4-88 PC
REV. 3 1 58

AUTHORITY FOR EXPENDITURE

CAPITAL

Department Petrochemical *Auth. No.* 1-34-

Authority is requested to expend (Show Cash and Warehouse Outlay Amount) $ 29,000

For Low Pressure Condensate Recovery System

Location VCM Plant - Westlake, Louisiana

Reason (Explain Fully)

Presently, condensate from ten users is being discharged to the sewer. In addition to the loss of 34,558 pounds per hour of condensate, the present mode of operation causes corrosion of the concrete paving and is hazardous, particularly during cold weather when the possibility of icing and fog exists.

A condensate recovery system, consisting of collection headers, a flash drum, steam condenser and return pump, will recover the condensate. Some of the condensate is obtained from heaters and reboilers which have corrosive material (HCl) on the process side at a higher pressure than the condensate. To protect the boiler plant in the event of a leak in any of these exchangers, a conductivity cell will be placed in the condensate flash drum. The cell will detect the presence of small amounts of HCl, shut down the return pump, and empty the condensate flash drum to the sewer.

The value of the recovered condensate (less operating cost) is approximately $10,500 per year. The $29,000 investment will yield a 19 percent DCF return based on a ten year life and straight line depreciation.

In addition to the economic advantages, this project will reduce outfall temperature thereby reducing our thermal pollution problem.

Signed: R. H. Gerlach
R. H. Gerlach
Chief Process Engineer

Approved: L N Vernon
L. N. Vernon
Plant Manager

Distribution: MBM-MPL-TWS-RWG-GBM-LNV

SUMMARY OF ESTIMATED COST	OTHER MATERIAL ON HAND		CASH AND WAREHOUSE OUTLAY	
Material: Air Cooled Condenser, 1027 gallon tank, 25 HP pump, Collection headers, Auxilliary Piping, Valves and Instrumentation.			$20	200
bor for Installation:			$ 8	800
TOTALS			$29	000
GRAND TOTAL			$29	000

Is this project provided for in Current Budget? Yes
If so in what amount $ 29,000 *Project No.* V-8
If not show contingency or allocated project number

DISTRIBUTION

Investment *Material*		
Investment *Intangibles*		
Total	$29	000
Expense		
Grand Total	$29	000

Date August 22, 1969

Calculations Correct W. L. Smith

Signed

Signed

Approved: Date

CCR 000007990

Auth No. 1-34-

JPM

LOW PRESSURE CONDENSATE SYSTEM

Process Description

The low pressure condensate recovery system will collect steam condensate from the following services (gaseous steam is collected from the oxy blowdown drum):

1.	EDC Tar Stills	S-104 A & B
2.	Vinyl Tar Stills	S-208 A & B
3.	R-304 Feed Heater	H-304
4.	Oxy Vent Heater	H-310
5.	Oxy Blowdown Drum	S-311
6.	HCl Feed Heater	H-309
7.	Ethylene Feed Heater	H-308
8.	HCl Evaporation	S-210 A & B
9.	HCl Reboiler	H-205

In addition to these services, we plan later to tie-in the condensate that drains from the R-304 steam vent line plus the bleed stream from the propylene K.O. drum plate coils.

The condensate is collected in a 1028-gallon drum (S-612) that is connected to a 15 H.P. air cooled heat exchanger (H-612). The heat exchanger condenses any flashed condensate in addition to the steam coming from the oxy blowdown drum. A small bleed is provided on the tube side of this exchanger to remove any inert gases that are trapped in this system. These inerts can cause corrosion or gas blinding of the exchanger. The level in the condensate drum is automatically controlled by a local controller. The collected condensate is then pumped, on level control, into the steam plant condensate return line for reuse. A pump recycle restriction orifice is provided to prevent the pump from overheating during low load operation.

The system is designed to handle 43,500 lbs./hr. condensate. The condenser is designed to handle 7200 lbs./hr. of flashed condensate and has a 7,000,000 BTU/hr. duty. Under normal conditions there will be 30,660 lbs./hr. of condensate, and the condenser will handle 5572 lbs./hr. of flashed steam. The flow to the steam plant condensate return line will be 64 gpm.

A separate condensate collection line is run from the HCl feed heater (H-309) to the condensate drum to eliminate freezeup problems which could occur if its condensate did not drain properly. Condensate collection pots are installed in the condensate lines from the oxy vent heater (H-310) and the HCl evaporators (S-210 A&B) because of similar freezeup problems. A separate line is run from the oxy blowdown drum to the condensate drum to handle the steam flow from this drum.

