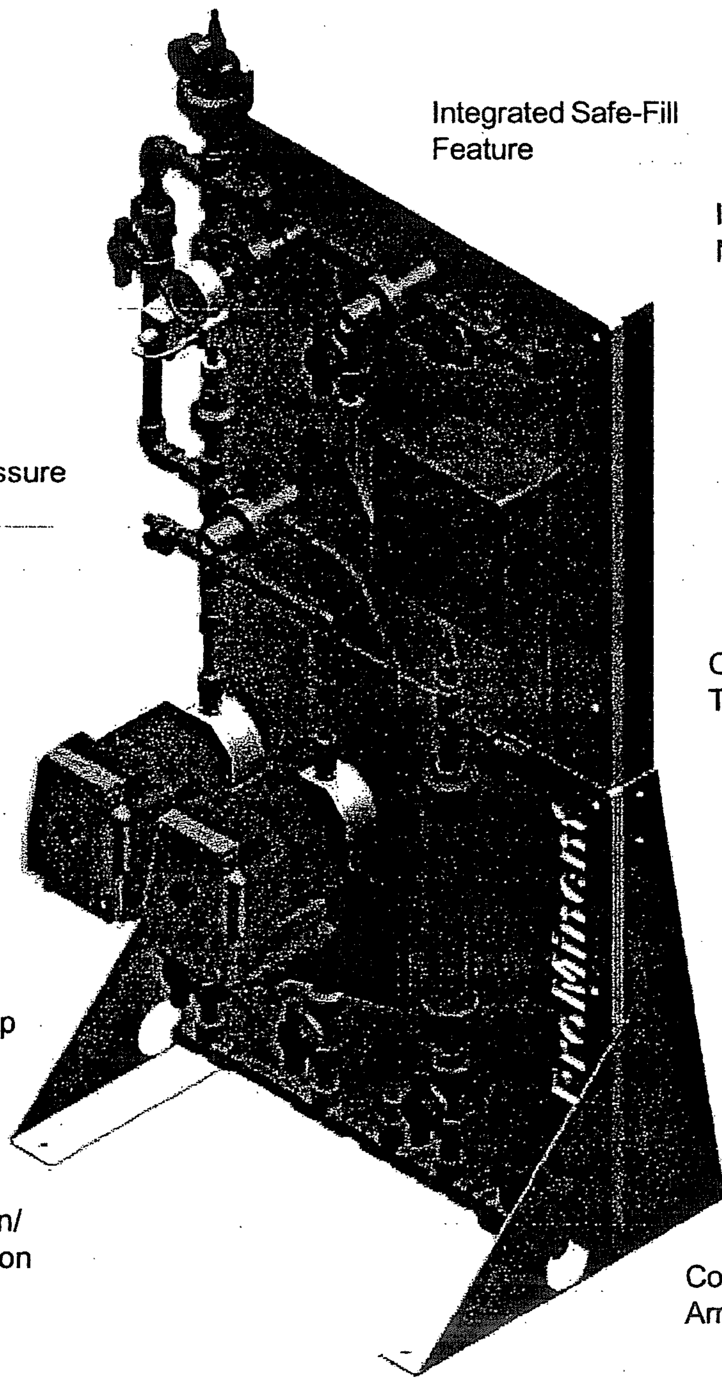
Equipment Facts

  www.betzdearborn.com Printed in the U.S.A.

MODULAR DOSING SYSTEM... Function by Design

ProMinent

Offering industry a new standard in convenience, safety, and reliability. ProMinent's new modular design concept allows custom-tailored arrangements to suit your immediate needs. Matched with our exceptional line of chemical metering pumps - the functionality, flexibility, and performance you demand is yours today - all this at an industry-valued price.



ProMinent Fluid Controls Ltd. 490 Southgate Drive, Guelph, Ontario, N1G 4P5 phone: 519-836-5692 fax: 519-836-5226
ProMinent Fluid Controls, Inc. 136 Industry Drive, Pittsburgh, PA, 15275-1014 phone: 412-787-2484 fax: 412-787-0704

MODULAR SELECTION... As Easy as 1-2-3

STEP ONE: Select Pump

Using Prominent's comprehensive catalog determine the pump capacity and pressure you require. Up to 2 pumps may be incorporated into a single package - dual pumps offer redundent function and convenience for continous dosing. You may choose any of ProMinent's line of compact Solenoid-driven metering pumps - Concept, Beta, Gamma, Gala in most sizes and materials.

STEP TWO: Select Modules

Two modules are currently available. The Suction Module includes provision for up to 2 pumps - 1 primary, the other a backup. A calibration column for setting the pump for optimum performance, and all manual control valves required to isolate and service the system easily. The Discharge Module comes standard with integrated safety relief valve, our "Safe-Fill" feature, dual function Priming/Bleed valve and all necessary isolation valves. Just add any or all of the options below for added functionality and performance...

STEP THREE Select Options and Accessories

Select from a handful of safety and performance enhancements like...

- Pressure Gauge/Seal to accurately tune your system for the best results.
- Pulsation Dampener to improve flow characteristics and repeatability.
- Back Pressure Valve for better pump performance under variable conditions.
- Flow Monitor for flow confirmation.
- Convenient junction box for all system wiring.
- Mounting arrangement - wall-mount is standard, or you may choose floor stands or tote mount hanging brackets.

MOD A B C - D E F - G H I - J K L - M

A

	I/O Connection Size / Type
1	1/2" FNPT

B

	Material Of Construction
1	Schedule 80 PVC

C

	Elastomer
1	EPDM
2	FPM (Viton)

D

	Suction Module
1	Wall-mount Module with Back Panel includes Pump Shelf (1), Calibration Column (1), Ball Valves (3), and Pipe & Fittings

E

	Calibration Column
1	100 mL
2	500 mL

Multiply Pump Strokes per Minute by Pump mL per Second for 60 sec. drawdown

F

	Backup Pump Mount Kit
0	Not Applicable
1	Kit includes Pump Shelf (1), Ball Valve (1), and Pipe & Fittings

G

	Discharge Module
0	Not Applicable
1	Wall-mount Module with Back Panel and "Safe-Fill" feature includes PRV (1), Ball Valves (3), and Pipe & Fittings

H

	Pressure Gauge & Seal Kit
0	Not Applicable
1	Kit includes Pressure Gauge with integral Seal (1), and Pipe & Fittings

I

	Pulsation Dampener Kit
0	Not Applicable
1	Kit includes Pulsation Dampener (1), and Pipe & Fittings

J

	Back Pressure Valve Kit
0	Not Applicable
1	Kit includes BPV (1), and Pipe & Fittings

K

	Flow Monitor Option
0	Not Applicable
1	Type 1 or 2 Flow Monitor (1), and Pipe & Fittings
2	Type 3 Flow Monitor (1) with Bypass includes Ball Valve (1) and Pipe & Fittings

L

	Back Panel Mount Option
0	Not Applicable
1	Corrosion-resistant, Plastic Floor Mount
2	Corrosion-resistant, Stainless Steel Tote Mount

M

	Junction Box Option
0	Not Applicable
1	Option includes Prewired JB (1) for Single Pump
2	Option includes Prewired JB (1) for Dual Pump

Circle each number that applies to your configuration and enter above each letter location.

Maximum Pressure:	200 psi at 70° F (13.8 bar at 21° C)
	120 psi at 120° F (6.9 bar at 49° C)
	70 psi at 140° F (4.8 bar at 60° C)

FLOW VS VELOCITY CHART

Velocities in **BOLD** indicate standard flow controller supplied with that rack. For other available Dole flow control valves, see Equipment Fact Sheet EF15-07.

OPTIONS

A Corrater™ probe may be installed in the corrosion rack to provide instantaneous corrosion readings to supplement the data provided by the weight loss corrosion coupons.

CORROSION TEST RACK INSTALLATION

1. The Corrosion Test Rack may be assembled for vertical mounting as shown in Figure 1, or a horizontal position, Figure 2. Items shown in single line schematic are not furnished.
2. Attach the corrosion rack to a wall or column. **DO NOT** suspend it from the supply and return piping alone.
3. To avoid air binding, pipe the corrosion rack so that water will flow upward through it, and in such a way that it will remain full of water at all times and not backdrain when the main recirculating system shuts own.
4. Install gate or ball-type isolation valves of both sides of the rack.
5. **DO NOT** use this bypass loop for any other purpose such as chemical injection, or mounting of conductivity or pH sensors.
6. For measurement of corrosion at points of highest temperature in the circulating system, the water supply to the corrosion rack should be from the exit of the heat exchanger(s). Average corrosion rate measurements may be obtained by supplying the corrosion rack with water from the main cooling tower riser, etc.
7. Return water may be piped to the recirculating pump suction header, cooling tower basin, or other suitable point with sufficiently low pressure to insure flow through the rack.
8. Flow velocities should not be variable. Avoid extremely high or low velocity conditions. A Dole™ or other suitable flow control valve is recommended to insure constant velocity.
9. For PVC Test Racks with transparent viewing sections, install the slotted polyfoam pipe insulation over the transparent sections to discourage algae growth.

CORROSION TEST COUPON INSTALLATION

1. Keep the metal test coupon in the special treated envelope **BEFORE AND AFTER** exposure.
2. **DO NOT** leave fingerprints on the coupon. They will cause false corrosion readings.
3. Attach the coupon to the mounting stud using the special nut and bolt provided.

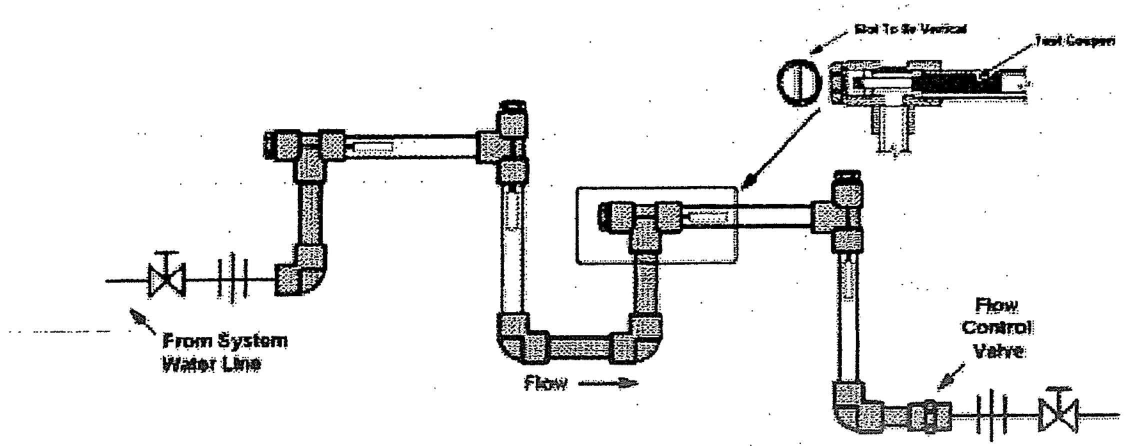


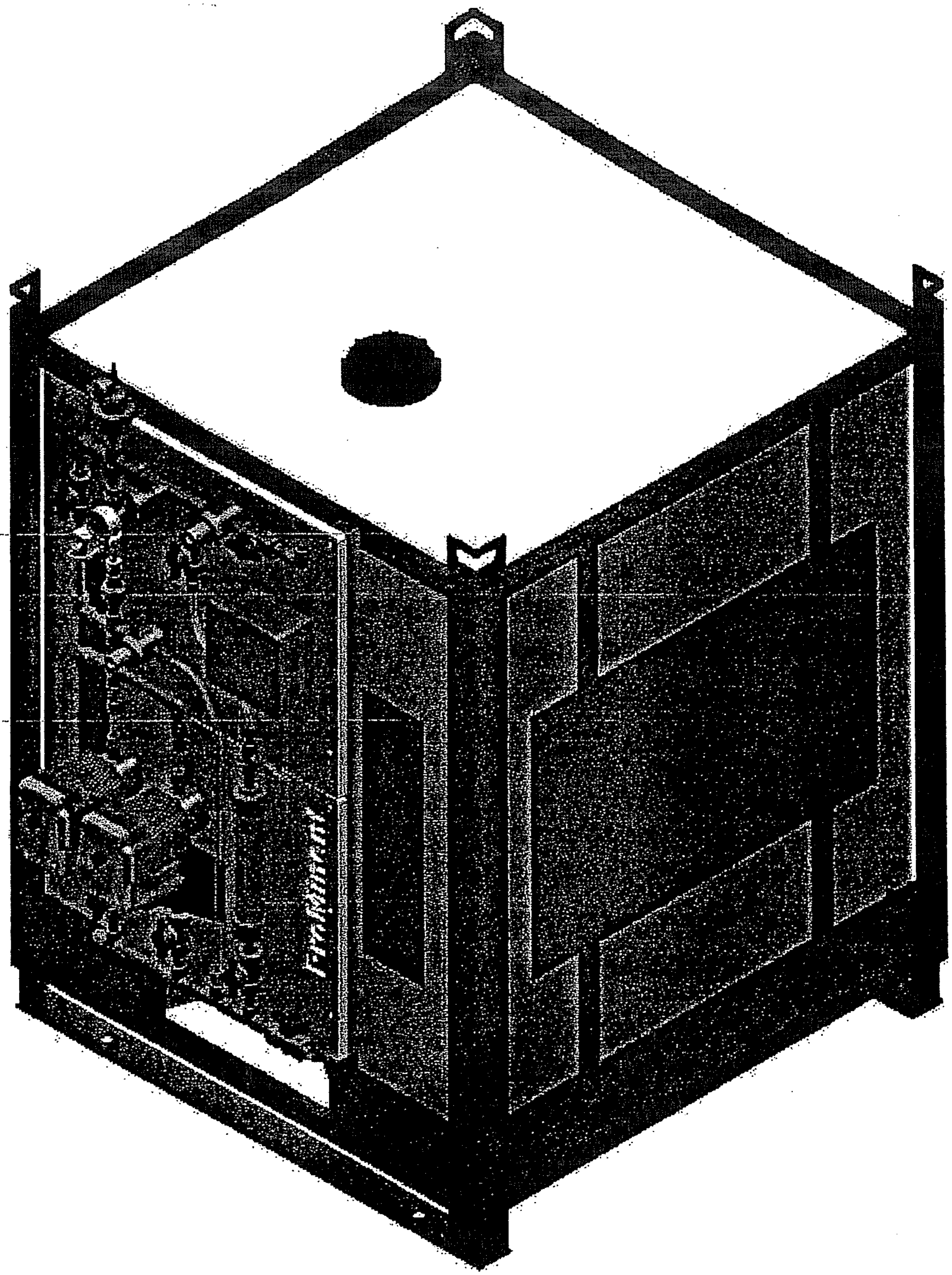
Figure 2

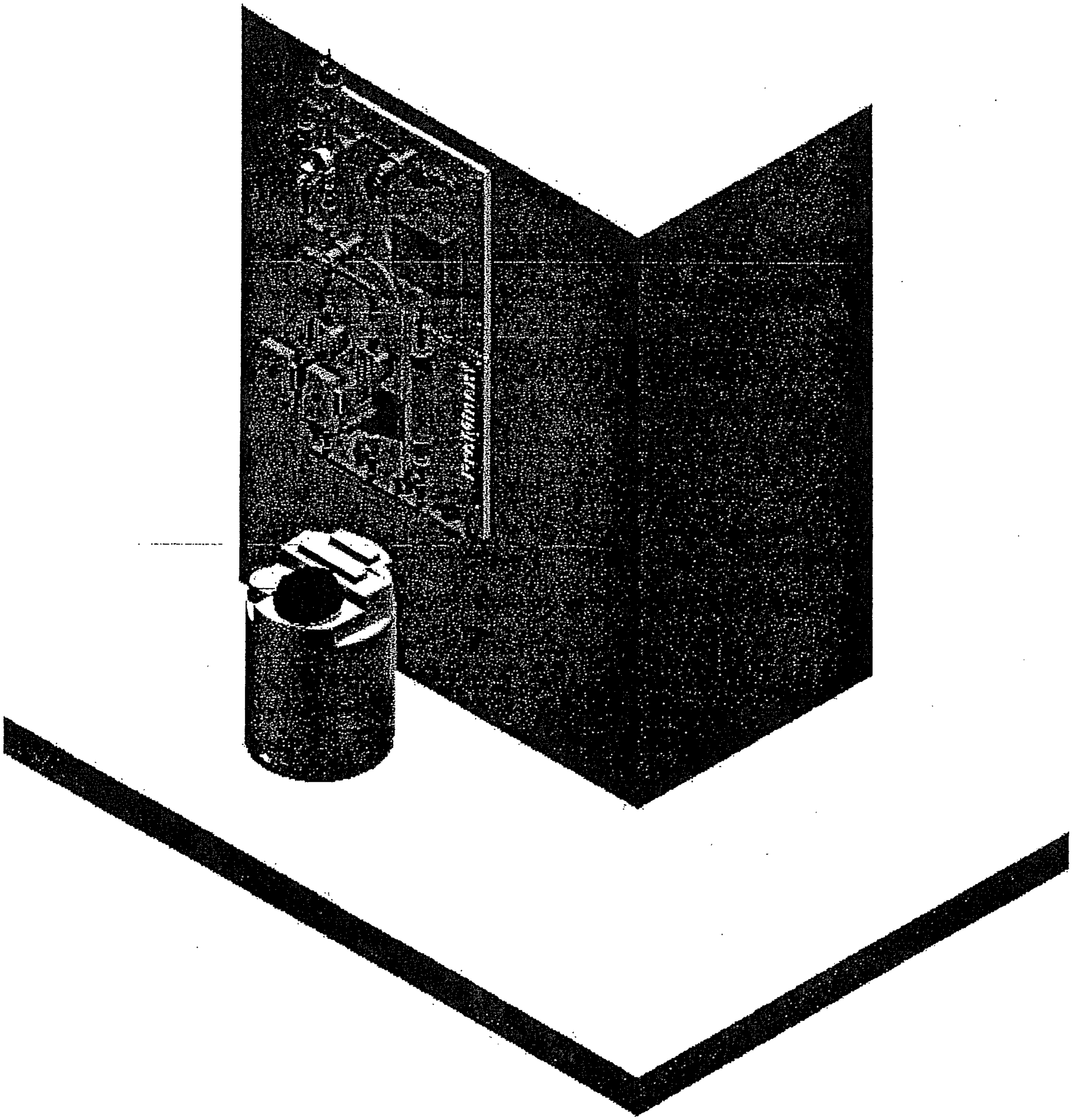
4. Corrosion coupons should always be installed so the water flow first over the plastic mounting rod and then over the coupon. Water flowing directly onto the coupon may cause erosion-corrosion and lead to false weight loss measurements.
5. Use **ONLY** Teflon™ thread sealing tape on mounting plug threads. **DO NOT** use pipe dope.
6. The witness slot on the coupon mounting plug should be parallel with the flat surface of the corrosion test coupon. Install the mounting plug in the tee and align the witness slot (and coupon) in the **VERTICAL** position as shown in Figure 1.
7. Note the date of installation on back of the white Tyvek™ Coupon Return Envelope (ENG 322) and retain both the Coupon Return Envelope and the treated brown envelope.
8. When removing, each test coupon should be carefully dismounted from the holder and immediately dried with a blast of hot air or blotted with a paper towel or clean rag. DO NOT CLEAN. Reinsert the coupon in the treated brown envelope in which it was received.
9. Complete the back of the white Coupon Return Envelope, insert the treated brown envelopes with coupons inside, and return the envelope with the coupons to the Woodlands laboratory.

Part Numbers

2013971	Corrosion Rack, PVC, 1" NPT, w/ 4 coupon holders & 8 gpm flow control valve.
2042205	Corrosion Rack, PVC, 1" NPT w/ 4 coupon holders, 8 gpm valve and 4 TRANSPARENT viewing sections.
2029978	Corrosion Rack, Black Iron, 1" NPT, w/ 4 coupon holders & 10 gpm flow control valve.
2032806	Corrosion Rack, 304 SS, 1" NPT, w/ 4 coupon holders.
2015850	Replacement Coupon Holder, 1" PVC w/ 6" stem.
2041977	Replacement Coupon Holder, 1" Black Iron w/ 6" Teflon™ Stem and Teflon nut & Screw

Corrosion test coupons and mounting screws are not supplied with the corrosion rack and must be ordered separately from the BetzDearborn Woodlands, TX laboratory.





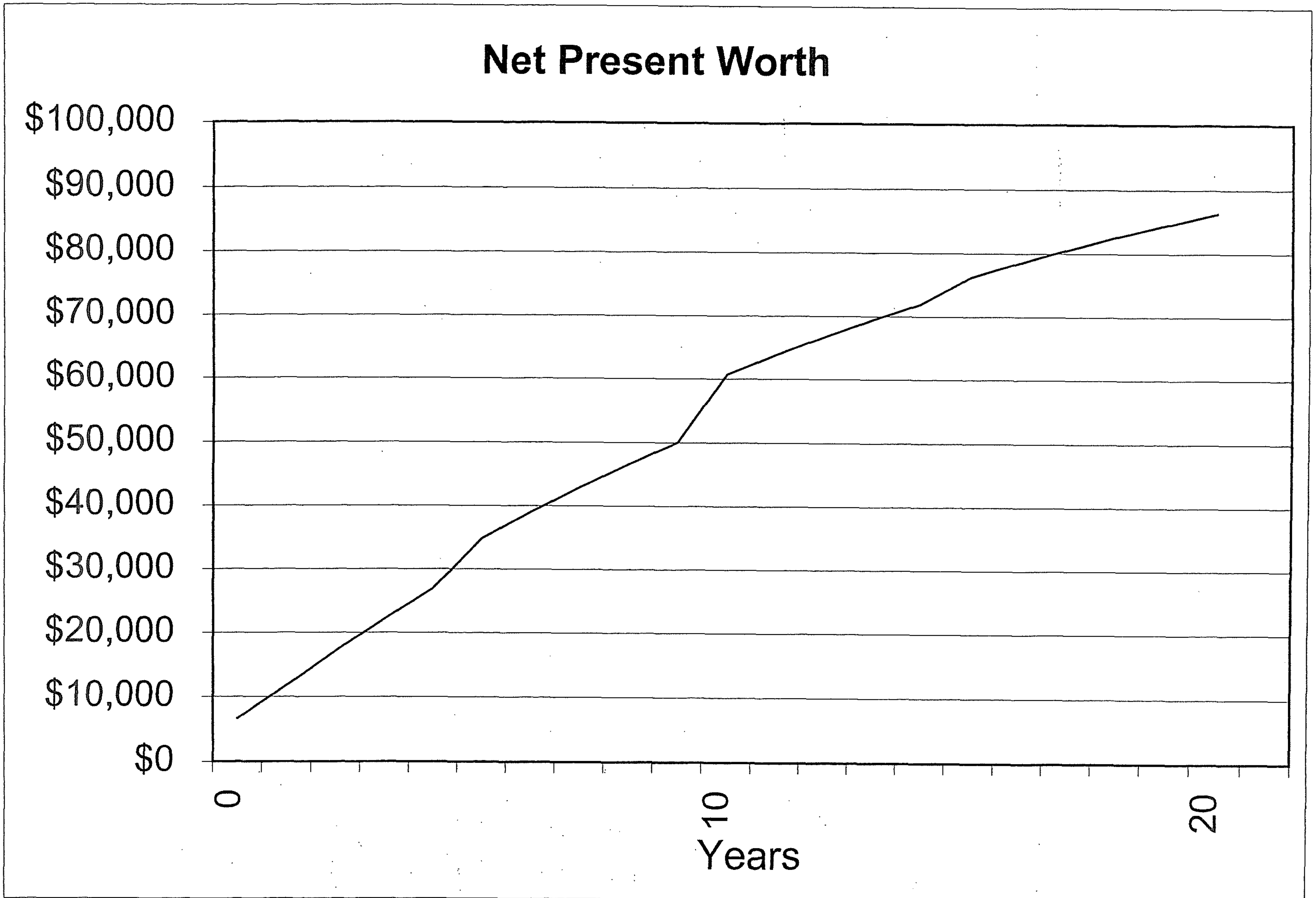
APPENDIX D

DO NOTHING

Capital Cost	
Total	0

Operating Cost	
Clean SAC (every yr)	$6,580
Clean SAC Piping (10 yr)	$5,543
Clean Gen Brg Coolers (5 yr)	$5,023
Clean Gen Brg Cooler Piping (10 yr)	$4,347

	Year	Cash Flow	NPW
0	2002	$6,580	$6,580
1	2003	$6,711	$11,765
2	2004	$6,846	$17,125
3	2005	$6,983	$22,163
4	2006	$7,122	$26,900
5	2007	$12,811	$34,752
6	2008	$7,410	$38,938
7	2009	$7,558	$42,874
8	2010	$7,709	$46,573
9	2011	$7,863	$50,051
10	2012	$26,201	$60,732
11	2013	$8,181	$63,805
12	2014	$8,345	$66,695
13	2015	$8,512	$69,411
14	2016	$8,682	$71,965
15	2017	$15,616	$76,199
16	2018	$9,033	$78,455
17	2019	$9,213	$80,577
18	2020	$9,398	$82,572
19	2021	$9,586	$84,447
20	2022	$9,777	$86,210

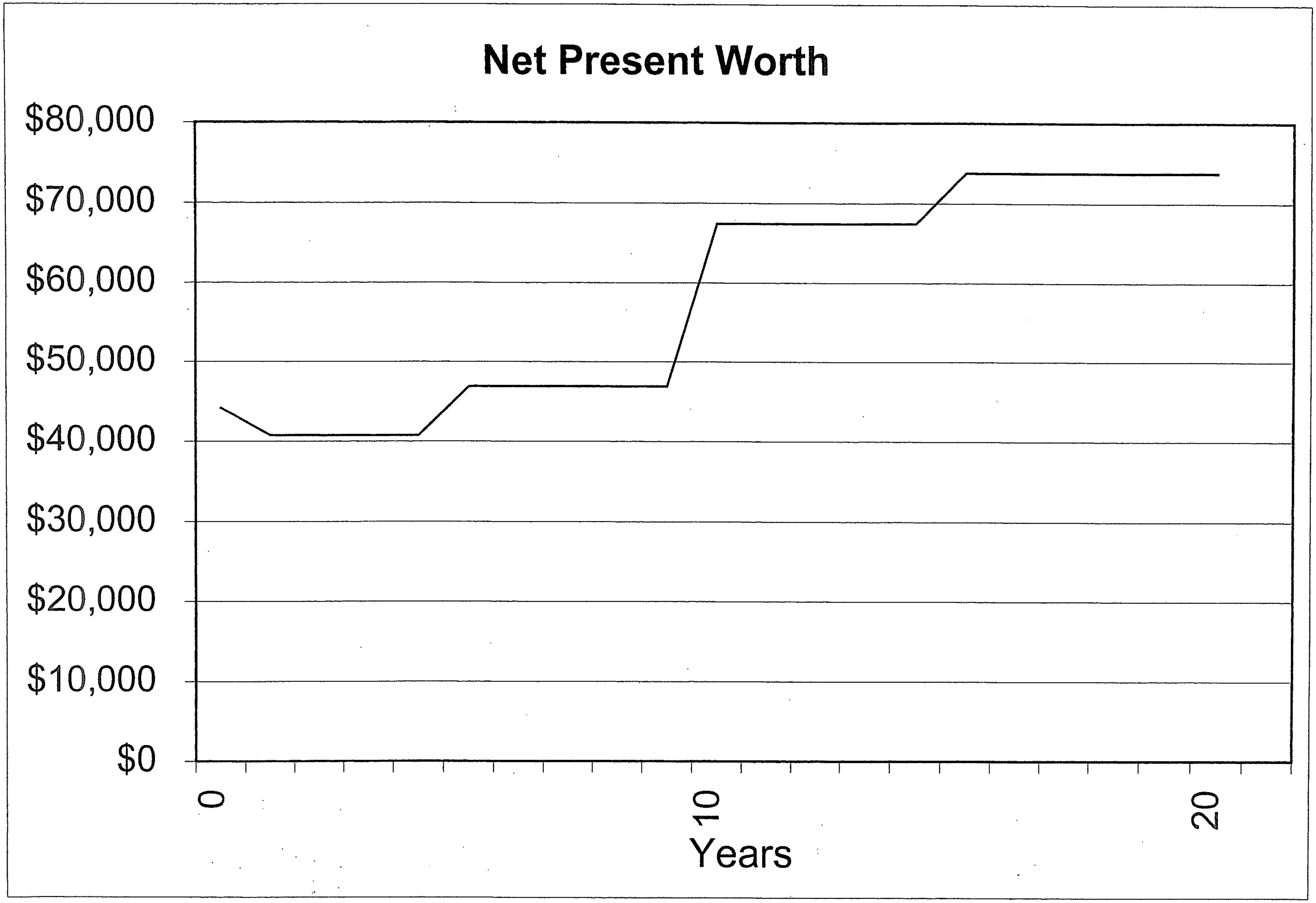

Net Present Worth
$100,000
$90,000
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
0
10
20
Years

REPLACE PIPING

Capital Cost	
Gen Brg Piping (Parts & Installation)	$13,705
Inlet Piping (Parts & Installation)	$20,134
Discharge Piping (Parts & Installation)	$10,355
Total	$44,194

Operating Cost	
Clean SAC (5yr)	$6,580
Clean SAC Piping (10 yr)	$5,543
Clean Gen Brg Coolers (10 yr)	$5,023
Clean Gen Brg Cooler Piping (10 yr)	$4,347

	Year	Cash Flow	NPW
0	2002	$44,194	$44,194
1	2003		$40,732
2	2004		$40,732
3	2005		$40,732
4	2006		$40,732
5	2007	$7,265	$46,903
6	2008		$46,903
7	2009		$46,903
8	2010		$46,903
9	2011		$46,903
10	2012	$26,201	$67,416
11	2013		$67,416
12	2014		$67,416
13	2015		$67,416
14	2016		$67,416
15	2017	$8,856	$73,806
16	2018		$73,806
17	2019		$73,806
18	2020		$73,806
19	2021		$73,806
20	2022		$73,806



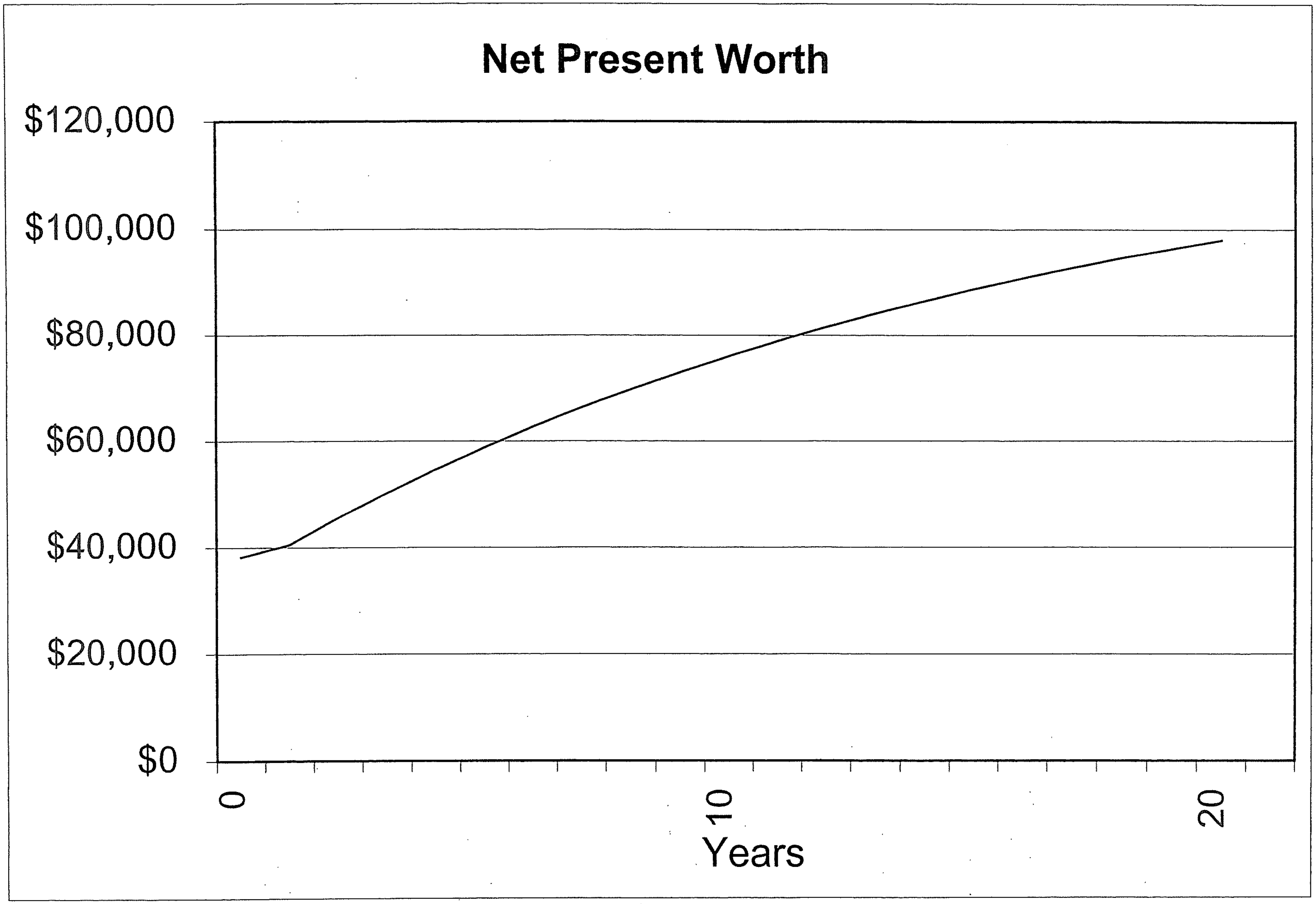
Net Present Worth
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
0
10
20
Years

CLOSED LOOP SYSTEM

Capital Cost	
Pump	$6,514
Heat Exchanger	$17,500
Installation Piping & Hardware	$8,000
Total	$32,014

Operating Cost	
Recir Pump Consumption (49 weeks)	$6,133

	Year	Cash Flow	NPW
0	2002	$38,147	$38,147
1	2003	$6,255	$40,472
2	2004	$6,381	$45,468
3	2005	$6,508	$50,164
4	2006	$6,638	$54,579
5	2007	$6,771	$58,729
6	2008	$6,907	$62,631
7	2009	$7,045	$66,299
8	2010	$7,186	$69,747
9	2011	$7,329	$72,988
10	2012	$7,476	$76,036
11	2013	$7,625	$78,901
12	2014	$7,778	$81,594
13	2015	$7,933	$84,126
14	2016	$8,092	$86,506
15	2017	$8,254	$88,744
16	2018	$8,419	$90,847
17	2019	$8,587	$92,825
18	2020	$8,759	$94,684
19	2021	$8,934	$96,432
20	2022	$9,113	$98,075



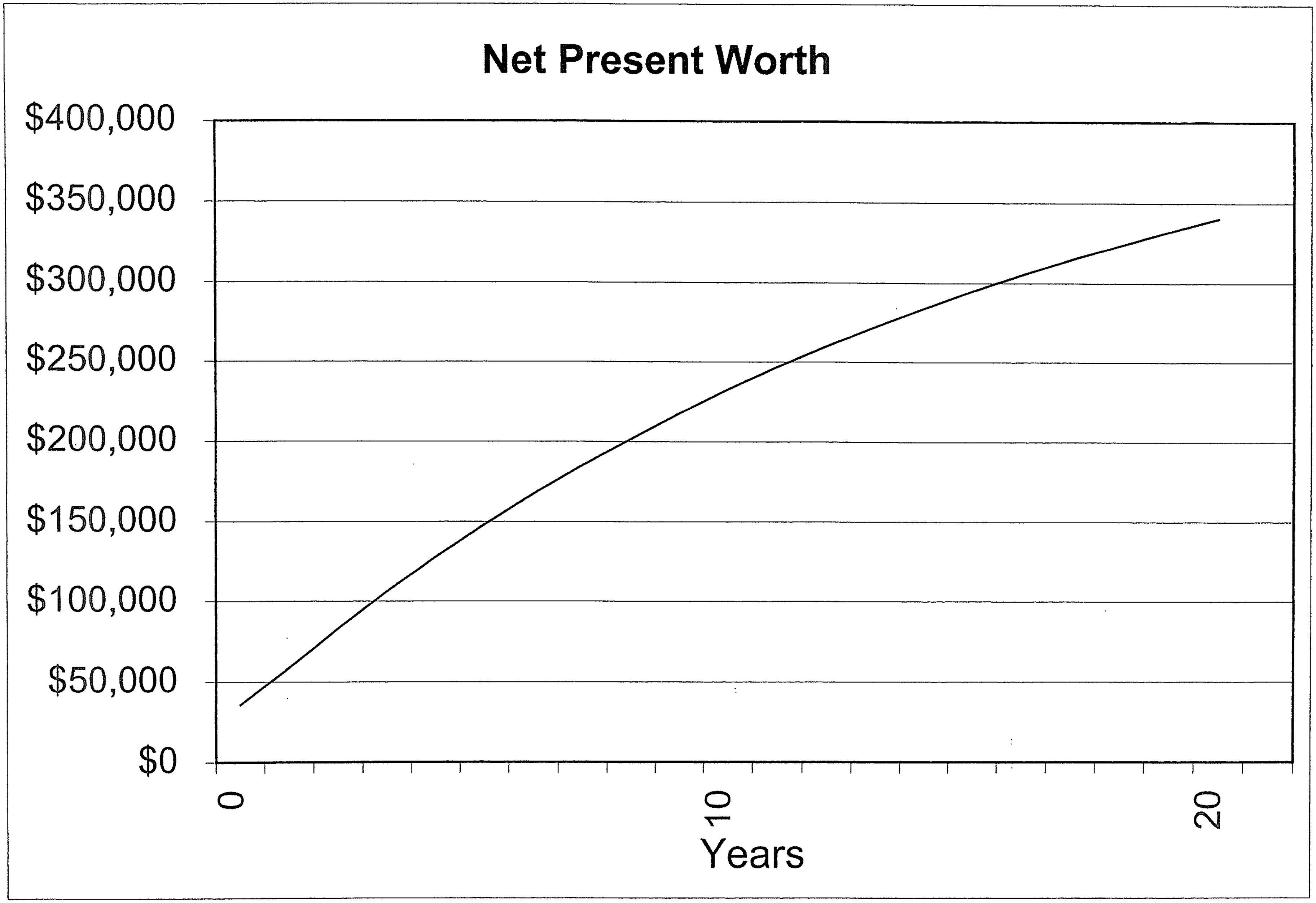
Net Present Worth
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
0
10
20
Years

CHEMICAL INJECTION

Capital Cost	
Injection System	$5,000
Test Coupon Rack	$515
Total	$5,515

Operating Cost	
Chemical (49 weeks)	$30,000

	Year	Cash Flow	NPW
0	2002	$35,515	$35,515
1	2003	$30,600	$58,726
2	2004	$31,212	$83,162
3	2005	$31,836	$106,134
4	2006	$32,473	$127,730
5	2007	$33,122	$148,033
6	2008	$33,785	$167,119
7	2009	$34,461	$185,061
8	2010	$35,150	$201,929
9	2011	$35,853	$217,786
10	2012	$36,570	$232,693
11	2013	$37,301	$246,707
12	2014	$38,047	$259,882
13	2015	$38,808	$272,267
14	2016	$39,584	$283,911
15	2017	$40,376	$294,856
16	2018	$41,184	$305,146
17	2019	$42,007	$314,820
18	2020	$42,847	$323,914
19	2021	$43,704	$332,463
20	2022	$44,578	$340,501



Net Present Worth
$400,000
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
0
10
20
Years

APPENDIX E

Labor Costs, USL

Gen. Brg. Piping

Estimate			Actual	
Description	Crew	Per Day	Quantity	Days
2" O.D Black sch10	1PLUM	43'	120'	2.80
2" 90°&45° Elbows	1PLUM	25	26	1.04
2" Tee	1PLUM	17	10	0.60
1" Coupling	1PLUM	50	74	1.48
2" Flange	1PLUM	23	2+2	~~0.09~~ 0.17
1"x 3/4" Reducer	1PLUM	52	4	0.08
2" Ball Valve	1PLUM	38	4	0.10
Nipple	1PLUM	52	4	0.08
1" Air Vent	1PLUM	38	4	0.1