As a precaution against possible condensate contamination by HCl system leaks, a conductivity probe is mounted in the condensate collection drum. The board-mounted conductivity meter reads 100 micromho's full scale. As a point of reference, distilled water has a conductivity of about 2 micromho's. For each ppm of dissolved salts the conductivity will rise about 2 micromho's; a ppm of HCl will raise the conductivity about 5 micromho's. Readings on this meter normally show a conductivity of 10 micromho's which represents about 5 ppm dissolved salts - this is considered to be good quality condensate. If the conductivity exceeds 30 micromho's, an alarm will sound, a dump valve on the condensate drum will automatically open emptying its contents to the sewer, and the condensate pump (P-610) will be shutdown. In the event that this occurs, the system will have to be manually restarted. Any conductivity reading that is "on-scale" will probably be good; any salt or HCl leak will probably "peg" the meter causing the dump valve to open. To prevent the condensate pump from cavitating under low level conditions, a low level sensing switch has been installed. This switch will shut down the condensate pump; the pump must be manually restarted if this occurs.

To provide protection against either high drum pressure or a high liquid level, a 3" loop seal pipe has been installed. In either case condensate will overflow through the loop seal into the sewer (steam will not vent out of this loop seal because its inlet at the condensate drum is extended to within a few inches of the drum's bottom).

One possible operating problem that can occur in this system is at the oxy blowdown drum (S-311). This drum collects the hot blowdown water from the oxy reactors' steam drums and flashes off low pressure steam which is piped to the condensate recovery system. The remaining blowdown water is manually drained to the sewer. If this drain is closed, the drum will fill up with liquid causing contaminated water to flow into the condensate system which will cause a high conductivity reading.

JDM

Conoco
Petrochemicals

CONTINENTAL OIL COMPANY
PETROCHEMICAL DEPARTMENT, V.C.M. PLANT
P. O. BOX 605, WESTLAKE, LOUISIANA 70669
PHONE: 318-433-6311

September 8, 1969

Mr. George Furgeson
Placement Director
Louisiana State University
College of Engineering
Baton Rouge, Louisiana

Sir:

The enclosed project entitled "Low Pressure Condensate System" has been successfully completed by Mr. John C. Lunn, Jr. during his employment at the VCM Plant of Continental Oil Company. The project has been reviewed by the plant management and is now approved for construction. It is expected that work on this project will start in late October and, hopefully, will be completed by the end of 1969.

We consider the report to be a good, complete study and design project and recommend that it be accepted as proof of completion of Chris' Engineering Practice Number 149 course.

Very truly yours,

John D. Minott

John D. Minott
Sr. Process Engineer
Continental VCM Plant

JDM-MC
cc: Mr. R. H. Gerlach
Attachment

Conoco
Petrochemicals

CONTINENTAL OIL COMPANY
PETROCHEMICAL DEPARTMENT, V.C.M. PLANT
P. O. BOX 605, WESTLAKE, LOUISIANA 70669
PHONE: 318-433-6311

August 29, 1969

Mr. George Furgeson
Placement Director
Louisiana State University
College of Engineering
Baton Rouge, Louisiana

Dear Sir:

The final design of the low pressure condensate system was completed August 29, 1969. The completed project is attached to this letter for approval by the College of Engineering. A summary of the steps used in the design of this system is also attached.

Because of Continental Oil Company's licensing agreement with Stauffer Chemical Company detailed descriptions of other projects are not permitted. However, general descriptions of some summer projects are presented as follows:

1. Design of a breather valve and vent line system for a storage tank (drawing attached).
2. Design of a nitrogen purge system on a relief vent (drawing attached).
3. Revision of a condensate system for a column. Specification of line sizes, pumps, condenser, and instrumentation was necessary. Condenser revision cost was also estimated.
4. Design and cost estimation of a caustic wash and decanting system. Design included specification of mixers, piping, tanks and instrumentation.
5. Study of the justification of a spare reactor.
6. Reranging flow meters.

7. Study of the percentage loading capacity for rail cars used for product shipment. Calculation of expansion factors.

8. Data collection and plotting of a chart giving the operating conditions of the oxychlorination reactors in the VCM Plant.

9. Design, justification, and cost estimation of a column feed preheater for the 1970 capital budget.

10. Collection of plant data for exchange with a similar Japanese VCM plant.

11. Visit to Continental's Ponca City, Oklahoma operations. Included tours of Process Engineering Group, Central Engineering, Maintenance Engineering, Refinery Process Engineering, and Petrochemical Research and Development.