} 6.45

2" Roll grove	Q-1	116	74	0.64

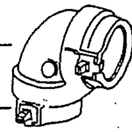
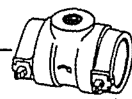
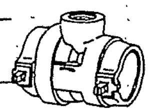
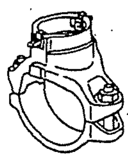
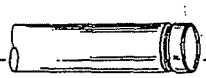
Time required for 1 PLUM.
= 6.45 days

Add additional worker reduces time by 25%.
- 6.45 x 0.75 = 4.84 days

Time required for Q-1 crew = 0.64 days

Total Time required for 2 workers
4.84 + 0.64 = 5.48 days (43.8 hrs)

15107 | Metal Pipe & Fittings

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
660	9342	4" to 8" pipe, 6" stem	1 Plum	14	.571	Ea.	38.50	19		57.50	71
	9343	8" pipe and larger, 6" stem	"	13	.615	"	38.50	20.50		59	73.50
	9400	Mechanical joint ends for plain end pipe									
	9410	Malleable iron, black									
	9420	90° Elbows, 1-1/4"	Q-1	29	.552	Ea.	9.30	16.50		25.80	35.50
	9430	1-1/2" 		27	.593		10.20	17.75		27.95	38
	9440	2"	↓	24	.667	↓	12.05	19.95		32	43.50
	9490	Tee, reducing outlet									
	9510	1-1/4" x 1/2"	Q-1	18	.889	Ea.	7.45	26.50		33.95	48.50
	9520	1-1/4" x 3/4"		18	.889		7.45	26.50		33.95	48.50
	9530	1-1/4" x 1"		18	.889		7.45	26.50		33.95	48.50
	9540	1-1/2" x 1/2" 		17	.941		7.90	28		35.90	51
	9550	1-1/2" x 3/4"		17	.941		7.90	28		35.90	51
	9560	1-1/2" x 1"		17	.941		7.90	28		35.90	51
	9570	2" x 1/2"		15	1.067		9.65	32		41.65	59
	9580	2" x 3/4"		15	1.067		9.65	32		41.65	59
	9590	2" x 1"	↓	15	1.067	↓	9.65	32		41.65	59
	9640	Tee, reducing run and outlet									
	9660	1-1/4" x 1" x 1/2"	Q-1	18	.889	Ea.	7.95	26.50		34.45	49.50
	9670	1-1/4" x 1" x 3/4"		18	.889		7.95	26.50		34.45	49.50
	9680	1-1/4" x 1" x 1"		18	.889		7.95	26.50		34.45	49.50
	9690	1-1/2" x 1-1/4" x 1/2"		17	.941		8.45	28		36.45	52
	9700	1-1/2" x 1-1/4" x 3/4" 		17	.941		8.45	28		36.45	52
	9710	1-1/2" x 1-1/4" x 1"		17	.941		8.45	28		36.45	52
	9720	2" x 1-1/2" x 1/2"		15	1.067		10.25	32		42.25	60
	9730	2" x 1-1/2" x 3/4"		15	1.067		10.25	32		42.25	60
	9740	2" x 1-1/2" x 1"	↓	15	1.067	↓	10.25	32		42.25	60
	9790	Tee, outlet									
	9810	3" x 1-1/4"	Q-1	29	.552	Ea.	18.05	16.50		34.55	45
	9820	3" x 1-1/2"		28	.571		18.05	17.10		35.15	46
	9830	3" x 2" 		26	.615		20	18.40		38.40	50
	9840	4" x 1-1/4"		28	.571		22.50	17.10		39.60	50.50
	9850	4" x 1-1/2"		26	.615		23.50	18.40		41.90	54
	9860	4" x 2"	↓	24	.667	↓	23.50	19.95		43.45	56
	9940	For galvanized fittings for plain end pipe, add					20%				
690	0010	PIPE, GROOVED-JOINT STEEL FITTINGS & VALVES									
	0020	Pipe includes coupling & clevis type hanger 10' O.C.									
	0500	Schedule 10, black									
	0550	2" diameter	1 Plum	43	.186	L.F.	3.02	6.20		9.22	12.65
	0560	2-1/2" diameter	Q-1	61	.262		3.65	7.85		11.50	15.90
	0570	3" diameter		55	.291		4.18	8.70		12.88	17.75
	0580	3-1/2" diameter		53	.302		5.35	9.05		14.40	19.55
	0590	4" diameter		49	.327		5.65	9.75		15.40	21
	0600	5" diameter	↓	40	.400		8.95	11.95		20.90	28
	0610	6" diameter	Q-2	46	.522		9.60	16.20		25.80	35
	0620	8" diameter	"	41	.585	↓	18.45	18.15		36.60	48
	0700	To delete couplings & hangers, subtract									
	0710	2" diam. to 5" diam.					25%	20%			
	0720	6" diam. to 8" diam.					27%	15%			
	1000	Schedule 40, black									
	1040	3/4" diameter	1 Plum	71	.113	L.F.	2.04	3.75		5.79	7.90
	1050	1" diameter		63	.127		2.17	4.22		6.39	8.80
	1060	1-1/4" diameter 		58	.138		2.64	4.59		7.23	9.85
	1070	1-1/2" diameter		51	.157		2.97	5.20		8.17	11.15
	1080	2" diameter	↓	40	.200	↓	3.46	6.65		10.11	13.85

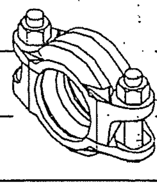
15107 | Metal Pipe & Fittings

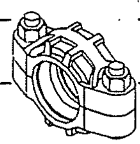
	15107 Metal Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
1090	2-1/2" diameter	Q-1	57	.281	L.F.	4.68	8.40		13.08	17.85
1100	3" diameter		50	.320		5.70	9.60		15.30	21
1110	4" diameter		45	.356		8.05	10.65		18.70	25
1120	5" diameter		37	.432		12.40	12.95		25.35	33
1130	6" diameter	Q-2	42	.571		15.90	17.75		33.65	44.50
1140	8" diameter		37	.649		23.50	20		43.50	56.50
1150	10" diameter		31	.774		36	24		60	76
1160	12" diameter		27	.889		47.50	27.50		75	93.50
1170	14" diameter		20	1.200		56	37		93	118
1180	16" diameter		17	1.412		79.50	44		123.50	154
1190	18" diameter		14	1.714		142	53		195	237
1200	20" diameter		12	2		108	62		170	213
1210	24" diameter		10	2.400		128	74.50		202.50	254
1740	To delete coupling & hanger, subtract									
1750	3/4" diam. to 2" diam.					35%	27%			
1760	2-1/2" diam. to 5" diam.					18%	18%			
1770	6" diam. to 12" diam.					14%	13%			
1800	Galvanized									
1840	3/4" diameter	1 Plum	71	.113	L.F.	2.27	3.75		6.02	8.15
1850	1" diameter		63	.127		2.34	4.22		6.56	9
1860	1-1/4" diameter		58	.138		2.85	4.59		7.44	10.10
1870	1-1/2" diameter		51	.157		3.23	5.20		8.43	11.45
1880	2" diameter		40	.200		3.81	6.65		10.46	14.25
1890	2-1/2" diameter	Q-1	57	.281		5.25	8.40		13.65	18.45
1900	3" diameter		50	.320		6.40	9.60		16	21.50
1910	4" diameter		45	.356		9.10	10.65		19.75	26
1920	5" diameter		37	.432		15.25	12.95		28.20	36.50
1930	6" diameter	Q-2	42	.571		19.80	17.75		37.55	49
1940	8" diameter		37	.649		29.50	20		49.50	63
1950	10" diameter		31	.774		44	24		68	85
1960	12" diameter		27	.889		58	27.50		85.50	106
2540	To delete coupling & hanger, subtract									
2550	3/4" diam. to 2" diam.					36%	27%			
2560	2-1/2" diam. to 5" diam.					19%	18%			
2570	6" diam. to 12" diam.					14%	13%			
2600	Schedule 80, black									
2610	3/4" diameter	1 Plum	65	.123	L.F.	2.31	4.09		6.40	8.75
2650	1" diameter		61	.131		2.50	4.36		6.86	9.35
2660	1-1/4" diameter		55	.145		3.12	4.84		7.96	10.75
2670	1-1/2" diameter		49	.163		3.57	5.45		9.02	12.15
2680	2" diameter		38	.211		4.35	7		11.35	15.40
2690	2-1/2" diameter	Q-1	54	.296		5.95	8.85		14.80	19.90
2700	3" diameter		48	.333		7.45	10		17.45	23.50
2710	4" diameter		44	.364		10.75	10.90		21.65	28.50
2720	5" diameter		35	.457		12.55	13.70		26.25	34.50
2730	6" diameter	Q-2	40	.600		20.50	18.60		39.10	50.50
2740	8" diameter		35	.686		47.50	21.50		69	84.50
2750	10" diameter		29	.828		75.50	25.50		101	122
2760	12" diameter		24	1		83.50	31		114.50	139
3240	To delete coupling & hanger, subtract									
3250	3/4" diam. to 2" diam.					30%	25%			
3260	2-1/2" diam. to 5" diam.					14%	17%			
3270	6" diam. to 12" diam.					12%	12%			
3300	Galvanized									
3310	3/4" diameter	1 Plum	65	.123	L.F.	2.01	4.09		6.10	8.40
3350	1" diameter		61	.131		2.06	4.36		6.42	8.85

690

15107	Metal Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
[illegible]0	1-1/4" diameter	1 Plum	55	.145	L.F.	2.51	4.84		7.35	10.05
[illegible]0	1-1/2" diameter		46	.174		2.83	5.80		8.63	11.85
3380	2" diameter		38	.211		3.26	7		10.26	14.20
3390	2-1/2" diameter	Q-1	54	.296		4.25	8.85		13.10	18.05
3400	3" diameter		48	.333		5.25	10		15.25	21
3410	4" diameter		44	.364		7.55	10.90		18.45	25
3420	5" diameter		35	.457		15.45	13.70		29.15	37.50
3430	6" diameter	Q-2	40	.600		26.50	18.60		45.10	57.50
3440	8" diameter		35	.686		46	21.50		67.50	82.50
3450	10" diameter		29	.828		73	25.50		98.50	120
3460	12" diameter		24	1		81	31		112	136
3920	To delete coupling & hanger, subtract									
3930	3/4" diam. to 2" diam.					30%	25%			
3940	2-1/2" diam. to 5" diam.					15%	17%			
3950	6" diam. to 12" diam.					11%	12%			
3990	Fittings: cplg. & labor required at joints not incl. in fitting									
3994	price. Add 1 per joint for installed price.									
4000	Elbow, 90° or 45°, painted									
4030	3/4" diameter	1 Plum	50	.160	Ea.	12.10	5.30		17.40	21.50
4040	1" diameter		50	.160		12.10	5.30		17.40	21.50
4050	1-1/4" diameter		40	.200		12.10	6.65		18.75	23.50
4060	1-1/2" diameter		33	.242		12.10	8.05		20.15	25.50
4070	2" diameter		25	.320		12.10	10.65		22.75	29.50
4080	2-1/2" diameter	Q-1	40	.400		12.10	11.95		24.05	31.50
4090	3" diameter		33	.485		21.50	14.50		36	45.50
4100	4" diameter		25	.640		23.50	19.15		42.65	55
[illegible]0	5" diameter		20	.800		56.50	24		80.50	98.50
4120	6" diameter	Q-2	25	.960		66.50	30		96.50	118
4130	8" diameter		21	1.143		139	35.50		174.50	207
4140	10" diameter		18	1.333		254	41.50		295.50	340
4150	12" diameter		15	1.600		405	49.50		454.50	520
4170	14" diameter		12	2		725	62		787	895
4180	16" diameter		11	2.182		945	67.50		1,012.50	1,150
4190	18" diameter	Q-3	15	2.133		1,200	67.50		1,267.50	1,425
4200	20" diameter		13	2.462		1,575	78		1,653	1,875
4210	24" diameter		11	2.909		2,300	92.50		2,392.50	2,675
4250	For galvanized elbows, add					26%				
4690	Tee, painted									
4700	3/4" diameter	1 Plum	38	.211	Ea.	18.65	7		25.65	31
4740	1" diameter		33	.242		18.65	8.05		26.70	32.50
4750	1-1/4" diameter		27	.296		18.65	9.85		28.50	35.50
4760	1-1/2" diameter		22	.364		18.65	12.10		30.75	39
4770	2" diameter		17	.471		18.65	15.65		34.30	44
4780	2-1/2" diameter	Q-1	27	.593		18.65	17.75		36.40	47.50
4790	3" diameter		22	.727		26	22		48	62
4800	4" diameter		17	.941		40	28		68	86.50
4810	5" diameter		13	1.231		93.50	37		130.50	159
4820	6" diameter	Q-2	17	1.412		108	44		152	186
4830	8" diameter		14	1.714		238	53		291	345
4840	10" diameter		12	2		495	62		557	640
4850	12" diameter		10	2.400		690	74.50		764.50	875
[illegible]51	14" diameter		9	2.667		730	83		813	930
[illegible]2	16" diameter		8	3		825	93		918	1,050
4853	18" diameter	Q-3	11	2.909		1,025	92.50		1,117.50	1,275
4854	20" diameter		10	3.200		1,475	101		1,576	1,775
4855	24" diameter		8	4		2,250	127		2,377	2,675

15107 | Metal Pipe & Fittings





	15107 Metal Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
4900	For galvanized tees, add				Ea.	24%				
4906	Couplings, rigid style, painted									
4908	1" diameter	1 Plum	100	.080	Ea.	8.80	2.66		11.46	13.65
4909	1-1/4" diameter		100	.080		8.80	2.66		11.46	13.65
4910	1-1/2" diameter		67	.119		8.80	3.97		12.77	15.65
4912	2" diameter		50	.160		9	5.30		14.30	17.95
4914	2-1/2" diameter	Q-1	80	.200		10.40	6		16.40	20.50
4916	3" diameter		67	.239		12.15	7.15		19.30	24
4918	4" diameter		50	.320		17.20	9.60		26.80	33.50
4920	5" diameter		40	.400		22.50	11.95		34.45	42.50
4922	6" diameter	Q-2	50	.480		30	14.90		44.90	55.50
4924	8" diameter		42	.571		47	17.75		64.75	78.50
4926	10" diameter		35	.686		84	21.50		105.50	125
4928	12" diameter		32	.750		94.50	23.50		118	139
4930	14" diameter		24	1		123	31		154	182
4931	16" diameter		20	1.200		161	37		198	234
4932	18" diameter		18	1.333		186	41.50		227.50	267
4933	20" diameter		16	1.500		221	46.50		267.50	315
4934	24" diameter	Q-9	13	1.231		325	36		361	415
4940	Flexible, standard, painted									
4950	3/4" diameter	1 Plum	100	.080	Ea.	6.30	2.66		8.96	10.95
4960	1" diameter		100	.080		6.30	2.66		8.96	10.95
4970	1-1/4" diameter		80	.100		8.40	3.33		11.73	14.30
4980	1-1/2" diameter		67	.119		9.20	3.97		13.17	16.10
4990	2" diameter		50	.160		9.70	5.30		15	18.70
5000	2-1/2" diameter	Q-1	80	.200		11.60	6		17.60	22
5010	3" diameter		67	.239		12.80	7.15		19.95	25
5020	3-1/2" diameter		57	.281		18.70	8.40		27.10	33
5030	4" diameter		50	.320		18.70	9.60		28.30	35
5040	5" diameter		40	.400		28.50	11.95		40.45	49.50
5050	6" diameter	Q-2	50	.480		34	14.90		48.90	60
5070	8" diameter		42	.571		55.50	17.75		73.25	88
5090	10" diameter		35	.686		92	21.50		113.50	133
5110	12" diameter		32	.750		105	23.50		128.50	150
5120	14" diameter		24	1		127	31		158	187
5130	16" diameter		20	1.200		167	37		204	240
5140	18" diameter		18	1.333		195	41.50		236.50	278
5150	20" diameter		16	1.500		305	46.50		351.50	410
5160	24" diameter		13	1.846		335	57.50		392.50	455
5176	Lightweight style, painted									
5178	1-1/2" diameter	1 Plum	67	.119	Ea.	8	3.97		11.97	14.80
5180	2" diameter		50	.160		8.20	5.30		13.50	17.05
5182	2-1/2" diameter	Q-1	80	.200		9.50	6		15.50	19.50
5184	3" diameter		67	.239		11.05	7.15		18.20	23
5186	3-1/2" diameter		57	.281		15.65	8.40		24.05	30
5188	4" diameter		50	.320		15.65	9.60		25.25	31.50
5190	5" diameter		40	.400		22.50	11.95		34.45	43
5192	6" diameter	Q-2	50	.480		27	14.90		41.90	52.50
5194	8" diameter		42	.571		42.50	17.75		60.25	74
5196	10" diameter		35	.686		115	21.50		136.50	158
5198	12" diameter		32	.750		128	23.50		151.50	176
5200	For galvanized couplings, add					33%				
5220	Tee, reducing, painted									
5225	2" x 1-1/2" diameter	Q-1	38	.421	Ea.	40.50	12.60		53.10	63.50
5226	2-1/2" x 2" diameter		28	.571		40.50	17.10		57.60	70.50
5227	3" x 2-1/2" diameter		23	.696		35.50	21		56.50	70.50

690

15107 | Metal Pipe & Fittings

		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
5228	4" x 3" diameter	Q-1	18	.889	Ea.	48	26.50		74.50	93.50
5229	5" x 4" diameter		15	1.067		103	32		135	163
5230	6" x 4" diameter	Q-2	18	1.333		114	41.50		155.50	188
5231	8" x 6" diameter		15	1.600		238	49.50		287.50	335
5232	10" x 8" diameter		13	1.846		310	57.50		367.50	430
5233	12" x 10" diameter		11	2.182		475	67.50		542.50	625
5234	14" x 12" diameter		10	2.400		530	74.50		604.50	700
5235	16" x 12" diameter		9	2.667		660	83		743	850
5236	18" x 12" diameter	Q-3	12	2.667		790	84.50		874.50	1,000
5237	18" x 16" diameter		11	2.909		1,000	92.50		1,092.50	1,250
5238	20" x 16" diameter		10	3.200		1,300	101		1,401	1,575
5239	24" x 20" diameter		9	3.556		2,050	113		2,163	2,450
5240	Reducer, concentric, painted									
5241	2-1/2" x 2" diameter	Q-1	43	.372	Ea.	14.10	11.15		25.25	32.50
5242	3" x 2-1/2" diameter		35	.457		17.05	13.70		30.75	39.50
5243	4" x 3" diameter		29	.552		20.50	16.50		37	47.50
5244	5" x 4" diameter		22	.727		29	22		51	64.50
5245	6" x 4" diameter	Q-2	26	.923		33.50	28.50		62	80
5246	8" x 6" diameter		23	1.043		87.50	32.50		120	145
5247	10" x 8" diameter		20	1.200		178	37		215	253
5248	12" x 10" diameter		16	1.500		320	46.50		366.50	420
5255	Eccentric, painted									
5256	2-1/2" x 2" diameter	Q-1	42	.381	Ea.	30	11.40		41.40	50.50
5257	3" x 2-1/2" diameter		34	.471		34	14.10		48.10	59
5258	4" x 3" diameter		28	.571		42	17.10		59.10	72
5259	5" x 4" diameter		21	.762		57	23		80	97
5260	6" x 4" diameter	Q-2	25	.960		66.50	30		96.50	118
5261	8" x 6" diameter		22	1.091		135	34		169	199
5262	10" x 8" diameter		19	1.263		370	39		409	470
5263	12" x 10" diameter		15	1.600		510	49.50		559.50	635
5270	Coupling, reducing, painted									
5272	2" x 1-1/2" diameter	1 Plum	52	.154	Ea.	14.20	5.10		19.30	23.50
5274	2-1/2" x 2" diameter	Q-1	82	.195		18.55	5.85		24.40	29.50
5276	3" x 2" diameter		69	.232		21	6.95		27.95	34
5278	4" x 2" diameter		52	.308		34	9.20		43.20	51.50
5280	5" x 4" diameter		42	.381		38.50	11.40		49.90	59.50
5282	6" x 4" diameter	Q-2	52	.462		58	14.30		72.30	85.50
5284	8" x 6" diameter		44	.545		87	16.95		103.95	122
5290	Outlet coupling, painted									
5294	1-1/2" x 1" pipe size	1 Plum	65	.123	Ea.	17.70	4.09		21.79	25.50
5296	2" x 1" pipe size		48	.167		18.20	5.55		23.75	28.50
5298	2-1/2" x 1" pipe size	Q-1	78	.205		28	6.15		34.15	40.50
5300	2-1/2" x 1" pipe size	1 Plum	70	.114		32	3.80		35.80	41
5302	3" x 1" pipe size	Q-1	65	.246		27	7.35		34.35	41
5304	4" x 3/4" pipe size		48	.333		40	10		50	59
5306	4" x 1-1/2" pipe size		46	.348		57	10.40		67.40	79
5308	6" x 1-1/2" pipe size	Q-2	44	.545		81	16.95		97.95	115
5750	Flange, w/groove gasket, black steel (see 15107-660-0620, bolt sets)									
5760	ANSI class 125 and 150, painted									
5780	2" pipe size	1 Plum	23	.348	Ea.	41.50	11.55		53.05	63
5790	2-1/2" pipe size	Q-1	37	.432		50	12.95		62.95	74.50
5800	3" pipe size		31	.516		54	15.45		69.45	83
5820	4" pipe size		23	.696		72.50	21		93.50	111
5830	5" pipe size		19	.842		84	25		109	131
5840	6" pipe size	Q-2	23	1.043		92	32.50		124.50	150
5850	8" pipe size		17	1.412		104	44		148	181

15107 | Metal Pipe & Fittings

		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
690 5860	10" pipe size	Q-2	14	1.714	Ea.	164	53		217	262
5870	12" pipe size		12	2		215	62		277	330
5880	14" pipe size		10	2.400		495	74.50		569.50	660
5890	16" pipe size		9	2.667		575	83		658	755
5900	18" pipe size		6	4		705	124		829	965
5910	20" pipe size		5	4.800		850	149		999	1,150
5920	24" pipe size		4.50	5.333		1,075	165		1,240	1,450
5940	ANSI class 350, painted									
5946	2" pipe size	1 Plum	23	.348	Ea.	50.50	11.55		62.05	73
5948	2-1/2" pipe size	Q-1	37	.432		58.50	12.95		71.45	84
5950	3" pipe size		31	.516		80	15.45		95.45	112
5952	4" pipe size		23	.696		107	21		128	150
5954	5" pipe size		19	.842		121	25		146	172
5956	6" pipe size	Q-2	23	1.043		141	32.50		173.50	205
5958	8" pipe size		17	1.412		162	44		206	246
5960	10" pipe size		14	1.714		259	53		312	365
5962	12" pipe size	1 Plum	12	.667		276	22		298	340
6100	Coupling, for PVC plastic pipe									
6110	2" diameter	1 Plum	50	.160	Ea.	10.80	5.30		16.10	19.95
6112	2-1/2" diameter	Q-1	80	.200		15.20	6		21.20	26
6114	3" diameter		67	.239		18.45	7.15		25.60	31.50
6116	4" diameter		50	.320		24	9.60		33.60	41
6118	6" diameter	Q-2	50	.480		40	14.90		54.90	66.50
6120	8" diameter		42	.571		65.50	17.75		83.25	99
6122	10" diameter		35	.686		108	21.50		129.50	150
6124	12" diameter		32	.750		136	23.50		159.50	185
7400	Suction diffuser									
7402	Grooved end inlet x flanged outlet									
7410	3" x 3"	Q-1	50	.320	Ea.	425	9.60		434.60	485
7412	4" x 4"		38	.421		620	12.60		632.60	705
7414	5" x 5"		30	.533		675	15.95		690.95	765
7416	6" x 6"	Q-2	38	.632		850	19.60		869.60	965
7418	8" x 8"		27	.889		1,575	27.50		1,602.50	1,800
7420	10" x 10"		20	1.200		2,150	37		2,187	2,425
7422	12" x 12"		16	1.500		3,550	46.50		3,596.50	3,975
7424	14" x 14"		15	1.600		4,475	49.50		4,524.50	5,000
7426	16" x 14"		14	1.714		4,600	53		4,653	5,150
7500	Strainer, tee type, painted									
7506	2" pipe size	1 Plum	38	.211	Ea.	265	7		272	300
7508	2-1/2" pipe size	Q-1	62	.258		278	7.70		285.70	315
7510	3" pipe size		50	.320		315	9.60		324.60	360
7512	4" pipe size		38	.421		355	12.60		367.60	410
7514	5" pipe size		30	.533		515	15.95		530.95	590
7516	6" pipe size	Q-2	38	.632		555	19.60		574.60	640
7518	8" pipe size		27	.889		855	27.50		882.50	980
7520	10" pipe size		20	1.200		1,250	37		1,287	1,425
7522	12" pipe size		16	1.500		1,625	46.50		1,671.50	1,850
7524	14" pipe size		15	1.600		5,750	49.50		5,799.50	6,400
7526	16" pipe size		14	1.714		7,150	53		7,203	7,925
7570	Expansion joint, max. 3" travel									
7572	2" diameter	1 Plum	38	.211	Ea.	218	7		225	250
7574	3" diameter	Q-1	50	.320		255	9.60		264.60	296
7576	4" diameter	"	38	.421		320	12.60		332.60	370
7578	6" diameter	Q-2	38	.632		555	19.60		574.60	645
7800	Ball valve w/handle, carbon steel trim									
7810	1-1/2" pipe size	1 Plum	50	.160	Ea.	64.50	5.30		69.80	79

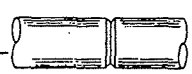
MECHANICAL 15

15107 | Metal Pipe & Fittings

		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
312	2" pipe size	1 Plum	38	.211	Ea.	89	7		96	109
7814	2-1/2" pipe size	Q-1	62	.258		184	7.70		191.70	214
7816	3" pipe size		50	.320		290	9.60		299.60	335
7818	4" pipe size		38	.421		445	12.60		457.60	510
7820	6" pipe size	Q-2	30	.800		1,300	25		1,325	1,500
7830	With gear operator									
7834	2-1/2" pipe size	Q-1	62	.258	Ea.	325	7.70		332.70	365
7836	3" pipe size		50	.320		430	9.60		439.60	485
7838	4" pipe size		38	.421		575	12.60		587.60	655
7840	6" pipe size	Q-2	30	.800		1,475	25		1,500	1,675
7870	Check valve									
7874	2-1/2" pipe size	Q-1	62	.258	Ea.	116	7.70		123.70	140
7876	3" pipe size		50	.320		137	9.60		146.60	166
7878	4" pipe size		38	.421		145	12.60		157.60	178
7880	5" pipe size		30	.533		241	15.95		256.95	289
7882	6" pipe size	Q-2	38	.632		286	19.60		305.60	345
7884	8" pipe size		27	.889		390	27.50		417.50	470
7886	10" pipe size		20	1.200		1,125	37		1,162	1,300
7888	12" pipe size		16	1.500		1,350	46.50		1,396.50	1,550
7900	Plug valve, balancing, w/lever operator									
7906	3" pipe size	Q-1	50	.320	Ea.	238	9.60		247.60	277
7908	4" pipe size	"	38	.421		262	12.60		274.60	305
7909	6" pipe size	Q-2	30	.800		470	25		495	555
7916	With gear operator									
7920	3" pipe size	Q-1	50	.320	Ea.	430	9.60		439.60	490
7922	4" pipe size	"	38	.421		455	12.60		467.60	520
924	6" pipe size	Q-2	38	.632		660	19.60		679.60	760
7926	8" pipe size		27	.889		885	27.50		912.50	1,025
7928	10" pipe size		20	1.200		1,400	37		1,437	1,575
7930	12" pipe size		16	1.500		2,025	46.50		2,071.50	2,300
8000	Butterfly valve, 2 position handle, with standard trim									
8010	1-1/2" pipe size	1 Plum	50	.160	Ea.	103	5.30		108.30	121
8020	2" pipe size	"	38	.211		103	7		110	124
8030	3" pipe size	Q-1	50	.320		147	9.60		156.60	177
8050	4" pipe size	"	38	.421		162	12.60		174.60	197
8070	6" pipe size	Q-2	38	.632		355	19.60		374.60	420
8080	8" pipe size		27	.889		540	27.50		567.50	635
8090	10" pipe size		20	1.200		775	37		812	910
8200	With stainless steel trim									
8240	1-1/2" pipe size	1 Plum	50	.160	Ea.	130	5.30		135.30	151
8250	2" pipe size	"	38	.211		130	7		137	154
8270	3" pipe size	Q-1	50	.320		175	9.60		184.60	207
8280	4" pipe size	"	38	.421		190	12.60		202.60	228
8300	6" pipe size	Q-2	38	.632		355	19.60		374.60	420
8310	8" pipe size		27	.889		605	27.50		632.50	705
8320	10" pipe size		20	1.200		960	37		997	1,100
8322	12" pipe size		16	1.500		1,225	46.50		1,271.50	1,425
8324	14" pipe size		15	1.600		1,600	49.50		1,649.50	1,850
8326	16" pipe size		14	1.714		2,200	53		2,253	2,500
8328	18" pipe size	Q-3	12	2.667		2,700	84.50		2,784.50	3,100
8330	20" pipe size		11	2.909		3,675	92.50		3,767.50	4,175
32	24" pipe size		10	3.200		4,675	101		4,776	5,275
336	Note: sizes 12" up w/manual gear operator									
9000	Cut one groove, labor									
9010	3/4" pipe size	Q-1	152	.105	Ea.		3.15		3.15	4.77
9020	1" pipe size		140	.114			3.42		3.42	5.15

15107 | Metal Pipe & Fittings

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
690	9030	1-1/4" pipe size	Q-1	124	.129	Ea.		3.86		3.86	5.85	690
	9040	1-1/2" pipe size		114	.140			4.20		4.20	6.35	
	9050	2" pipe size		104	.154			4.60		4.60	6.95	
	9060	2-1/2" pipe size		96	.167			4.99		4.99	7.55	
	9070	3" pipe size		88	.182			5.45		5.45	8.25	
	9080	3-1/2" pipe size		83	.193			5.75		5.75	8.75	
	9090	4" pipe size		78	.205			6.15		6.15	9.30	
	9100	5" pipe size		72	.222			6.65		6.65	10.05	
	9110	6" pipe size		70	.229			6.85		6.85	10.35	
	9120	8" pipe size		54	.296			8.85		8.85	13.40	
	9130	10" pipe size		38	.421			12.60		12.60	19.05	
	9140	12" pipe size		30	.533			15.95		15.95	24	
	9150	14" pipe size		20	.800			24		24	36	
	9160	16" pipe size		19	.842			25		25	38	
	9170	18" pipe size		18	.889			26.50		26.50	40.50	
	9180	20" pipe size		17	.941			28		28	42.50	
	9190	24" pipe size		15	1.067			32		32	48.50	
	9210	Roll one groove										
	9220	3/4" pipe size	Q-1	266	.060	Ea.		1.80		1.80	2.72	
	9230	1" pipe size		228	.070			2.10		2.10	3.18	
	9240	1-1/4" pipe size		200	.080			2.39		2.39	3.62	
	9250	1-1/2" pipe size		178	.090			2.69		2.69	4.07	
	9260	2" pipe size		116	.138			4.13		4.13	6.25	
	9270	2-1/2" pipe size		110	.145			4.35		4.35	6.60	
	9280	3" pipe size		100	.160			4.79		4.79	7.25	
	9290	3-1/2" pipe size		94	.170			5.10		5.10	7.70	
	9300	4" pipe size		86	.186			5.55		5.55	8.40	
	9310	5" pipe size		84	.190			5.70		5.70	8.60	
	9320	6" pipe size		80	.200			6		6	9.05	
	9330	8" pipe size		66	.242			7.25		7.25	11	
	9340	10" pipe size		58	.276			8.25		8.25	12.50	
	9350	12" pipe size		46	.348			10.40		10.40	15.75	
	9360	14" pipe size		30	.533			15.95		15.95	24	
	9370	16" pipe size		28	.571			17.10		17.10	26	
	9380	18" pipe size		27	.593			17.75		17.75	27	
	9390	20" pipe size		25	.640			19.15		19.15	29	
	9400	24" pipe size		23	.696			21		21	31.50	
920	0010	**PIPE, STAINLESS STEEL**										920
	0020	Welded, with clevis type hangers 10' O.C.										
	0500	Schedule 5, type 304										
	0540	1/2" diameter	Q-15	128	.125	L.F.	3.91	3.74	.38	8.03	10.35	
	0550	3/4" diameter		116	.138		4.46	4.13	.42	9.01	11.60	
	0560	1" diameter		103	.155		5.35	4.65	.47	10.47	13.40	
	0570	1-1/4" diameter		93	.172		6.05	5.15	.52	11.72	15.10	
	0580	1-1/2" diameter		85	.188		6.95	5.65	.57	13.17	16.80	
	0590	2" diameter		69	.232		8.30	6.95	.71	15.96	20.50	
	0600	2-1/2" diameter		53	.302		11.40	9.05	.92	21.37	27	
	0610	3" diameter		48	.333		13.70	10	1.02	24.72	31.50	
	0620	4" diameter		44	.364		17.45	10.90	1.11	29.46	37	
	0630	5" diameter		36	.444		35	13.30	1.36	49.66	60	
	0640	6" diameter	Q-16	42	.571		32	17.75	1.16	50.91	64	
	0650	8" diameter		34	.706		49	22	1.43	72.43	88.50	
	0660	10" diameter		26	.923		69	28.50	1.87	99.37	122	
	0670	12" diameter		21	1.143		90.50	35.50	2.32	128.32	156	
	0700	To delete hangers, subtract										



MECHANICAL 15

Labour Costs, USL

Inlet Piping

Q-1 crew = 1 Plum, 1 App.

Estimate			Actual		
Description	crew	per day	Quantity	days	
6" O.D PVC Sch 80	Q1	38'	100'	2.60	3.98
3" O.D PVC Sch 80	Q1	50'	60'	1.20	
2" O.D PVC Sch 80	Q1	55'	10'	0.18	
1½" O.D PVC Sch 80	1 Plum	34'	10'	0.29	
6" 90° & 45° Elbows Epoxy	Q1	8	5	0.62	1.17
3" 90° & 45° Elbows Epoxy	Q1	16	4	0.25	
2" 90° & 45° Elbows Epoxy	Q1	23	1	0.04	
1½" 90° & 45° Elbows Epoxy	Q1	23	6	0.26	
6" Tee PVC	Q1	5	3	0.60	0.78
2" Tee PVC	Q1	17	2	0.12	
½" Tee PVC	Q1	17	1	0.06	
6" Flange PVC	Q1	16	13+2	~~0.81~~ 0.94	0.96
2" Flange PVC	Q1	46	1	0.02	
3"x2" Reducer PVC	Q1	22	1	0.05	0.18
2"x1½" Reducer PVC	Q1	30	4	0.13	
6"x3" Reducing Tee PVC	Q1	8	2	0.25	0.64
x2" Reducing Tee PVC	Q1	8	1	0.12	
" Reducing Tee PVC	Q1	12	2	0.17	
x ½" Reducing Tee PVC	Q1	20	2	0.10	

.abour Costs, USL

Inlet Piping

Q-16 crew = 2 Plum, 1 App, 1 Welding Machine

Estimate			Actual	
Description	Crew	Per Day	Quantity	Days
6" Flange Steel	Q-16	6	1	0.17
6" Valve	Q-1	12	6	0.5
2" Valve	~~Q-1~~ 1 Plum	17	2	0.12
1½" Valve	1 Plum	20	5	0.25

V. Time required for 1 Plum.
= 0.29 + 0.12 + 0.25 = 0.66 days

Add additional worker reduces time by 25%
= 0.66 x 0.75 = 0.50 days

Time required for Q-1 crew
= 3.98 + 1.17 + 0.78 + 0.96 + 0.18 + 0.64 + 0.5 = 8.21

Total time for Q-1 crew
= 8.21 + 0.50 = 8.71 days (69.7 hrs)

Add additional worker reduces time by 25%
= 8.71 x 0.75 = 6.53 days

Total Time for Q-16 crew (2 Plum, 1 App.)
= 6.53 + 0.17 = 6.70 days (53.6 hrs)

abour Costs, USL
Auxiliary Piping
Estimate

Description	Crew	Per day	Actual Quantity	Days	
3" O.D PVC Sch80	Q-1	50'	60'	1.2	1.39 ~~2.32~~
2½" O.D PVC Sch80	Q-1	52'	10'	0.19	
1' O.D PVC Sch80	1 Plum	43'	40'	0.93	
3" 90°+45° Elbows Epoxy	Q-1	16	10	0.62	0.85
" 90°+45° Elbows Epoxy	Q-1	19	2	0.10	
" 90°+45° Elbows Epoxy	Q-1	23	3	0.13	
" Tee PVC	Q-1	10	1	0.10	0.25
Tee PVC	Q-1	17	2	0.12	
½" Flange	Q-1	39	1	0.03	
" x 2½" Reducer	Q-1	22	1	0.05	0.09
x 1" Reducer	Q-1	26	1	0.04	
Value	1 Plum	23	2	0.09	

Time required for 1 Plum.
0.93 + 0.09 = 1.02 days

Add additional worker reduces time by 25%
1.02 × 0.75 = 0.765 days

Time required for Q-1 crew (1 Plum + 1 Appr.)
= 1.39 + 0.85 + 0.25 + 0.09 = 2.58 days

Total time for Q-1 crew
2.58 + 0.765 = 3.34 days (26.7 hrs)

-abovr Costs, USL

Discharge Piping

Q-1 crew = 1 Plum, 1 Appr.