Other summer work consisted of general plant process engineering similar to the above projects. I hope this summary is satisfactory for completion of Engineering Practice 149.

Very truly yours,

John C Lunn Jr.

John C. Lunn, Jr.
Chemical Engineering-4
Student No. 438-74-0886

JCL-MC
cc: RHG-JDM-DKP
Attachment

Low Pressure Condensate Design Outline

The basis of design for the low pressure condensate system is to recover condensate which is presently being lost to the sewer. Actual operating pressures on the various steam users were too small to allow the use of the existing condensate system.

The steps followed in justification and design of the low pressure condensate recovery system are presented as follows:

1. Justification

A survey was made to determine the amount of condensate being lost to the sewer. From plant cost, a value was placed on the condensate loss for one year. Using a discounted cash flow (DCF) of 18%, a justifiable investment was calculated. The design cost of the condensate recovery system was required to stay under this value.

2. Piping layout

The next step in the design was to locate each unit and make a rough piping and equipment layout. These approximate dimensions were used in line sizing.

3. Preliminary Flowsheet

A preliminary flowsheet including material and energy balances was then prepared to be used in line sizing.

4. Line Sizing

Using the method of Chenoweth and Martin for two-phase flow (Pet. Ref.-1955), the various condensate headers were sized. Sizing began at the condensate drum. Line sizes were calculated to keep the pressure drops below the operating pressures of the various steam users. Lines were sized assuming all horizontal pipe, all condensate flashed to atmospheric pressure, and 10% greater flows than original plant design.

5. Equipment Specifications

The next step was to size and specify the major pieces of equipment. This included specification of a pump, an air-cooled condenser, a condensate drum and the various instruments used to control liquid levels.

6. Alarm System

Because of the possibility of acid leaks into the condensate system, a conductivity alarm system was specified. A conductivity probe is located in the condensate drum. Upon detection of a leak, a control room alarm will sound, the condensate return pump will shut down and an automatic dump valve will empty the condensate to the sewer.

7. Flowsheet

A detailed flowsheet was then prepared.

8. Equipment Prices

Quotations for the larger pieces of equipment (condenser, alarm, and pump) were then obtained to insure remaining within the justified investment limit.