Estimate			Actual		
Description	Crew	Per day	Quantity	Days	
6" O.D PVC Sch 80	Q-1	38'	60'	1.60	2.0
" O.D PVC Sch 80	Q-1	46'	10'	0.22	
2" O.D PVC Sch 80	Q-1	55'	10'	0.18	
6" 90°+45° Elbows Epxy	Q-1	8	9	1.12	1.29
90°+45° Elbows Epxy	Q-1	13	1	0.08	
" 90°+45° Elbows Epxy	Q-1	23	2	0.09	
" Tee PVC	Q-1	5	3	0.60	
Flange PVC	Q-1	16	~~3~~ 6+2	~~0.40~~ 0.50	0.66
' Flange PVC	Q-1	26	2	0.08	
Flange PVC	Q-1	32	2	0.06	
Flange PVC	Q-1	46	1	0.02	
4" Reducer	Q-1	15	2	0.13	0.25
x3" Reducer	Q-1	16	2	0.12	
x2" Reducing Tee	Q-1	8	1	0.12	
" Valve	Q-1	12	2	0.17	0.28
Valve	Q-1	20	1	0.05	
Valve	~~[illegible]~~ 1 Plum	17	1	0.06	

Labour Costs, USL

Discharge Piping

Time required for 1 PLUM.
= 0.06 days

Add additional worker reduces time by 25%.
= 0.06 x 0.75 = 0.04 days

Time required for Q-1 crew (1 PLUM, 1 Appr.)
= 2.0 + 1.29 + 0.66 + 0.25 + 0.28 = 4.48 days

Total time for Q-1 crew
4.48 + 0.04 = 4.52 days (36.2 hrs)

107 | Metal Pipe & Fittings

	Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P	
2"	Q-1	9	1.778	Ea.	133	53		186	227	960
For couplings and unions use 3000 lb., type 316										
3000 lb., type 304										
Coupling										
1/8"	1 Plum	19	.421	Ea.	2.41	14		16.41	23.50	
1/4"		19	.421		2.53	14		16.53	24	
3/8"		19	.421		3.04	14		17.04	24.50	
1/2"		19	.421		4.84	14		18.84	26.50	
3/4"		18	.444		7.30	14.80		22.10	30.50	
1"		15	.533		12.40	17.75		30.15	40.50	
1-1/4"	Q-1	26	.615		28	18.40		46.40	58.50	
1-1/2"		24	.667		32	19.95		51.95	65.50	
2"		21	.762		46	23		69	85.50	
Union										
1/8"	1 Plum	12	.667	Ea.	25.50	22		47.50	61.50	
1/4"		12	.667		25.50	22		47.50	61.50	
3/8"		12	.667		27.50	22		49.50	63.50	
1/2"		11	.727		27.50	24		51.50	66.50	
3/4"		10	.800		33.50	26.50		60	77	
1"		9	.889		56	29.50		85.50	106	
1-1/4"	Q-1	16	1		78.50	30		108.50	132	
1-1/2"		15	1.067		88	32		120	146	
2"		13	1.231		123	37		160	192	
3000 lb., type 316										
Coupling										
1/8"	1 Plum	19	.421	Ea.	2.95	14		16.95	24.50	
1/4"		19	.421		3.25	14		17.25	24.50	
3/8"		19	.421		3.46	14		17.46	25	
1/2"		19	.421		5.60	14		19.60	27	
3/4"		18	.444		8.25	14.80		23.05	31.50	
1"		15	.533		13.95	17.75		31.70	42.50	
1-1/4"	Q-1	26	.615		32	18.40		50.40	63.50	
1-1/2"		24	.667		36.50	19.95		56.45	70	
2"		21	.762		53	23		76	93	
Union										
1/8"	1 Plum	12	.667	Ea.	26	22		48	62.50	
1/4"		12	.667		26	22		48	62.50	
3/8"		12	.667		32	22		54	69	
1/2"		11	.727		32	24		56	72	
3/4"		10	.800		36.50	26.50		63	80	
1"		9	.889		63	29.50		92.50	114	
1-1/4"	Q-1	16	1		94	30		124	149	
1-1/2"		15	1.067		118	32		150	178	
2"		13	1.231		154	37		191	225	

108 | Plastic Pipe & Fittings

	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
PIPE, PLASTIC										520
Fiberglass reinforced, couplings 10' O.C., hangers 3 per 10'										
General service										
2" diameter	Q-1	59	.271	L.F.	9.65	8.10		17.75	23	
3" diameter		52	.308		13	9.20		22.20	28.50	
4" diameter		48	.333		15.85	10		25.85	32.50	
6" diameter		39	.410		23	12.30		35.30	43.50	
8" diameter	Q-2	49	.490		36.50	15.20		51.70	63	
10" diameter		41	.585		53.50	18.15		71.65	86.50	
12" diameter		36	.667		65.50	20.50		86	104	

15108 | Plastic Pipe & Fittings

			Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
520	0200	High strength									
	0240	2" diameter	Q-1	58	.276	L.F.	10.75	8.25		19	24.50
	0260	3" diameter		51	.314		14.65	9.40		24.05	30.50
	0280	4" diameter		47	.340		17.65	10.20		27.85	35
	0300	6" diameter		38	.421		26	12.60		38.60	47.50
	0320	8" diameter	Q-2	48	.500		41	15.50		56.50	68.50
	0340	10" diameter		40	.600		60	18.60		78.60	94
	0360	12" diameter		36	.667		73.50	20.50		94	113
	0550	To delete coupling & hangers, subtract									
	0560	2" diam. to 6" diam.					33%	56%			
	0570	8" diam. to 12" diam.					31%	52%			
	0600	PVC, high impact/pressure, cplgs. 10' O.C., hangers 3 per 10'									
	1020	Schedule 80									
	1040	1/4" diameter	1 Plum	58	.138	L.F.	2.17	4.59		6.76	9.35
	1060	3/8" diameter		55	.145		2.26	4.84		7.10	9.80
	1070	1/2" diameter		50	.160		2	5.30		7.30	10.25
	1080	3/4" diameter		47	.170		2.20	5.65		7.85	10.95
	1090	1" diameter		43	.186		2.68	6.20		8.88	12.30
	1100	1-1/4" diameter		39	.205		2.80	6.80		9.60	13.40
	1110	1-1/2" diameter		34	.235		3.01	7.80		10.81	15.15
	1120	2" diameter	Q-1	55	.291		3.19	8.70		11.89	16.65
	1130	2-1/2" diameter		52	.308		3.30	9.20		12.50	17.55
	1140	3" diameter		50	.320		4.56	9.60		14.16	19.50
	1150	4" diameter		46	.348		6.05	10.40		16.45	22.50
	1160	5" diameter		42	.381		10.35	11.40		21.75	28.50
	1170	6" diameter		38	.421		9.30	12.60		21.90	29.50
	1180	8" diameter	Q-2	47	.511		14.95	15.85		30.80	40.50
	1190	10" diameter		42	.571		23.50	17.75		41.25	53
	1200	12" diameter		38	.632		30	19.60		49.60	62.50
	1730	To delete coupling & hangers, subtract									
	1740	1/4" diam. to 1/2" diam.					62%	80%			
	1750	3/4" diam. to 1-1/4" diam.					58%	73%			
	1760	1-1/2" diam. to 6" diam.					40%	57%			
	1770	8" diam. to 12" diam.					34%	50%			
	1800	PVC, couplings 10' O.C., hangers 3 per 10'									
	1820	Schedule 40									
	1860	1/2" diameter	1 Plum	54	.148	L.F.	1.90	4.93		6.83	9.55
	1870	3/4" diameter		51	.157		2.06	5.20		7.26	10.15
	1880	1" diameter		46	.174		2.57	5.80		8.37	11.60
	1890	1-1/4" diameter		42	.190		2.61	6.35		8.96	12.45
	1900	1-1/2" diameter		36	.222		2.81	7.40		10.21	14.30
	1910	2" diameter	Q-1	59	.271		2.83	8.10		10.93	15.40
	1920	2-1/2" diameter		56	.286		3.52	8.55		12.07	16.80
	1930	3" diameter		53	.302		4.05	9.05		13.10	18.10
	1940	4" diameter		48	.333		5.50	10		15.50	21
	1950	5" diameter		43	.372		7.50	11.15		18.65	25
	1960	6" diameter		39	.410		8.30	12.30		20.60	27.50
	1970	8" diameter	Q-2	48	.500		13.15	15.50		28.65	38
	1980	10" diameter		43	.558		27.50	17.30		44.80	56.50
	1990	12" diameter		42	.571		35	17.75		52.75	65.50
	2000	14" diameter		31	.774		108	24		132	156
	2010	16" diameter		23	1.043		136	32.50		168.50	198
	2340	To delete coupling & hangers, subtract									
	2360	1/2" diam. to 1-1/4" diam.					65%	74%			
	2370	1-1/2" diam. to 6" diam.					44%	57%			
	2380	8" diam. to 12" diam.					41%	53%			

08 | Plastic Pipe & Fittings

	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
14" diam. to 16" diam.					48%	45%				520
Schedule 80										
1/4" diameter	1 Plum	58	.138	L.F.	1.91	4.59		6.50	9.05	
3/8" diameter		55	.145		1.91	4.84		6.75	9.40	
1/2" diameter		50	.160		2.08	5.30		7.38	10.35	
3/4" diameter		47	.170		2.31	5.65		7.96	11.10	
1" diameter		43	.186		2.84	6.20		9.04	12.50	
1-1/4" diameter		39	.205		3.02	6.80		9.82	13.60	
1-1/2" diameter		34	.235		3.27	7.80		11.07	15.45	
2" diameter	Q-1	55	.291		3.57	8.70		12.27	17.10	
2-1/2" diameter		52	.308		3.86	9.20		13.06	18.20	
3" diameter		50	.320		5.30	9.60		14.90	20.50	
4" diameter		46	.348		7.15	10.40		17.55	23.50	
5" diameter		42	.381		9.75	11.40		21.15	28	
6" diameter		38	.421		11.35	12.60		23.95	31.50	
8" diameter	Q-2	47	.511		18.10	15.85		33.95	44	
10" diameter		42	.571		28	17.75		45.75	57.50	
12" diameter		38	.632		36	19.60		55.60	69	
To delete coupling & hangers, subtract										
1/4" diam. to 1/2" diam.					66%	80%				
3/4" diam. to 1-1/4" diam.					61%	73%				
1-1/2" diam. to 6" diam.					41%	57%				
8" diam. to 12" diam.					31%	50%				
Schedule 120										
1/2" diameter	1 Plum	50	.160	L.F.	2.63	5.30		7.93	10.95	
3/4" diameter		47	.170		3.03	5.65		8.68	11.90	
1" diameter		43	.186		3.89	6.20		10.09	13.65	
1-1/4" diameter		39	.205		4.50	6.80		11.30	15.25	
1-1/2" diameter		33	.242		5.05	8.05		13.10	17.75	
2" diameter	Q-1	54	.296		6.10	8.85		14.95	20	
2-1/2" diameter		52	.308		8.30	9.20		17.50	23	
3" diameter		49	.327		10.45	9.75		20.20	26.50	
4" diameter		45	.356		15.70	10.65		26.35	33.50	
6" diameter		37	.432		27.50	12.95		40.45	50	
To delete coupling & hangers, subtract										
1/2" diam. to 1-1/4" diam.					52%	74%				
1-1/2" diam. to 4" diam.					30%	57%				
6" diam.					17%	50%				
PVC, pressure, couplings 10' O.C., hangers 3 per 10'										
SDR 26, 160 psi										
1-1/4" diameter	1 Plum	42	.190	L.F.	2.44	6.35		8.79	12.30	
1-1/2" diameter	"	36	.222		2.62	7.40		10.02	14.10	
2" diameter	Q-1	59	.271		2.80	8.10		10.90	15.40	
2-1/2" diameter		56	.286		3.15	8.55		11.70	16.40	
3" diameter		53	.302		3.65	9.05		12.70	17.65	
4" diameter		48	.333		5.10	10		15.10	20.50	
6" diameter		39	.410		8.05	12.30		20.35	27.50	
8" diameter	Q-2	48	.500		13.15	15.50		28.65	38	
To delete coupling & hangers, subtract										
1-1/4" diam.					63%	68%				
1-1/2" diam. to 4" diam.					48%	57%				
6" diam. to 8" diam.					60%	54%				
SDR 21, 200 psi, 1/2" diameter	1 Plum	54	.148	L.F.	2.01	4.93		6.94	9.65	
3/4" diameter		51	.157		2.18	5.20		7.38	10.30	
1" diameter		46	.174		2.63	5.80		8.43	11.65	
1-1/4" diameter		42	.190		2.75	6.35		9.10	12.60	

15108 | Plastic Pipe & Fittings		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
520 3770	1-1/2″ diameter	1 Plum	36	.222	L.F.	2.96	7.40		10.36	[illegible]
3780	2″ diameter	Q-1	59	.271		3.17	8.10		11.27	[illegible]
3790	2-1/2″ diameter		56	.286		4.15	8.55		12.70	[illegible]
3800	3″ diameter		53	.302		4.58	9.05		13.63	[illegible]
3810	4″ diameter		48	.333		6.25	10		16.25	[illegible]
3830	6″ diameter		39	.410		10.05	12.30		22.35	[illegible]
3840	8″ diameter	Q-2	48	.500		16.70	15.50		32.20	[illegible]
4000	To delete coupling & hangers, subtract									
4010	1/2″ diam. to 3/4″ diam.					71%	77%			
4020	1″ diam. to 1-1/4″ diam.					63%	70%			
4030	1-1/2″ diam. to 6″ diam.					44%	57%			
4040	8″ diam.					46%	54%			
4100	DWV type, schedule 40, couplings 10′ O.C., hangers 3 per 10′									
4120	ABS									
4140	1-1/4″ diameter	1 Plum	42	.190	L.F.	2.58	6.35		8.93	[illegible]
4150	1-1/2″ diameter	″	36	.222		2.56	7.40		9.96	[illegible]
4160	2″ diameter	Q-1	59	.271		2.66	8.10		10.76	[illegible]
4170	3″ diameter		53	.302		3.28	9.05		12.33	[illegible]
4180	4″ diameter		48	.333		4.44	10		14.44	[illegible]
4190	6″ diameter		39	.410		7.10	12.30		19.40	[illegible]
4360	To delete coupling & hangers, subtract									
4370	1-1/4″ diam.					64%	68%			
4380	1-1/2″ diam. to 6″ diam.					54%	57%			
4400	PVC									
4410	1-1/4″ diameter	1 Plum	42	.190	L.F.	2.66	6.35		9.01	[illegible]
4420	1-1/2″ diameter	″	36	.222		2.73	7.40		10.13	[illegible]
4460	2″ diameter	Q-1	59	.271		2.91	8.10		11.01	[illegible]
4470	3″ diameter		53	.302		3.79	9.05		12.84	[illegible]
4480	4″ diameter		48	.333		5.10	10		15.10	[illegible]
4490	6″ diameter		39	.410		7.40	12.30		19.70	[illegible]
4500	8″ diameter	Q-2	48	.500		16.35	15.50		31.85	[illegible]
4750	To delete coupling & hangers, subtract									
4760	1-1/4″ diam. to 1-1/2″ diam.					71%	64%			
4770	2″ diam. to 8″ diam.					60%	57%			
4800	PVC, clear pipe, cplgs. 10′ O.C., hangers 3 per 10′, Sched. 40									
4840	1/4″ diameter	1 Plum	59	.136	L.F.	2.32	4.51		6.83	[illegible]
4850	3/8″ diameter		56	.143		2.51	4.75		7.26	[illegible]
4860	1/2″ diameter		54	.148		2.87	4.93		7.80	[illegible]
4870	3/4″ diameter		51	.157		3.36	5.20		8.56	[illegible]
4880	1″ diameter		46	.174		4.51	5.80		10.31	[illegible]
4890	1-1/4″ diameter		42	.190		5.25	6.35		11.60	[illegible]
4900	1-1/2″ diameter		36	.222		5.95	7.40		13.35	[illegible]
4910	2″ diameter	Q-1	59	.271		7.25	8.10		15.35	[illegible]
4920	2-1/2″ diameter		56	.286		10.20	8.55		18.75	[illegible]
4930	3″ diameter		53	.302		12.75	9.05		21.80	[illegible]
4940	3-1/2″ diameter		50	.320		15.65	9.60		25.25	[illegible]
4950	4″ diameter		48	.333		16.40	10		26.40	[illegible]
5250	To delete coupling & hangers, subtract									
5260	1/4″ diam. to 3/8″ diam.					60%	81%			
5270	1/2″ diam. to 3/4″ diam.					41%	77%			
5280	1″ diam. to 1-1/2″ diam.					26%	67%			
5290	2″ diam. to 4″ diam.					16%	58%			
5360	CPVC, couplings 10′ O.C., hangers 3 per 10′									
5380	Schedule 40									
5460	1/2″ diameter	1 Plum	54	.148	L.F.	2.63	4.93		7.56	[illegible]
5470	3/4″ diameter		51	.157		3.04	5.20		8.24	[illegible]

15 MECHANICAL

08 | Plastic Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
1" diameter	1 Plum	46	.174	L.F.	3.98	5.80		9.78	13.15	520
1-1/4" diameter		42	.190		4.57	6.35		10.92	14.65	
1-1/2" diameter		36	.222		5.20	7.40		12.60	16.90	
2" diameter	Q-1	59	.271		6.05	8.10		14.15	19	
2-1/2" diameter		56	.286		8.85	8.55		17.40	22.50	
3" diameter		53	.302		10.55	9.05		19.60	25.50	
4" diameter		48	.333		14.50	10		24.50	31	
6" diameter		43	.372		26	11.15		37.15	45.50	
To delete coupling & hangers, subtract										
1/2" diam. to 3/4" diam.					37%	77%				
1" diam. to 1-1/4" diam.					27%	70%				
1-1/2" diam. to 3" diam.					21%	57%				
4" diam. to 6" diam.					16%	57%				
Schedule 80										
1/2" diameter	1 Plum	50	.160	L.F.	2.74	5.30		8.04	11.05	
3/4" diameter		47	.170		3.22	5.65		8.87	12.10	
1" diameter		43	.186		4.24	6.20		10.44	14	
1-1/4" diameter		39	.205		4.96	6.80		11.76	15.75	
1-1/2" diameter		34	.235		5.70	7.80		13.50	18.15	
2" diameter	Q-1	55	.291		6.85	8.70		15.55	20.50	
2-1/2" diameter		52	.308		9.90	9.20		19.10	25	
3" diameter		50	.320		12.10	9.60		21.70	28	
4" diameter		46	.348		17	10.40		27.40	34.50	
6" diameter		38	.421		31.50	12.60		44.10	53.50	
8" diameter	Q-2	47	.511		68.50	15.85		84.35	99.50	
To delete couplings & hangers, subtract										
1/2" diam. to 3/4" diam.					44%	77%				
1" diam. to 1-1/4" diam.					32%	71%				
1-1/2" diam. to 4" diam.					25%	58%				
6" diam. to 8" diam.					20%	53%				
CTS, 1/2" diameter	1 Plum	54	.148	L.F.	2.08	4.93		7.01	9.75	
3/4" diameter		51	.157		2.80	5.20		8	11	
1" diameter		46	.174		3.58	5.80		9.38	12.70	
1 1/4"		42	.190		4.22	6.35		10.57	14.25	
1 1/2" diameter		36	.222		5.05	7.40		12.45	16.75	
2" diameter	Q-1	59	.271		7.10	8.10		15.20	20	
To delete coupling & hangers, subtract										
1/2" diam.					51%	79%				
3/4" diam.					40%	76%				
1" thru 2" diam.					72%	68%				
Polyethylene, flexible, no couplings or hangers										
Note: For labor costs add 25% to the couplings and fittings labor total.										
SDR 15, 100 psi										
3/4" diameter				L.F.	.17			.17	.19	
1" diameter					.22			.22	.24	
1-1/4" diameter					.40			.40	.44	
1-1/2" diameter					.50			.50	.55	
2" diameter					.80			.80	.88	
SIDR 9, 160 psi										
1/2" diameter				L.F.	.23			.23	.25	
3/4" diameter					.23			.23	.25	
1" diameter					.36			.36	.40	
1-1/4" diameter					.60			.60	.66	
1-1/2" diameter					.84			.84	.92	
2" diameter					1.38			1.38	1.52	
SDR 9, 200 psi										

MECHANICAL 15

	15108 | Plastic Pipe & Fittings		Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
520	8150	3/4" diameter				L.F.	.20			.20	.22
	8160	1" diameter					.33			.33	.36
	8170	1-1/4" diameter					.49			.49	.54
	8420	SDR 7, 250 psi									
	8440	3/4" diameter				L.F.	.29			.29	.32
	8450	1" diameter					.46			.46	.51
	8460	1-1/4" diameter					.79			.79	.87
	8800	PVC, type PSP, drain & sewer, belled end gasket jnt., no hngr.									
	8840	3" diameter				L.F.	.32			.32	.35
	8850	4" diameter					.40			.40	.44
	8860	6" diameter					.89			.89	.98
	9000	Perforated									
	9040	4" diameter				L.F.	.42			.42	.46
560	0010	PIPE, PLASTIC, FITTINGS									
	0030	Epoxy resin, fiberglass reinforced, general service									
	0090	Elbow, 90°, 2"	Q-1	23	.696	Ea.	45.50	21		66.50	81.50
	0100	3" 2.5" .19		16	1		64.50	30		94.50	116
	0110	4"		13	1.231		104	37		141	170
	0120	6"		8	2		156	60		216	263
	0130	8"	Q-2	9	2.667		260	83		343	410
	0140	10"		7	3.429		360	106		466	555
	0150	12"		5	4.800		500	149		649	775
	0160	45° Elbow, same as 90°									
	0170	Elbow, 90°, flanged									
	0172	2"	Q-1	23	.696	Ea.	91	21		112	132
	0173	3"		16	1		105	30		135	162
	0174	4"		13	1.231		138	37		175	207
	0176	6"		8	2		249	60		309	365
	0177	8"	Q-2	9	2.667		450	83		533	615
	0178	10"		7	3.429		615	106		721	835
	0179	12"		5	4.800		835	149		984	1,150
	0186	Elbow, 45°, flanged									
	0188	2"	Q-1	23	.696	Ea.	91.50	21		112.50	133
	0189	3"		16	1		105	30		135	162
	0190	4"		13	1.231		137	37		174	207
	0192	6"		8	2		251	60		311	365
	0193	8"	Q-2	9	2.667		450	83		533	620
	0194	10"		7	3.429		615	106		721	835
	0195	12"		5	4.800		835	149		984	1,150
	0290	Tee, 2" 2.5" 13	Q-1	17	.941		61	28		89	110
	0300	3"		10	1.600		71.50	48		119.50	151
	0310	4"		8	2		85	60		145	184
	0320	6"		5	3.200		228	96		324	395
	0330	8"	Q-2	6	4		263	124		387	475
	0340	10"		5	4.800		420	149		569	685
	0350	12"		4	6		510	186		696	840
	0352	Tee, flanged									
	0354	2"	Q-1	17	.941	Ea.	124	28		152	179
	0355	3"		10	1.600		166	48		214	256
	0356	4"		8	2		185	60		245	294
	0358	6"		5	3.200		365	96		461	545
	0359	8"	Q-2	6	4		625	124		749	875
	0360	10"		5	4.800		905	149		1,054	1,225
	0361	12"		4	6		1,150	186		1,336	1,550
	0365	Wye, flanged									

08 | Plastic Pipe & Fittings

	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
2″	Q-1	17	.941	Ea.	320	28		348	395	560
3″		10	1.600		355	48		403	465	
4″		8	2		440	60		500	575	
6″		5	3.200		530	96		626	725	
8″	Q-2	6	4		690	124		814	945	
10″		5	4.800		1,175	149		1,324	1,500	
12″		4	6		1,425	186		1,611	1,825	
Couplings										
2″	Q-1	28	.571	Ea.	10.90	17.10		28	38	
3″		20	.800		18.85	24		42.85	56.50	
4″		17	.941		20	28		48	64.50	
6″		12	1.333		38	40		78	103	
8″	Q-2	15	1.600		58	49.50		107.50	139	
10″		11	2.182		87.50	67.50		155	198	
12″		10	2.400		117	74.50		191.50	242	
High corrosion resistant couplings, add					30%					
Reducer, concentric, flanged										
2″ x 1-1/2″	Q-1	30	.533	Ea.	132	15.95		147.95	169	
3″ x 2″		24	.667		150	19.95		169.95	195	
4″ x 3″		19	.842		158	25		183	212	
6″ x 4″		15	1.067		206	32		238	276	
8″ x 6″	Q-2	16	1.500		289	46.50		335.50	390	
10″ x 8″		13	1.846		385	57.50		442.50	510	
12″ x 10″		11	2.182		555	67.50		622.50	710	
Adapter, bell x male or female										
2″	Q-1	28	.571	Ea.	19.65	17.10		36.75	47.50	
3″		20	.800		25	24		49	63.50	
4″		17	.941		34.50	28		62.50	80.50	
6″		12	1.333		68.50	40		108.50	136	
8″	Q-2	15	1.600		95.50	49.50		145	180	
10″		11	2.182		168	67.50		235.50	287	
Flange										
2″ 2.5'' 39	Q-1	46	.348	Ea.	17.40	10.40		27.80	35	
3″		32	.500		21	14.95		35.95	46	
4″		26	.615		29.50	18.40		47.90	60.50	
6″		16	1		50	30		80	101	
8″	Q-2	18	1.333		82	41.50		123.50	153	
10″		14	1.714		114	53		167	207	
12″		10	2.400		161	74.50		235.50	290	
PVC schedule 80										
90° elbow, 1/2″	1 Plum	18	.444	Ea.	.89	14.80		15.69	23.50	
3/4″		17	.471		1.14	15.65		16.79	25	
1″		15	.533		1.83	17.75		19.58	29	
1-1/4″		14	.571		2.44	19		21.44	31	
1-1/2″		13	.615		2.62	20.50		23.12	34	
2″	Q-1	22	.727		3.16	22		25.16	36.50	
3″		14	1.143		8.30	34		42.30	61	
4″		12	1.333		12.65	40		52.65	74.50	
6″		7	2.286		42.50	68.50		111	151	
8″	Q-2	8	3		117	93		210	270	
45° elbow, 1/2″	1 Plum	18	.444		1.68	14.80		16.48	24.50	
3/4″		17	.471		2.54	15.65		18.19	26.50	
1″		15	.533		3.84	17.75		21.59	31	
1-1/4″		14	.571		4.87	19		23.87	34	
1-1/2″		13	.615		5.75	20.50		26.25	37.50	
2″	Q-1	22	.727		7.45	22		29.45	41	

15108 | Plastic Pipe & Fittings

		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
560 2320	3"	Q-1	14	1.143	Ea.	19.05	34		53.05	73
2330	4"		12	1.333		34.50	40		74.50	98
2340	6"		7	2.286		43	68.50		111.50	152
2350	8"	Q-2	8	3		83	93		176	232
2400	Tee, 1/2"	1 Plum	12	.667		2.50	22		24.50	36.50
2420	3/4"		11	.727		2.62	24		26.62	39.50
2430	1"		10	.800		3.27	26.50		29.77	43.50
2440	1-1/4"		9	.889		9	29.50		38.50	54.50
2450	1-1/2"		8	1		9	33.50		42.50	60.50
2460	2"	Q-1	14	1.143		11.25	34		45.25	64.50
2470	3"		9	1.778		15.30	53		68.30	97.50
2480	4"		8	2		17.70	60		77.70	110
2490	6"		5	3.200		60.50	96		156.50	212
2500	8"	Q-2	6	4		85.50	124		209.50	282
2510	Flange, socket, 150 lb., 1/2"	1 Plum	34	.235		4.84	7.80		12.64	17.15
2514	3/4"		32	.250		5.20	8.30		13.50	18.25
2518	1"		28	.286		5.80	9.50		15.30	20.50
2522	1-1/2"		24	.333		6.10	11.10		17.20	23.50
2526	2"	Q-1	42	.381		8.10	11.40		19.50	26
2530	4"		30	.533		17.45	15.95		33.40	43
2534	6"		22	.727		27.50	22		49.50	63
2538	8"	Q-2	26	.923		50	28.50		78.50	98.50
2550	Coupling, 1/2"	1 Plum	18	.444		1.61	14.80		16.41	24.50
2570	3/4"		17	.471		2.17	15.65		17.82	26
2580	1"		15	.533		2.23	17.75		19.98	29.50
2590	1-1/4"		14	.571		3.39	19		22.39	32
2600	1-1/2"		13	.615		3.66	20.50		24.16	35
2610	2"	Q-1	22	.727		3.92	22		25.92	37.50
2620	3"		19	.842		11.10	25		36.10	50
2630	4"		16	1		13.90	30		43.90	61
2640	6"		12	1.333		30	40		70	93.50
2650	8"	Q-2	14	1.714		54	53		107	140
2660	10"		13	1.846		84	57.50		141.50	179
2670	12"		12	2		112	62		174	217
2700	PVC (white), schedule 40, socket joints									
2760	90° elbow, 1/2"	1 Plum	22	.364	Ea.	.23	12.10		12.33	18.55
2770	3/4"		21	.381		.25	12.65		12.90	19.45
2780	1"		18	.444		.45	14.80		15.25	23
2790	1-1/4"		17	.471		.80	15.65		16.45	24.50
2800	1-1/2"		16	.500		.85	16.65		17.50	26
2810	2"	Q-1	28	.571		1.34	17.10		18.44	27.50
2820	2-1/2"		22	.727		4.06	22		26.06	37.50
2830	3"		17	.941		4.86	28		32.86	48
2840	4"		14	1.143		8.70	34		42.70	61.50
2850	5"		12	1.333		22.50	40		62.50	85
2860	6"		8	2		27.50	60		87.50	121
2870	8"	Q-2	10	2.400		77	74.50		151.50	198
2980	45° elbow, 1/2"	1 Plum	22	.364		.37	12.10		12.47	18.70
2990	3/4"		21	.381		.57	12.65		13.22	19.80
3000	1"		18	.444		.68	14.80		15.48	23.50
3010	1-1/4"		17	.471		.96	15.65		16.61	24.50
3020	1-1/2"		16	.500		1.20	16.65		17.85	26.50
3030	2"	Q-1	28	.571		1.57	17.10		18.67	27.50
3040	2-1/2"		22	.727		4.07	22		26.07	37.50
3050	3"		17	.941		6.30	28		34.30	49.50
3060	4"		14	1.143		11.35	34		45.35	64.50

Important: See the Reference Section for critical supporting data - Reference Nos., Crews, & City Cost Indexes

8 | Plastic Pipe & Fittings

	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
5"	Q-1	12	1.333	Ea.	22.50	40		62.50	85	560
6"		8	2		28	60		88	122	
8"	Q-2	10	2.400		93	74.50		167.50	215	
Tee, 1/2"	1 Plum	14	.571		.28	19		19.28	29	
3/4"		13	.615		.32	20.50		20.82	31.50	
1"		12	.667		.59	22		22.59	34	
1-1/4"		11	.727		.94	24		24.94	37.50	
1-1/2"		10	.800		1.13	26.50		27.63	41	
2"	Q-1	17	.941		1.65	28		29.65	44.50	
2-1/2"		14	1.143		5.45	34		39.45	58	
3"		11	1.455		7.15	43.50		50.65	74	
4"		9	1.778		12.90	53		65.90	94.50	
5"		8	2		31	60		91	125	
6"		5	3.200		43.50	96		139.50	193	
8"	Q-2	6	4		53	124		177	246	
Coupling, 1/2"	1 Plum	22	.364		.18	12.10		12.28	18.50	
3/4"		21	.381		.24	12.65		12.89	19.40	
1"		18	.444		.41	14.80		15.21	23	
1-1/4"		17	.471		.57	15.65		16.22	24	
1-1/2"		16	.500		.61	16.65		17.26	25.50	
2"	Q-1	28	.571		.95	17.10		18.05	27	
2-1/2"		20	.800		2.08	24		26.08	38.50	
3"		19	.842		3.27	25		28.27	41.50	
4"		16	1		4.72	30		34.72	50.50	
5"		14	1.143		8.65	34		42.65	61.50	
6"		12	1.333		14.90	40		54.90	77	
8"	Q-2	14	1.714		28	53		81	111	
Reducing insert, schedule 40, socket weld										
3/4"	1 Plum	20	.400	Ea.	.70	13.30		14	21	
1"		18	.444		1.19	14.80		15.99	24	
1-1/2"		16	.500		1.25	16.65		17.90	26.50	
2"	Q-1	31	.516		1.59	15.45		17.04	25.50	
4"		22	.727		7.05	22		29.05	41	
6"		14	1.143		17.45	34		51.45	71	
8"	Q-2	18	1.333		61	41.50		102.50	130	
Reducing insert, socket weld x female/male thread										
1/2"	1 Plum	24	.333	Ea.	1.41	11.10		12.51	18.30	
3/4"		23	.348		.87	11.55		12.42	18.45	
1"		20	.400		1.22	13.30		14.52	21.50	
1-1/2"		16	.500		2.20	16.65		18.85	27.50	
2"	Q-1	26	.615		1.17	18.40		19.57	29.50	
4"	"	14	1.143		4.61	34		38.61	57	
Male adapter, socket weld x male thread										
1/2"	1 Plum	24	.333	Ea.	.27	11.10		11.37	17.05	
3/4"		23	.348		.30	11.55		11.85	17.85	
1"		20	.400		.53	13.30		13.83	20.50	
1-1/2"		16	.500		.87	16.65		17.52	26	
2"	Q-1	26	.615		1.14	18.40		19.54	29.50	
4"	"	14	1.143		6.30	34		40.30	59	
Female adapter, socket weld x female thread										
1/2"	1 Plum	24	.333	Ea.	.33	11.10		11.43	17.10	
3/4"		23	.348		.42	11.55		11.97	17.95	
1"		20	.400		.49	13.30		13.79	20.50	
1-1/2"		16	.500		.87	16.65		17.52	26	
2"	Q-1	26	.615		1.17	18.40		19.57	29.50	
4"	"	14	1.143		6.60	34		40.60	59.50	

MECHANICAL 15

15108 | Plastic Pipe & Fittings

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
560	3800	PVC, schedule 80, socket joints									
	3810	Reducing insert									
	3812	3/4"	1 Plum	23	.348	Ea.	.67	11.55		12.22	18.25
	3813	1"		20	.400		1.91	13.30		15.21	22
	3815	1-1/2"		16	.500		4.09	16.65		20.74	29.50
	3816	2"	Q-1	28	.571		5.35	17.10		22.45	32
	3817	4"		16	1		22	30		52	70
	3818	6"		12	1.333		31	40		71	94.50
	3819	8"	Q-2	14	1.714		22.50	53		75.50	106
	3830	Reducing insert, socket weld x female/male thread									
	3832	1/2"	1 Plum	24	.333	Ea.	1.78	11.10		12.88	18.70
	3833	3/4"		23	.348		1.11	11.55		12.66	18.70
	3834	1"		20	.400		1.92	13.30		15.22	22
	3836	1-1/2"		16	.500		3.22	16.65		19.87	28.50
	3837	2"	Q-1	28	.571		4.66	17.10		21.76	31
	3838	4"	"	16	1		41	30		71	91
	3844	Adapter, male socket x male thread									
	3846	1/2"	1 Plum	24	.333	Ea.	1.01	11.10		12.11	17.85
	3847	3/4"		23	.348		1.11	11.55		12.66	18.70
	3848	1"		20	.400		1.92	13.30		15.22	22
	3850	1-1/2"		16	.500		3.22	16.65		19.87	28.50
	3851	2"	Q-1	28	.571		4.66	17.10		21.76	31
	3852	4"	"	16	1		10.45	30		40.45	57
	3860	Adapter, female socket x female thread									
	3862	1/2"	1 Plum	24	.333	Ea.	.81	11.10		11.91	17.65
	3863	3/4"		23	.348		2.88	11.55		14.43	20.50
	3864	1"		20	.400		4.25	13.30		17.55	24.50
	3866	1-1/2"		16	.500		8.45	16.65		25.10	34.50
	3867	2"	Q-1	28	.571		14.75	17.10		31.85	42
	3868	4"	"	16	1		45	30		75	95
	3872	Union, socket joints									
	3874	1/2"	1 Plum	19	.421	Ea.	4.25	14		18.25	25.50
	3875	3/4"		18	.444		5.40	14.80		20.20	28.50
	3876	1"		15	.533		6.15	17.75		23.90	34
	3878	1-1/2"		13	.615		13.85	20.50		34.35	46.50
	3879	2"	Q-1	27	.593		18.80	17.75		36.55	47.50
	3888	Cap									
	3890	1/2"	1 Plum	36	.222	Ea.	2.03	7.40		9.43	13.45
	3891	3/4"		34	.235		2.13	7.80		9.93	14.20
	3892	1"		30	.267		3.80	8.85		12.65	17.60
	3894	1-1/2"		26	.308		4.58	10.25		14.83	20.50
	3895	2"	Q-1	44	.364		9.05	10.90		19.95	26.50
	3896	4"		32	.500		36.50	14.95		51.45	62.50
	3897	6"		24	.667		83	19.95		102.95	122
	3898	8"	Q-2	28	.857		107	26.50		133.50	157
	4500	DWV, ABS, non pressure, socket joints									
	4540	1/4 Bend, 1-1/4"	1 Plum	17	.471	Ea.	.99	15.65		16.64	24.50
	4560	1-1/2"	"	16	.500		.53	16.65		17.18	25.50
	4570	2"	Q-1	28	.571		.87	17.10		17.97	27
	4580	3"		17	.941		2.05	28		30.05	45
	4590	4"		14	1.143		3.57	34		37.57	56
	4600	6"		8	2		22.50	60		82.50	116
	4650	1/8 Bend, same as 1/4 Bend									
	4800	Tee, sanitary									
	4820	1-1/4"	1 Plum	11	.727	Ea.	1.25	24		25.25	38
	4830	1-1/2"	"	10	.800		.77	26.50		27.27	41

15108 | Plastic Pipe & Fittings

	Plastic Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
	2"	Q-1	17	.941	Ea.	1.10	28		29.10	43.50 560
	3"		11	1.455		2.79	43.50		46.29	69
	4"		9	1.778		6.90	53		59.90	88
2	Tee, sanitary, reducing, 2" x 1-1/2"		17	.941		1.63	28		29.63	44.50
4	3" x 2"		11	1.455		2.36	43.50		45.86	68.50
	4" x 3"		10	1.600		7.70	48		55.70	81
	Combination Y and 1/8 bend									
2	1-1/2"	1 Plum	10	.800	Ea.	2.34	26.50		28.84	42.50
	2"	Q-1	17	.941		2.84	28		30.84	45.50
	3"		11	1.455		5	43.50		48.50	71.50
78	4"		9	1.778		9.85	53		62.85	91.50
	3" x 1-1/2"		11	1.455		5.85	43.50		49.35	72.50
	4" x 3"		10	1.600		8.80	48		56.80	82
00	Wye, 1-1/4"	1 Plum	11	.727		1.44	24		25.44	38
02	1-1/2"	"	10	.800		1.47	26.50		27.97	41.50
	2"	Q-1	17	.941		1.51	28		29.51	44
	3"		11	1.455		3.47	43.50		46.97	70
908	4"		9	1.778		8.20	53		61.20	89.50
	6"		5	3.200		31	96		127	180
	3" x 1-1/2"		11	1.455		3.43	43.50		46.93	70
920	4" x 3"		10	1.600		5.70	48		53.70	79
922	6" x 4"		6	2.667		25.50	80		105.50	150
	Double Wye, 1-1/2"	1 Plum	8	1		3.12	33.50		36.62	54
	2"	Q-1	12	1.333		4.01	40		44.01	65
4934	3"		8	2		10.35	60		70.35	102
	4"		6	2.667		21	80		101	144
	2" x 1-1/2"		11	1.455		4.01	43.50		47.51	70.50
4942	3" x 2"		8	2		7.70	60		67.70	99
4944	4" x 3"		7	2.286		16.65	68.50		85.15	122
6	6" x 4"		5	3.200		34.50	96		130.50	183
4950	Reducer bushing, 2" x 1-1/2"		30	.533		.51	15.95		16.46	24.50
4952	3" x 1-1/2" (3"x2" 22)		24	.667		1.85	19.95		21.80	32
54	4" x 2"		20	.800		4.27	24		28.27	40.50
56	6" x 4"		17	.941		11.40	28		39.40	55
4960	Couplings, 1-1/2"	1 Plum	16	.500		.56	16.65		17.21	25.50
62	2"	Q-1	28	.571		.33	17.10		17.43	26.50
63	3"		22	.727		1.15	22		23.15	34.50
4964	4"		17	.941		1.77	28		29.77	44.50
4966	6"		12	1.333		11.85	40		51.85	73.50
970	2" x 1-1/2"		30	.533		.34	15.95		16.29	24.50
972	3" x 1-1/2"		24	.667		1.15	19.95		21.10	31.50
4974	4" x 3"		19	.842		4.53	25		29.53	43
978	Closet flange, 4"	1 Plum	32	.250		4.69	8.30		12.99	17.70
980	4" x 3"	"	34	.235		4.02	7.80		11.82	16.25
5000	DWV, PVC, schedule 40, socket joints									
5040	1/4 bend, 1-1/4"	1 Plum	17	.471	Ea.	.93	15.65		16.58	24.50
5060	1-1/2"	"	16	.500		.41	16.65		17.06	25.50
5070	2"	Q-1	28	.571		.63	17.10		17.73	26.50
5080	3"		17	.941		1.57	28		29.57	44
5090	4"		14	1.143		2.82	34		36.82	55
5100	6"		8	2		17.15	60		77.15	109
5105	8"	Q-2	10	2.400		34.50	74.50		109	151
5106	10"	"	7	3.429		37.50	106		143.50	202
5110	1/4 bend, long sweep, 1-1/2"	1 Plum	16	.500		1.28	16.65		17.93	26.50
5112	2"	Q-1	28	.571		1.05	17.10		18.15	27
5114	3"		17	.941		2.73	28		30.73	45.50