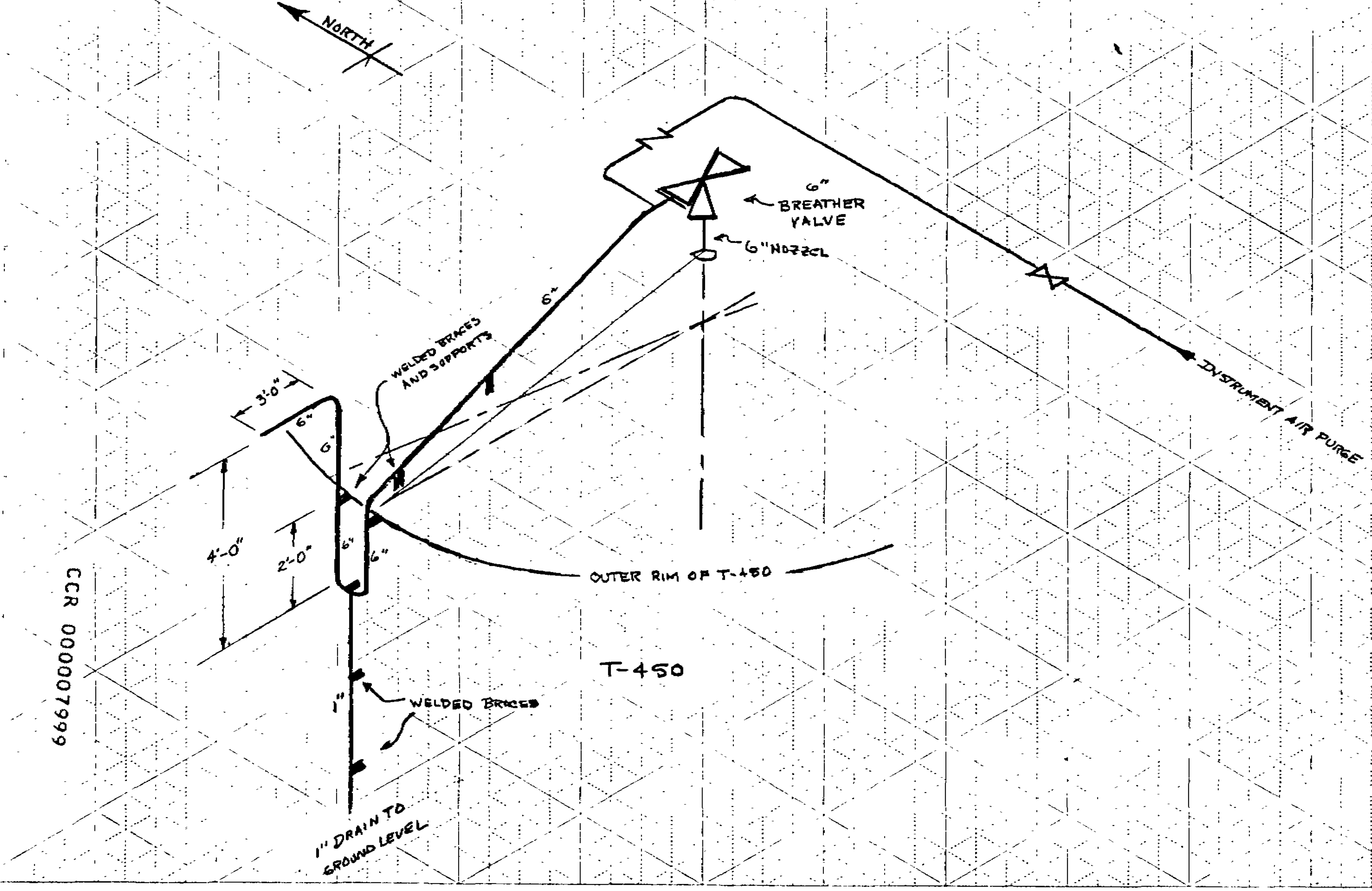
9. Work List

A work list was then made outlining the steps to be taken to install the low pressure condensate recovery system.

10. Cost Estimate

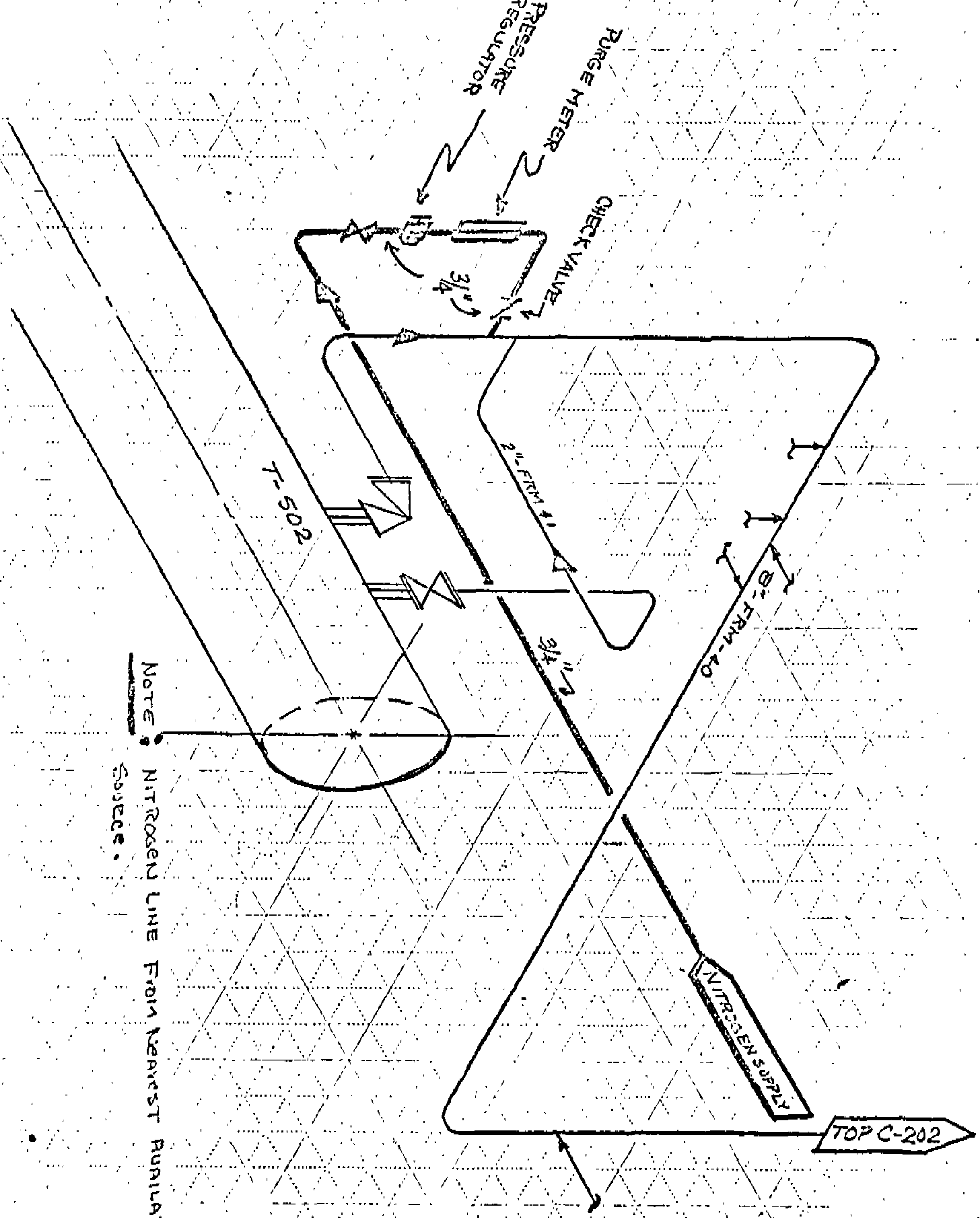
A final cost estimate was then made for the system and a DCF was calculated. The design was then submitted to the plant Senior Process Engineer and Chief Process Engineer for approval. Following approval an AFE (Authority for Expenditure) was written and the design turned over to the plant Mechanical Department for construction.