MECHANICAL 15

15108 | Plastic Pipe & Fittings

		DESCRIPTION	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
60	5116	4"	Q-1	14	1.143	Ea.	5.40	34		39.40	58
	5150	1/8 bend, 1-1/4"	1 Plum	17	.471		.82	15.65		16.47	24.50
	70	1-1/2"	"	16	.500		.46	16.65		17.11	25.50
	5180	2"	Q-1	28	.571		.66	17.10		17.76	26.50
	5190	3"		17	.941		1.35	28		29.35	44
	5200	4"		14	1.143		2.25	34		36.25	54.50
	5210	6"	↓	8	2		15.70	60		75.70	108
	5215	8"	Q-2	10	2.400		41	74.50		115.50	158
	5216	10"		7	3.429		62	106		168	230
	5217	12"	↓	6	4		99.50	124		223.50	297
	5250	Tee, sanitary 1-1/4"	1 Plum	11	.727		1.45	24		25.45	38
	5254	1-1/2"	"	10	.800		.61	26.50		27.11	40.50
	5255	2"	Q-1	17	.941		.83	28		28.83	43.[illegible]
	5256	3"		11	1.455		2.29	43.50		45.79	68.[illegible]
	5257	4"		9	1.778		4.38	53		57.38	85.[illegible]
	5259	6"	↓	5	3.200		25.50	96		121.50	173
	5261	8"	Q-2	6	4		76	124		200	272
	5264	2" x 1-1/2"	Q-1	17	.941		2.05	28		30.05	45
	5266	3" x 1-1/2"		12	1.333		1.76	40		41.76	62.[illegible]
	5268	4" x 3"		12	1.333		8.05	40		48.05	69.[illegible]
	5271	6" x 4"	↓	8	2	↓	25	60		85	118
	5276	Tee, sanitary, reducing									
	5281	2" x 1-1/2" x 1-1/2"	Q-1	17	.941	Ea.	.87	28		28.87	43.[illegible]
	5282	2" x 1-1/2" x 2"		17	.941		1.63	28		29.63	44.[illegible]
	5283	2" x 2" x 1-1/2"		16	1		1.03	30		31.03	46.[illegible]
	5284	3" x 3" x 1-1/2"		12	1.333		2.13	40		42.13	63
	5285	3" x 3" x 2"		11	1.455		2.36	43.50		45.86	68.50
	86	4" x 4" x 1-1/2"		11	1.455		6.15	43.50		49.65	73
	287	4" x 4" x 2"		10	1.600		5.90	48		53.90	79
	5288	4" x 4" x 3"		9	1.778		8.05	53		61.05	89.[illegible]
	5291	6" x 6" x 4"	↓	6	2.667	↓	24.50	80		104.50	148
	5294	Tee, double sanitary									
	5295	1-1/2"	1 Plum	8	1	Ea.	1.57	33.50		35.07	52
	5296	2"	Q-1	12	1.333		2.66	40		42.66	63.[illegible]
	5297	3"		8	2		7.45	60		67.45	96.[illegible]
	5298	4"	↓	6	2.667	↓	12	80		92	134
	5303	Wye, reducing									
	5304	2" x 1-1/2" x 1-1/2"	Q-1	17	.941	Ea.	2.25	28		30.25	45
	5305	2" x 2" x 1-1/2"		15	1.067		2.13	32		34.13	51
	5306	3" x 3" x 2"		12	1.333		4.40	40		44.40	65.[illegible]
	5307	4" x 4" x 2"		11	1.455		4.10	43.50		47.60	70.[illegible]
	5309	4" x 4" x 3"	↓	10	1.600		4.79	48		52.79	78
	5314	Combination Y & 1/8 bend, 1-1/2"	1 Plum	10	.800		1.88	26.50		28.38	42
	5315	2"	Q-1	17	.941		2.50	28		30.50	45.[illegible]
	5317	3"		11	1.455		4.12	43.50		47.62	70.[illegible]
	5318	4"		9	1.778		8.10	53		61.10	89.[illegible]
	5319	6"	↓	5	3.200		62.50	96		158.50	214
	5320	8"	Q-2	6	4	↓	100	124		224	298
	5324	Combination Y & 1/8 bend, reducing									
	5325	2" x 2" x 1-1/2"	Q-1	17	.941	Ea.	3.64	28		31.64	46.[illegible]
	5327	3" x 3" x 1-1/2"		13	1.231		4.80	37		41.80	61
	5328	3" x 3" x 2"		12	1.333		3.01	40		43.01	64
	5329	4" x 4" x 2"	↓	11	1.455		6.70	43.50		50.20	73.[illegible]
	31	Wye, 1-1/4"	1 Plum	11	.727		1.39	24		25.39	38
	5332	1-1/2"	"	10	.800		1.21	26.50		27.71	41.[illegible]
	5333	2"	Q-1	17	.941	↓	1.21	28		29.21	44

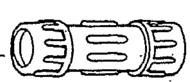
08 | Plastic Pipe & Fittings

	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
3"	Q-1	11	1.455	Ea.	2.79	43.50		46.29	69	560
4"		9	1.778		5.10	53		58.10	86	
6"		5	3.200		33	96		129	182	
8"	Q-2	5	4.800		37.50	149		186.50	267	
10"		4	6		58.50	186		244.50	345	
12"		3	8		86.50	248		334.50	470	
2" x 1-1/2"	Q-1	17	.941		2.13	28		30.13	45	
3" x 1-1/2"		12	1.333		2.82	40		42.82	63.50	
4" x 3"		10	1.600		4.79	48		52.79	78	
6" x 4"		6	2.667		18.80	80		98.80	142	
8" x 6"	Q-2	8	3		45	93		138	191	
Double wye, 1-1/2"	1 Plum	8	1		2.57	33.50		36.07	53.50	
2"	Q-1	12	1.333		3.30	40		43.30	64	
3"		8	2		8.50	60		68.50	100	
4"		6	2.667		17.25	80		97.25	140	
2" x 1-1/2"		11	1.455		3.02	43.50		46.52	69.50	
3" x 2"		8	2		6.35	60		66.35	97.50	
4" x 3"		7	2.286		13.70	68.50		82.20	119	
6" x 4"		5	3.200		28.50	96		124.50	177	
Coupling, 1-1/4"	1 Plum	17	.471		.78	15.65		16.43	24.50	
1-1/2"	"	16	.500		.26	16.65		16.91	25.50	
2"	Q-1	28	.571		.27	17.10		17.37	26.50	
3"		22	.727		.78	22		22.78	34	
4"		17	.941		1.28	28		29.28	44	
6"		12	1.333		6.85	40		46.85	68	
8"	Q-2	14	1.714		15.45	53		68.45	97.50	
2" x 1-1/2"	Q-1	30	.533		.68	15.95		16.63	25	
3" x 1-1/2"		25	.640		2.15	19.15		21.30	31.50	
4" x 3"		18	.889		3.73	26.50		30.23	44.50	
Reducer bushing, 2" x 1-1/4"		31	.516		.46	15.45		15.91	24	
2" x 1-1/2"		30	.533		.46	15.95		16.41	24.50	
3" x 1-1/2"		25	.640		2.01	19.15		21.16	31	
3" x 2"		24	.667		.93	19.95		20.88	31	
4" x 2"		22	.727		3.51	22		25.51	37	
4" x 3"		20	.800		1.94	24		25.94	38	
6" x 4"		14	1.143		10.05	34		44.05	63	
8" x 6"	Q-2	18	1.333		20	41.50		61.50	84.50	
Closet flange 4"	Q-1	32	.500		4.73	14.95		19.68	27.50	
4" x 3"	"	34	.471		3.55	14.10		17.65	25.50	
Solvent cement for PVC, industrial grade, per quart				Qt.	10.80			10.80	11.90	
CPVC, Schedule 80, threaded joints										
90° Elbow, 1/4"	1 Plum	20	.400	Ea.	5.35	13.30		18.65	26	
1/2"		18	.444		2.09	14.80		16.89	25	
3/4"		17	.471		2.67	15.65		18.32	26.50	
1"		15	.533		4.24	17.75		21.99	31.50	
1-1/4"		14	.571		9.20	19		28.20	38.50	
1-1/2"		13	.615		10.25	20.50		30.75	42.50	
2"	Q-1	22	.727		12.40	22		34.40	46.50	
2-1/2"		18	.889		28.50	26.50		55	72	
3"		14	1.143		32	34		66	87.50	
4"		12	1.333		58	40		98	125	
6"		7	2.286		117	68.50		185.50	232	
45° Elbow same as 90° Elbow										
Tee, 1/4"	1 Plum	14	.571	Ea.	6.55	19		25.55	35.50	
1/2"		12	.667		6.55	22		28.55	40.50	
3/4"		11	.727		6.65	24		30.65	44	

MECHANICAL 15

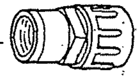
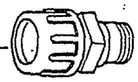
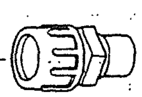
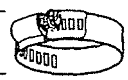
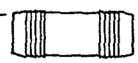
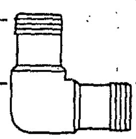
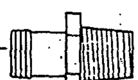
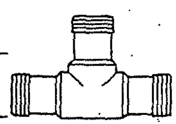
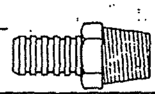
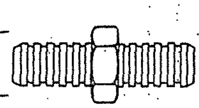
15108 | Plastic Pipe & Fittings

		Description	Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
560	5890	1"	1 Plum	10	.800	Ea.	8.15	26.50		34.65	49
	5900	1-1/4"		9	.889		12.90	29.50		42.40	58.50
	5910	1-1/2"		8	1		14.80	33.50		48.30	67
	5920	2"	Q-1	14	1.143		16.45	34		50.45	70
	5930	2-1/2"		12	1.333		42	40		82	107
	5940	3"		9	1.778		42	53		95	127
	5950	4"		8	2		56	60		116	152
	5960	6"		5	3.200		145	96		241	305
	6000	Coupling, 1/4"	1 Plum	20	.400		5.70	13.30		19	26.50
	6020	1/2"		18	.444		2.21	14.80		17.01	25
	6030	3/4"		17	.471		3.09	15.65		18.74	27
	6040	1"		15	.533		4.16	17.75		21.91	31.50
	6050	1-1/4"		14	.571		6.25	19		25.25	35.50
	6060	1-1/2"		13	.615		7.85	20.50		28.35	39.50
	6070	2"	Q-1	22	.727		9.15	22		31.15	43
	6080	2-1/2"		20	.800		20.50	24		44.50	58.50
	6090	3"		19	.842		22	25		47	62.50
	6100	4"		16	1		29	30		59	77.50
	6110	6"		12	1.333		68	40		108	136
	6120	8"	Q-2	14	1.714		126	53		179	220
	6200	CTS, 100 psi at 180°F, hot and cold water									
	6230	90° Elbow, 1/2"	1 Plum	20	.400	Ea.	.07	13.30		13.37	20
	6250	3/4"		19	.421		.16	14		14.16	21
	6251	1"		16	.500		.52	16.65		17.17	25.50
	6252	1-1/4"		15	.533		.89	17.75		18.64	28
	6253	1-1/2"		14	.571		1.43	19		20.43	30
	6254	2"	Q-1	23	.696		3.08	21		24.08	35
	6260	45° Elbow, 1/2"	1 Plum	20	.400		.12	13.30		13.42	20
	6280	3/4"		19	.421		.18	14		14.18	21
	6281	1"		16	.500		.48	16.65		17.13	25.50
	6282	1-1/4"		15	.533		.94	17.75		18.69	28
	6283	1-1/2"		14	.571		1.49	19		20.49	30
	6284	2"	Q-1	23	.696		3.14	21		24.14	35
	6290	Tee, 1/2"	1 Plum	13	.615		.10	20.50		20.60	31
	6310	3/4"		12	.667		.23	22		22.23	34
	6311	1"		11	.727		1.18	24		25.18	38
	6312	1-1/4"		10	.800		1.80	26.50		28.30	42
	6313	1-1/2"		10	.800		2.34	26.50		28.84	42.50
	6314	2"	Q-1	17	.941		3.80	28		31.80	46.50
	6320	Coupling, 1/2"	1 Plum	22	.364		.09	12.10		12.19	18.40
	6340	3/4"		21	.381		.10	12.65		12.75	19.25
	6341	1"		18	.444		.45	14.80		15.25	23
	6342	1-1/4"		17	.471		.56	15.65		16.21	24
	6343	1-1/2"		16	.500		.79	16.65		17.44	26
	6344	2"	Q-1	28	.571		1.58	17.10		18.68	27.50
	6360	Solvent cement for CPVC, commercial grade, per quart				Qt.	7.30			7.30	8
	7990	Polybutyl/polyethyl pipe, for copper fittings see 15107-460-7000									
	8000	Compression type, PVC, 160 psi cold water									
	8010	Coupling, 3/4" CTS	1 Plum	21	.381	Ea.	1.90	12.65		14.55	21
	8020	1" CTS		18	.444		2.34	14.80		17.14	25
	8030	1-1/4" CTS		17	.471		3.27	15.65		18.92	27
	8040	1-1/2" CTS		16	.500		4.50	16.65		21.15	30
	8050	2" CTS		15	.533		6.30	17.75		24.05	34
	8060	Female adapter, 3/4" FPT x 3/4" CTS		23	.348		3.01	11.55		14.56	21
	8070	3/4" FPT x 1" CTS		21	.381		4.50	12.65		17.15	24
	8080	1" FPT x 1" CTS		20	.400		4.53	13.30		17.83	25



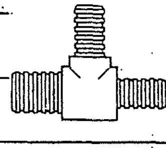
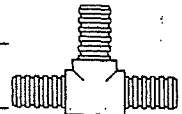
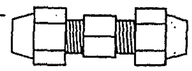
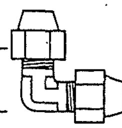
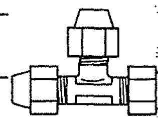
MECHANICAL

Plastic Pipe & Fittings

Plastic Pipe & Fittings	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
1-1/4" FPT x 1-1/4" CTS	1 Plum	18	.444	Ea.	5.95	14.80		20.75	29 560
1-1/2" FPT x 1-1/2" CTS 		16	.500		6.95	16.65		23.60	32.50
2" FPT x 2" CTS		13	.615		10.30	20.50		30.80	42.50
Male adapter, 3/4" MPT x 3/4" CTS		23	.348		2.71	11.55		14.26	20.50
3/4" MPT x 1" CTS		21	.381		3.34	12.65		15.99	23
1" MPT x 1" CTS		20	.400		3.42	13.30		16.72	24
1-1/4" MPT x 1-1/4" CTS		18	.444		5.25	14.80		20.05	28.50
1-1/2" MPT x 1-1/2" CTS 		16	.500		6.05	16.65		22.70	31.50
2" MPT x 2" CTS		13	.615		9.70	20.50		30.20	41.50
Spigot adapter, 3/4" IPS x 3/4" CTS		23	.348		2.71	11.55		14.26	20.50
3/4" IPS x 1" CTS		21	.381		2.71	12.65		15.36	22
1" IPS x 1" CTS 		20	.400		2.94	13.30		16.24	23
1-1/4" IPS x 1-1/4" CTS		18	.444		5.25	14.80		20.05	28.50
1-1/2" IPS x 1-1/2" CTS		16	.500		6.05	16.65		22.70	31.50
2" IPS x 2" CTS		13	.615		9.70	20.50		30.20	41.50
Price includes insert stiffeners									
250 psi is same price as 160 psi									
Insert type, nylon, 160 & 250 psi, cold water									
Clamp ring stainless steel, 3/4" IPS 	1 Plum	115	.070	Ea.	.62	2.31		2.93	4.18
1" IPS		107	.075		.63	2.49		3.12	4.45
1-1/4" IPS		101	.079		.63	2.63		3.26	4.67
1-1/2" IPS		95	.084		.64	2.80		3.44	4.94
2" IPS 		85	.094		.64	3.13		3.77	5.45
Coupling, 3/4" IPS		22	.364		.56	12.10		12.66	18.90
1-1/4" IPS		18	.444		1.34	14.80		16.14	24
1-1/2" IPS		17	.471		1.74	15.65		17.39	25.50
2" IPS		16	.500		2.09	16.65		18.74	27.50
Elbow, 90°, 3/4" IPS 		22	.364		.82	12.10		12.92	19.20
1" IPS		19	.421		.90	14		14.90	22
1-1/4" IPS		18	.444		1.01	14.80		15.81	23.50
1-1/2" IPS		17	.471		1.19	15.65		16.84	25
2" IPS		16	.500		1.67	16.65		18.32	27
Male adapter, 3/4" IPS x 3/4" MPT		25	.320		.57	10.65		11.22	16.75
1" IPS x 1" MPT 		21	.381		.74	12.65		13.39	19.95
1-1/4" IPS x 1-1/4" MPT		20	.400		1.23	13.30		14.53	21.50
1-1/2" IPS x 1-1/2" MPT		18	.444		1.63	14.80		16.43	24.50
2" IPS x 2" MPT		15	.533		2.09	17.75		19.84	29.50
Tee, 3/4" IPS		14	.571		1.07	19		20.07	29.50
1" IPS 		13	.615		1.75	20.50		22.25	33
1-1/4" IPS		12	.667		3.14	22		25.14	37
1-1/2" IPS		11	.727		3.95	24		27.95	41
2" IPS		10	.800		5.35	26.50		31.85	46
Insert type, PVC, 100 psi @ 180°F, hot & cold water									
Coupler, male, 3/8" CTS x 3/8" MPT	1 Plum	29	.276	Ea.	.96	9.15		10.11	14.95
3/8" CTS x 1/2" MPT		28	.286		.96	9.50		10.46	15.40
1/2" CTS x 1/2" MPT		27	.296		.30	9.85		10.15	15.25
1/2" CTS x 3/4" MPT 		26	.308		.86	10.25		11.11	16.45
3/4" CTS x 1/2" MPT		25	.320		.86	10.65		11.51	17.05
3/4" CTS x 3/4" MPT		25	.320		4.11	10.65		14.76	20.50
Coupling, 3/8" CTS x 1/2" CTS		25	.320		2.15	10.65		12.80	18.45
1/2" CTS 		23	.348		2.50	11.55		14.05	20.50
1/2" CTS x stub		23	.348		1.96	11.55		13.51	19.65
3/4" CTS		22	.364		3.96	12.10		16.06	22.50
Elbow 90°, 3/8" CTS		25	.320		.65	10.65		11.30	16.80
1/2" CTS		23	.348		.65	11.55		12.20	18.20
3/4" CTS		22	.364		.82	12.10		12.92	19.20

MECHANICAL 15

15108 | Plastic Pipe & Fittings

		15108 Plastic Pipe & Fittings	Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
560	8800	Rings, crimp, copper, 3/8" CTS	1 Plum	120	.067	Ea.	.11	2.22		2.33	3.47
	8810	1/2" CTS		117	.068		.12	2.27		2.39	3.57
	8820	3/4" CTS		115	.070		.15	2.31		2.46	3.67
	8850	Reducer tee, 3/8" x 3/8" x 1/2" CTS		17	.471		1.46	15.65		17.11	25
	8860	1/2" x 3/8" x 1/2" CTS		15	.533		1.25	17.75		19	28.50
	8870	3/4" x 1/2" x 1/2" CTS		14	.571		1.31	19		20.31	30
	8890	3/4" x 3/4" x 1/2" CTS		14	.571		1.24	19		20.24	30
	8900	3/4" x 1/2" x 3/8" CTS		14	.571		1.09	19		20.09	29.50
	8930	Tee, 3/8" CTS		17	.471		1.05	15.65		16.70	24.50
	8940	1/2" CTS		15	.533		1.19	17.75		18.94	28.50
	8950	3/4" CTS	↓	14	.571	↓	1.29	19		20.29	30
	8960	Copper rings included in fitting price									
	9000	Flare type, assembled, acetal, hot & cold water									
	9010	Coupling, 1/4" & 3/8" CTS	1 Plum	24	.333	Ea.	2.14	11.10		13.24	19.10
	9020	1/2" CTS		22	.364		2.45	12.10		14.55	21
	9030	3/4" CTS		21	.381		3.61	12.65		16.26	23
	9040	1" CTS		18	.444		4.61	14.80		19.41	27.50
	9050	Elbow 90°, 1/4" CTS		26	.308		2.38	10.25		12.63	18.10
	9060	3/8" CTS		24	.333		2.55	11.10		13.65	19.[illegible]
	9070	1/2" CTS		22	.364		3.01	12.10		15.11	21.[illegible]
	9080	3/4" CTS		21	.381		4.61	12.65		17.26	24
	9090	1" CTS		18	.444		5.80	14.80		20.60	29
	9110	Tee, 1/4" & 3/8" CTS		15	.533		2.62	17.75		20.37	30
	9120	1/2" CTS		14	.571		3.44	19		22.44	32.50
	9130	3/4" CTS		13	.615		5.25	20.50		25.75	37
	9140	1" CTS	↓	12	.667	↓	7	22		29	41
	9550	For plastic hangers see 15060-300-8000									
	9560	For copper/brass fittings see 15107-460-7000									
590	0010	**PIPE, HIGH DENSITY POLYETHYLENE PLASTIC (HDPE)**									
	0020	Not incl. hangers, trenching, backfill, hoisting or digging equipment.									
	0030	Standard length is 40', add a weld for each joint.									
	0050	Straight									
	0054	1" diameter DR 11				L.F.	.28			.28	[illegible]
	0058	1-1/2" diameter DR 11					.62			.62	[illegible]
	0062	2" diameter DR 11					.79			.79	[illegible]
	0066	3" diameter DR 11					1.72			1.72	[illegible]
	0070	3" diameter DR 17					1.15			1.15	[illegible]
	0074	4" diameter DR 11					2.84			2.84	[illegible]
	0078	4" diameter DR 17					1.91			1.91	[illegible]
	0082	6" diameter DR 11					6.15			6.15	[illegible]
	0086	6" diameter DR 17					4.13			4.13	[illegible]
	0090	8" diameter DR 11					10.40			10.40	[illegible]
	0094	8" diameter DR 26					4.69			4.69	[illegible]
	0098	10" diameter DR 11					16.20			16.20	[illegible]
	0102	10" diameter DR 26					7.25			7.25	8
	0106	12" diameter DR 11					23			23	25
	0110	12" diameter DR 26					10.25			10.25	[illegible]
	0114	16" diameter DR 11					34			34	37
	0118	16" diameter DR 26					15.20			15.20	[illegible]
	0122	18" diameter DR 11					43			43	47
	0126	18" diameter DR 26					19.20			19.20	21
	0130	20" diameter DR 11					53			53	58
	0134	20" diameter DR 26					23.50			23.50	26
	0138	22" diameter DR 11					64			64	70.[illegible]
	0142	22" diameter DR 26					28.50			28.50	31.[illegible]
	0146	24" diameter DR 11				↓	76			76	84