BREATHER VALVE AND VENT LINE FOR T-450



17 July 69

2. N_2 PURGE SYSTEM



NOTE: NITROGEN LINE FROM NEAREST AVAILABLE SOURCE.

FROM SPOOL DRAWING No. LC 203-14

7/15/

LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION ⑥

$W = 1400$ lbs/HR　　$W + 10\% W = 1540$ lbs/HR

$\omega = 0.39$ lbs/SEC　　$\omega + 10\% \omega = 0.43$ lbs/SEC

$Q = 473{,}900$ Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1400 \\ 1150.4x + 180.07y = 473{,}900 \end{cases}$$

$$x = \frac{(473900) - (1400)180.07}{970.33}$$

VOLUME

$x = 228.6 \times 26.8 = 6126$

$y = 1171 \times 0.01672 = 19.6$

TOTAL $= 6145.6$

$\left.\begin{matrix} 19.6 \\ 6145.6 \end{matrix}\right\} = \text{LVF} = 0.0032$

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
2"	1.67×10^4	0.0070	3.64×10^5	0.0050
3"	1.12×10^4	0.0075	1.6×10^5	0.0047

MADE BY J
CHECKED BY
DATE
PAGE 1 OF 3

CONTINENTAL OIL COMPANY
CALCULATION SHEET

TITLE

JOB NO.

* TWOPHASE FLOW – METHOD OF CHENOWETH AND MARTIN PET. REF FIELD OCT-1955

STATE

13-231-P8

⑦ PIPE DIAMETER	2"		3"			
LENGTH 320	L/D = 1858		L/D = 1251		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALVES L/D = 13						
7 ELBOWS (90°) L/D = 30	3.64	53.7	3.50	70.5		
TEE (RUN) L/D = 20						
TEE (BRANCH) L/D = 60						
OTHER						
SW 2×3	0.30	2				
TOTAL	3.94	55.7	3.50	70.5		
TOTAL + EQ. LENGTH		376		391		

CONTINENTAL OIL COMPANY
CALCULATION SHEET

MADE BY
CHECKED BY
DATE
PAGE 2 OF 3
TITLE
JOB NO.
FIELD
STATE

④ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
2''	ψ_G	$(0.0050)(1853) + 3.94 =$	13.23	x 1603 =	1255	140
	ψ_L	$(0.0070)(1858) + 3.94 =$	16.9			
3''	ψ_G	$(0.0047)(1251) + 3.5 =$	9.38	x 1603 =	1167	140
	ψ_L	$(0.0075)(1251) + 3.5 =$	12.88			
	ψ_G	$(\quad)(\quad) + \quad =$		x 1603 =		
	ψ_L	$(\quad)(\quad) + \quad =$				

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
2''	$\frac{2.25 \times 10^{-7} (0.007)(376)(1540)^2}{(37.72)} =$	0.037	x 140 =	5.18
USE → 3''	$\frac{2.25 \times 10^{-7} (0.0075)(391)(1540)^2}{(271.8)} =$	0.0058	x 140 =	0.81
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		x =	

CONTINENTAL OIL COMPANY
CALCULATION SHEET

13-231-PS

MADE BY
CHECKED BY
DATE
PAGE 3 OF 3
TITLE
JOB NO.
FIELD
STATE

SUBJECT R-304 STEAM CONTROL VALVE

DATE 25 AUG 70

1-51X3

TO

DEBS GAMBLIN

~~RICH GERLACH~~ — J Day

FROM

JC LUNN, JR

Dept.

MEMO

EXISTING VALUE: FISHER SINGLE PORT DESIGN "A" BODY V-PUP VALVE PLUG

4" BODY 4" PORT C_V MAX = 270

@ 16# DRUM PRESSURE — MAX FLOW: 15325 lbs/HR.

NEW VALUE: FISHER SINGLE PORT DESIGN "A" BODY V-PUP VALVE PLUG

6" BODY 6" PORT C_V MAX = 600

@ 16# DRUM PRESSURE — MAX FLOW: 34056 lbs/HR.

SIGNED

REPLY

DATE

SIGNED

FILE AND FOLLOW-UP COPY

QUOTATION

GOULDS PUMPS

CENTRIFUGAL PUMP

REPLY TO:
GOULDS PUMPS, INC.
5828 Star Lane, P. O. Box 25146
Houston, Texas 77005
Ph: 713 - 782-7530

All quotations subject to terms and conditions on the reverse side and expire unless accepted within 30 days from date of quotation. All quotations subject to change with or without notice.

FORM 57911

To: Continental Oil - VCM Plant
P.O. Box 3605
Westlake, La. 70669

Date: 9-26-69
Page: 1 of 2
Proposal No.: 69-9-716XK
Revision No.:

Attention: Betty Peloquin
Inquiry Date:
Inquiry No.: Verbal/Betty
Item No.:

Copies:	
Continental Oil	(3)
Hosea	(1)

In answer to your inquiry, we propose to furnish GOULDS PUMPS as described below:

CONDITIONS OF SERVICE —

LIQUID Steam Condenaate-Water

G.P.M.	100	T.D.H.	313'	Disch. Press.	131.5	Suct. Press	3.32
Suct. Lift		Pumping Temp.	212°F	Sp. Gr. @ 60°F.		Sp. Gr. @ P.T.	0.96
Visc. @ P.T.	0.3 CP	Vapor Press.@P.T.		N.P.S.H. Avail.	7	N.P.S.H. Req'd.	5.5
ph value		Abrasives		Solids, %		Solids size	

PUMP DESCRIPTION —

QUANTITY	One	Case	CI	Lubrication	Grease	Efficiency	50%
MODEL	3755	Impeller	CI	Bedplate	CI	B.H.P. @ Rating	15.2
Size	1½x2-9	Shaft	Steel	Coupling	Falk	Max. B.H.P.	19.5
Group	M	Wearing Rings	CI	Direction of Rotation from		IMPELLER DIAMETER:	
Stages	One	Shaft Sleeves	CI	Coupling End	CW	Approx. @ Rating	9 1/4
For detailed specifications see Bulletin			715.1	Performance Curve	I141-2	Min. / Max.	6 7/8 / 9 7/8

DRIVER —

H.P.	20	R.P.M.	3500	Phase/Cycles	3/60	Volts	230/460
Enclosure	TEFC	Insulation	B	Frame	256T	Furnished by	Goulds

UNIT PRICES —

PRICES ARE F.O.B., SENECA FALLS, N.Y.

	$	Weight, pounds:
PUMP, BEDPLATE and COUPLING	384.00	338
Packed Pump		
DRIVER	248.00	250
FREIGHT (estimated)	30.00	
TOTAL UNIT PRICE	$662.00	TOTAL WEIGHT 588

SHIPMENT: 10 weeks after complete engineering and manufacturing information and full approval to proceed with work.

TERMS: 30 DAYS NET

Extra for oil lubrication--------------------------$40.00

The following outside equipment not of our manufacture is subject to the same percentage of price increase as may be made by our supplier to us - "MOTORS".