Important: See the Reference Section for critical supporting data - Reference Nos., Crews, & City Cost Indexes

10 | Valves

	Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P	
1-1/2" size	1 Stpi	11	.727	Ea.	274	24.50		298.50	335	400
2" size	"	8	1		330	33.50		363.50	415	
2-1/2" size	Q-5	5	3.200		360	96.50		456.50	540	
3" size	"	4.50	3.556		380	107		487	580	
Flanged										
3" size	Q-5	4.20	3.810	Ea.	415	115		530	630	
4" size	"	3	5.333		835	161		996	1,175	
5" size	Q-6	3.80	6.316		990	197		1,187	1,400	
6" size		3	8		1,200	250		1,450	1,700	
8" size		2.50	9.600		1,775	300		2,075	2,400	
10" size		2.20	10.909		2,525	340		2,865	3,300	
12" size		2.10	11.429		7,075	355		7,430	8,350	
14" size		2	12		10,100	375		10,475	11,700	
VALVES, PLASTIC (R15100-090)										500
Angle, PVC, threaded										
1/4" size	1 Plum	26	.308	Ea.	47.50	10.25		57.75	67.50	
1/2" size		26	.308		47.50	10.25		57.75	67.50	
3/4" size		25	.320		55.50	10.65		66.15	77	
1" size		23	.348		66.50	11.55		78.05	90.50	
Ball, PVC, socket or threaded, single union										
1/4" size	1 Plum	26	.308	Ea.	22	10.25		32.25	39.50	
3/8" size		26	.308		22	10.25		32.25	39.50	
1/2" size		26	.308		22	10.25		32.25	39.50	
3/4" size		25	.320		26.50	10.65		37.15	45	
1" size		23	.348		31	11.55		42.55	51.50	
1-1/4" size		21	.381		41.50	12.65		54.15	65	
1-1/2" size		20	.400		52	13.30		65.30	77	
2" size		17	.471		74.50	15.65		90.15	105	
2-1/2" size	Q-1	26	.615		185	18.40		203.40	232	
3" size		24	.667		185	19.95		204.95	234	
4" size		20	.800		320	24		344	385	
For PVC, flanged, add					100%	15%				
Double union 1/2" size	1 Plum	26	.308		25	10.25		35.25	43	
3/4" size		25	.320		28	10.65		38.65	46.50	
1" size		23	.348		35	11.55		46.55	56	
1-1/4" size		21	.381		58	12.65		70.65	83	
1-1/2" size		20	.400		58	13.30		71.30	84	
2" size		17	.471		79.50	15.65		95.15	111	
CPVC, socket or threaded, single union										
1/2" size	1 Plum	26	.308	Ea.	36.50	10.25		46.75	55.50	
3/4" size		25	.320		43.50	10.65		54.15	63.50	
1" size		23	.348		51	11.55		62.55	73.50	
1-1/4" size		21	.381		88	12.65		100.65	116	
1-1/2" size		20	.400		88	13.30		101.30	117	
2" size		17	.471		118	15.65		133.65	154	
3" size	Q-1	24	.667		248	19.95		267.95	305	
For CPVC, flanged, add					65%	15%				
For true union, socket or threaded, add					50%	5%				
Polypropylene, threaded										
1/4" size	1 Plum	26	.308	Ea.	30	10.25		40.25	48.50	
3/8" size		26	.308		30	10.25		40.25	48.50	
1/2" size		26	.308		30	10.25		40.25	48.50	
3/4" size		25	.320		37.50	10.65		48.15	57	
1" size		23	.348		44.50	11.55		56.05	66.50	
1-1/4" size		21	.381		64.50	12.65		77.15	90	

MECHANICAL 15

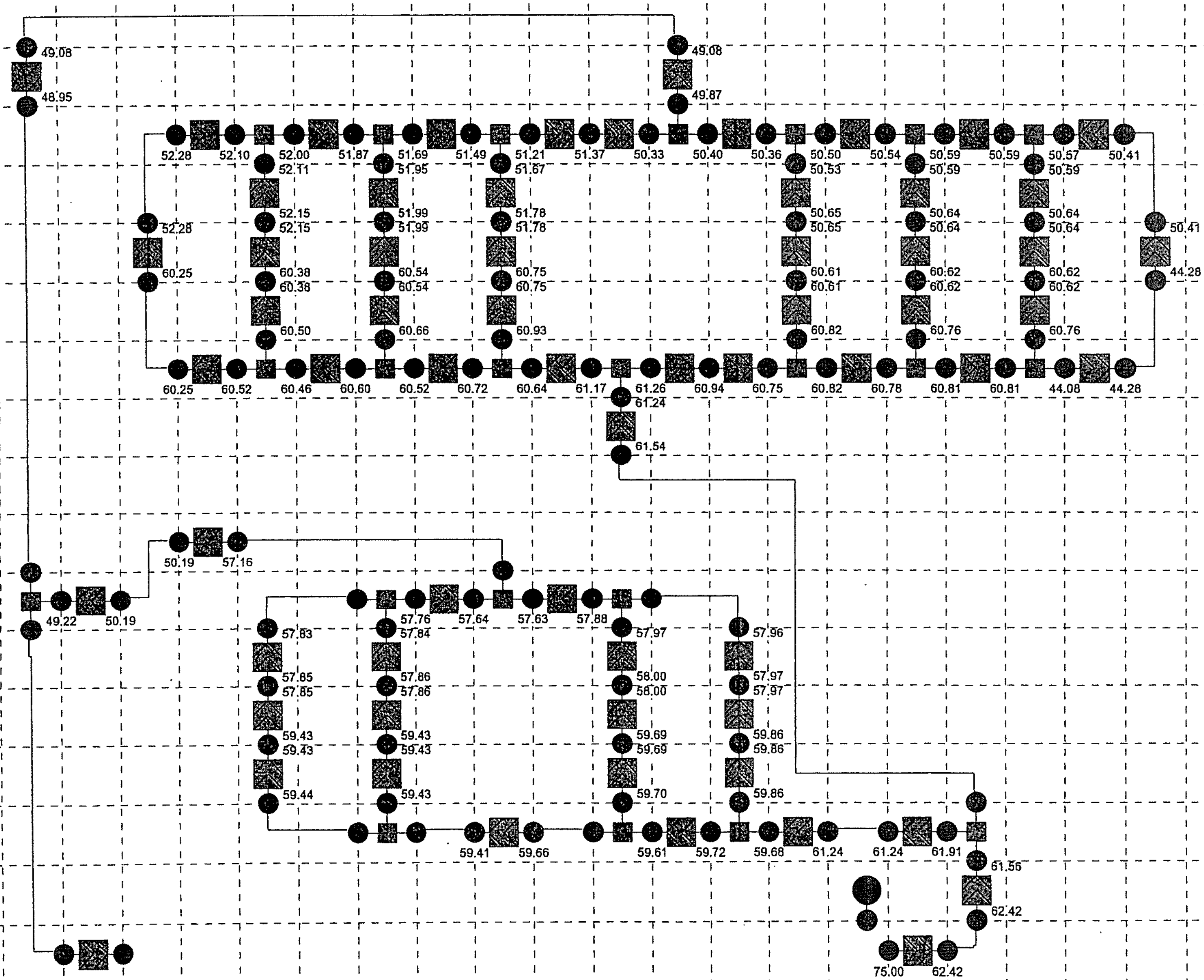
15110 | Valves			DAILY OUTPUT	LABOR-HOURS	UNIT	2000 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
		CREW								
500 2170	1-1/2" size R15100-090	1 Plum	20	.400	Ea.	74	13.30		87.30	102
2180	2" size		17	.471		101	15.65		116.65	135
2190	3" size	Q-1	24	.667		266	19.95		285.95	325
2200	4" size	"	20	.800		445	24		469	525
2550	PVC, three way, socket or threaded									
2600	1/2" size	1 Plum	26	.308	Ea.	56.50	10.25		66.75	77.50
2640	3/4" size		25	.320		64	10.65		74.65	86.50
2650	1" size		23	.348		69.50	11.55		81.05	94
2660	1-1/2" size		20	.400		140	13.30		153.30	174
2670	2" size		17	.471		188	15.65		203.65	231
2680	3" size	Q-1	24	.667		455	19.95		474.95	530
2740	For flanged, add					60%	15%			
3150	Ball check, PVC, socket or threaded									
3200	1/4" size	1 Plum	26	.308	Ea.	25	10.25		35.25	43
3220	3/8" size		26	.308		25	10.25		35.25	43
3240	1/2" size		26	.308		25	10.25		35.25	43
3250	3/4" size		25	.320		28	10.65		38.65	46.50
3260	1" size		23	.348		35	11.55		46.55	56
3270	1-1/4" size		21	.381		58	12.65		70.65	83
3280	1-1/2" size		20	.400		58	13.30		71.30	84
3290	2" size		17	.471		79	15.65		94.65	111
3310	3" size	Q-1	24	.667		183	19.95		202.95	231
3320	4" size	"	20	.800		259	24		283	320
3360	For PVC, flanged, add					50%	15%			
3750	CPVC, socket or threaded									
3800	1/2" size	1 Plum	26	.308	Ea.	36.50	10.25		46.75	55.50
3840	3/4" size		25	.320		43.50	10.65		54.15	63.50
3850	1" size		23	.348		51	11.55		62.55	73.50
3860	1-1/2" size		20	.400		88	13.30		101.30	117
3870	2" size		17	.471		118	15.65		133.65	154
3880	3" size	Q-1	24	.667		249	19.95		268.95	305
3920	4" size	"	20	.800		335	24		359	400
3930	For CPVC, flanged, add					40%	15%			
4340	Polypropylene, threaded									
4360	1/2" size	1 Plum	26	.308	Ea.	25	10.25		35.25	43
4400	3/4" size		25	.320		29	10.65		39.65	48
4440	1" size		23	.348		37.50	11.55		49.05	58.50
4450	1-1/2" size		20	.400		72.50	13.30		85.80	100
4460	2" size		17	.471		91	15.65		106.65	124
4500	For polypropylene flanged, add					200%	15%			
4850	Foot valve, PVC, socket or threaded									
4900	1/2" size	1 Plum	34	.235	Ea.	36.50	7.80		44.30	52
4930	3/4" size		32	.250		41.50	8.30		49.80	58
4940	1" size		28	.286		54	9.50		63.50	74
4950	1-1/4" size		27	.296		104	9.85		113.85	129
4960	1-1/2" size		26	.308		104	10.25		114.25	130
4970	2" size		24	.333		120	11.10		131.10	149
4980	3" size		20	.400		287	13.30		300.30	335
4990	4" size		18	.444		505	14.80		519.80	580
5000	For flanged, add					25%	10%			
5050	CPVC, socket or threaded									
5060	1/2" size	1 Plum	34	.235	Ea.	64.50	7.80		72.30	83
5070	3/4" size		32	.250		78	8.30		86.30	98.50
5080	1" size		28	.286		92	9.50		101.50	115
5090	1-1/4" size		27	.296		129	9.85		138.85	157
5100	1-1/2" size		26	.308		150	10.25		160.25	181

15110 | Valves

Description	Crew	Daily Output	Labor-Hours	Unit	2000 Bare Costs Mat.	2000 Bare Costs Labor	2000 Bare Costs Equip.	2000 Bare Costs Total	Total Incl O&P	
2" size (R15100-090)	1 Plum	24	.333	Ea.	193	11.10		204.10	230	500
3" size		20	.400		365	13.30		378.30	420	
4" size		18	.444		790	14.80		804.80	890	
For flanged, add					25%	10%				
Needle valve, PVC, threaded										
1/4" size	1 Plum	26	.308	Ea.	32	10.25		42.25	50.50	
3/8" size		26	.308		37	10.25		47.25	56	
1/2" size		26	.308		37	10.25		47.25	56	
For polypropylene, add					10%					
Y check, PVC, socket or threaded										
1/2" size	1 Plum	26	.308	Ea.	52.50	10.25		62.75	73	
3/4" size		25	.320		56.50	10.65		67.15	78	
1" size		23	.348		62	11.55		73.55	85.50	
1-1/4" size		21	.381		97	12.65		109.65	126	
1-1/2" size		20	.400		105	13.30		118.30	136	
2" size		17	.471		131	15.65		146.65	169	
2-1/2" size		15	.533		277	17.75		294.75	330	
3" size	Q-1	24	.667		260	19.95		279.95	315	
4" size	"	20	.800		455	24		479	535	
For PVC flanged, add					45%	15%				
Y sediment strainer, PVC, socket or threaded										
1/2" size	1 Plum	26	.308	Ea.	29.50	10.25		39.75	48	
3/4" size		24	.333		32	11.10		43.10	52.50	
1" size		23	.348		39	11.55		50.55	60.50	
1-1/4" size		21	.381		64.50	12.65		77.15	90	
1-1/2" size		20	.400		67.50	13.30		80.80	94.50	
2" size		17	.471		78.50	15.65		94.15	110	
2-1/2" size		15	.533		192	17.75		209.75	238	
3" size	Q-1	24	.667		192	19.95		211.95	241	
4" size	"	20	.800		320	24		344	385	
For PVC, flanged, add					55%	15%				
VALVES, SEMI-STEEL (R15100-090)										600
Lubricated plug valve, threaded, 200 psi										
1/2" pipe size	1 Plum	18	.444	Ea.	61.50	14.80		76.30	90	
3/4" pipe size		16	.500		61.50	16.65		78.15	92.50	
1" pipe size		14	.571		79	19		98	116	
1-1/4" pipe size		12	.667		95	22		117	139	
1-1/2" pipe size		11	.727		102	24		126	149	
2" pipe size		8	1		120	33.50		153.50	183	
2-1/2" pipe size	Q-1	5	3.200		186	96		282	350	
3" pipe size	"	4.50	3.556		228	106		334	410	
Flanged, 200 psi										
2" pipe size	1 Plum	8	1	Ea.	145	33.50		178.50	211	
2-1/2" pipe size	Q-1	5	3.200		218	96		314	385	
3" pipe size		4.50	3.556		264	106		370	450	
4" pipe size		3	5.333		335	160		495	610	
5" pipe size		2.50	6.400		500	192		692	840	
6" pipe size	Q-2	3	8		655	248		903	1,100	
8" pipe size		2.50	9.600		1,125	298		1,423	1,700	
10" pipe size		2.20	10.909		1,725	340		2,065	2,400	
12" pipe size		1.70	14.118		2,975	440		3,415	3,925	
VALVES, STEEL (R15100-090)										
[illegible]										
Check valve, swing type, 150 lb., flanged										
2" size	1 Plum	8	1	Ea.	465	33.50		498.50	565	

APPENDIX F

Pressure in PSIA

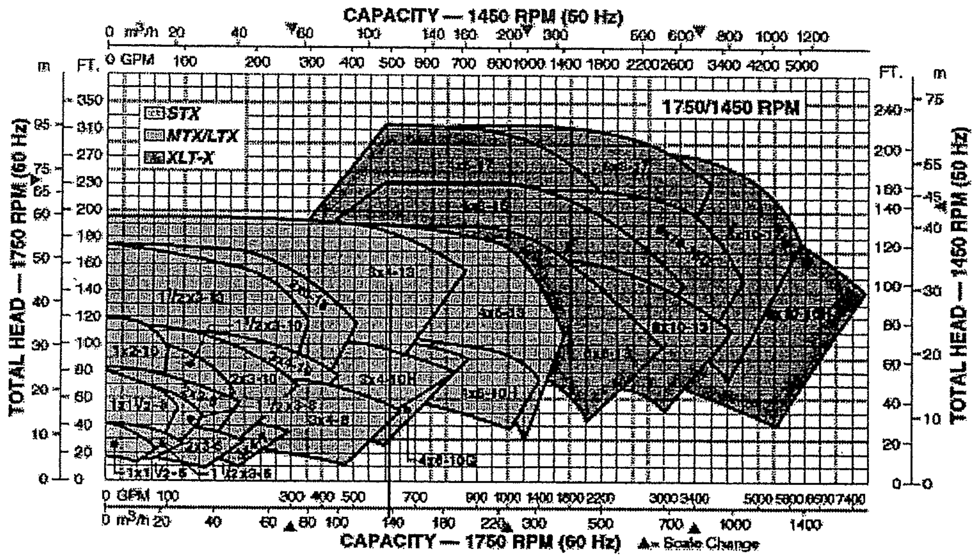


APPENDIX G

Goulds Pumps | Industrial Pumps

ITT Industries
Engineered for life

Previous Page



50 Hz 1480 RPM	60 Hz 1780 RPM
1X1.5-6-Alloy	1X1.5-6-Alloy
1x1.5-6-Iron	1X1.5-6-Iron
1.5X3-6	1.5X3-6
2x3-6-Alloy	2x3-6-Alloy
2x3-6-Iron	2x3-6-Iron
1x1.5-8-Alloy	1x1.5-8-Alloy
1x1.5-8-Iron	1X1.5-8-Iron
1.5X3-8-Alloy	1.5X3-8-Alloy
1.5X3-8-Iron	1.5X3-8-Iron
2X3-8-Alloy	2X3-8-Alloy
2X3-8-Iron	2X3-8-Iron
3x4-7	3x4-7
3X4-8	3X4-8
3X4-8G	3X4-8G
1X2-10-Alloy	1X2-10-Alloy
1X2-10-Iron	1X2-10-Iron
1.5X3-10-Alloy	1.5X3-10-Alloy
1.5X3-10-Iron	1.5X3-10-Iron
2X3-10	2X3-10
3x4-10	3X4-10
3X4-10H	3X4-10H
4X6-10	4X6-10
4X6-10H-Alloy	4x6-10H-Alloy
4x6-10H-Iron	4x6-10H-Iron
4X6-10G	4X6-10G
1.5x3-13-Alloy	1.5x3-13-Alloy
1.5x3-13-Iron	1.5x3-13-Iron
2X3-13	2X3-13
3x4-13	3x4-13
4X6-13	4X6-13
6X8-13	6X8-13
8x10-13	8x10-13
6X8-15	6X8-15
8X10-15	8X10-15G
8X10-15G	8x10-16H

USL

Goulds Pumps

ITT Industries

CENTRIFUGAL PUMP CHARACTERISTICS

RPM 1770 CDS 5381

Model: 3196

Size: 4X6-10G

Imp. Dwg. C06088A

Pattern 1E645

Eye Area 25.97 in^2