CCR 000008005

BULLETIN 725.1

November 28, 1968 • Sup. Bul. 1-31-66

GOULDS

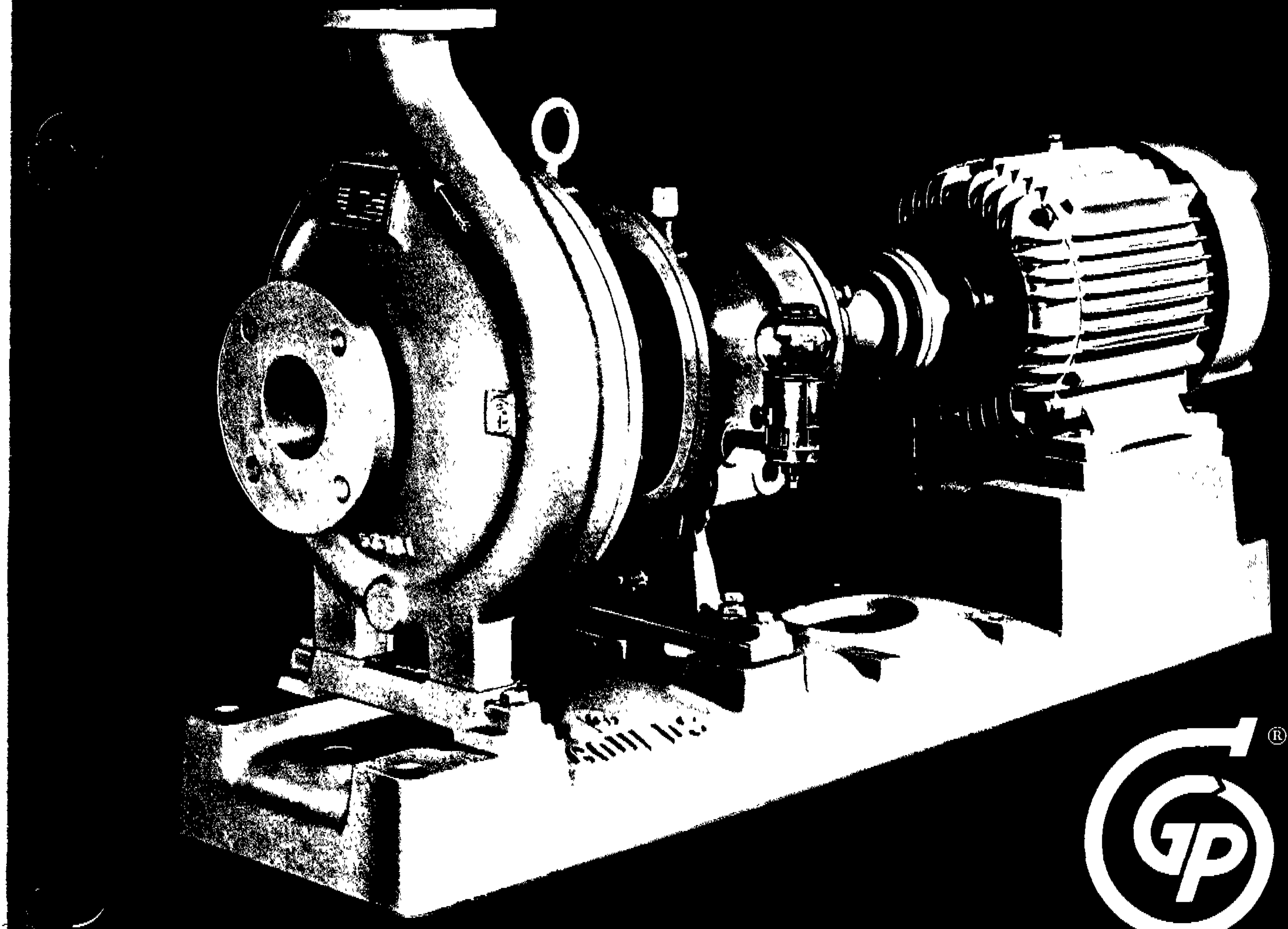
STANDARD DIMENSION PROCESS PUMPS

For Industry:

- ***CHEMICAL***
  PETROCHEMICAL
  PULP and PAPER
  PRIMARY METALS
  GENERAL SERVICE APPLICATIONS

RANGE OF COVERAGE

Capacity	**5 to 1,600 GPM**
Head	**10 to 750 feet TDH**
Temperature	**—350° t + 500° F.**
Working Pressure	**0 PSIA to 375 PSIG**



GOULDS PUMPS, INC., SENECA FALLS, N. Y.

GOULDS PUMPS & STANDARDIZATION

Goulds offers you:

1. **The most complete and experienced line of standard dimension chemical pumps;**
2. **Thousands of sizes and models of other pumps to fill your many requirements —** double suction pumps, vertical pumps, glassed pumps, multi-stage pumps, centripetal pumps and heavy duty process pumps.

Over six years ago, Goulds introduced a line of standard dimension process pumps for the chemical and allied industries. The design of this line provided both flexibility and interchangeability within the framework of practical standardization.

User acceptance of the Goulds design stimulated the forces interested in the benefits of pump standardization into action. American Voluntary Standards by a number of pump manufacturers developed.

Today thousands of Goulds "standardized" chemical pumps are in service. It is Goulds intent to continue to be a leader in this effort by providing users not only with the most experience but . . . the most practical design . . . quality . . . and service!

Note the table below. You will see that in regard to the standard dimension pumps that Goulds gives you maximum hydraulic coverage beyond that recommended by AVS . . . all conforming to AVS dimensional specifications.

American Voluntary Standard Designations and Length	Goulds STD Model Number	Goulds Basic Standard Units	Goulds Bonus Alternate 3196 Units
AA-17½	3197	1 x 1½-6	1 x 2-6*
AB-17½	3197	1½ x 3-6	1½ x 3-6*
A05-23½	3196	1 x 2-8	
A10-23½	3196	2 x 3-6	
A20-23½	3196	1½ x 3-13	
A30-23½	3196	2 x 3-13	
A40-23½	3196	3 x 4-13	
A50-23½	3196	1½ x 3-10	1½ x 3-8☐
A60-23½	3196	2 x 3-10	2 x 3-8☐
A70-23½	3196	3 x 4-10	3 x 4-8☐ and 3 x 4-8G☐
▲ A75-23½	3196	4 x 6-10	
▲ A80-23½	3196	4 x 6-13	

☐These bonus alternates are dimensionally interchangeable with the corresponding Goulds Basic Units.

*These alternates allow complete standardization with 23½" sizes.

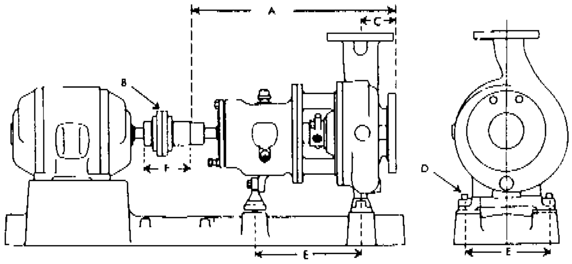
▲ Goulds recommendation for AVS adoption.

GOULDS Model STD

DIMENSIONAL INTERCHANGEABILITY

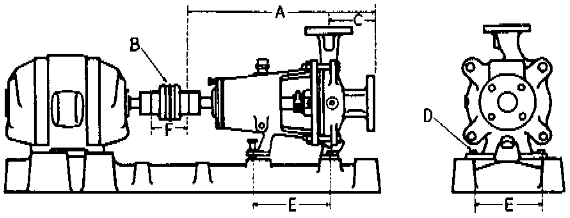
Shown below are the constant dimensions that apply to both the 23½" and 17½" standardized chemical pumps. Goulds concept of maximum dimensional interchangeability is the "design key" to the interchangeability and flexibility benefits that users obtain with pump standardization.

Model 3196-STD
23½ INCHES LONG ALL 16 SIZES



A ONE length for all sizes—23½"
B ONE coupling for all sizes—1⅛"
C ONE dimension end of suction to centerline of discharge—4"
D ONE bolt size to hold to base—½"
E ONE bolt spacing
F ONE spacer coupling length for all sizes—3½"

Model 3197-STD
17½ INCHES LONG 2 SIZES



A ONE length for 2 sizes—17½"
B ONE coupling for 2 sizes—⅞"
C ONE dimension end of suction to centerline of discharge—4"
D ONE bolt size to hold to base—½"
E ONE bolt spacing
F ONE spacer coupling length for 2 sizes—3½"

GOULDS GIVES YOU MAXIMUM FLEXIBILITY BETWEEN BOTH PUMPS AND PUMP PARTS

In addition to bonus sizes in the Model 3196-STD, Goulds gives you a choice of bearing frame and shaft arrangements. You can mount pump ends on S, M and L bearing frames with corresponding 1¼", 1¾" and 2⅛"shafts, or all pump ends on one frame. This flexibility provides for selection on the basis of an economic evaluation as well as these other necessary considerations: technical design, plant inventory, future system changes, and maintenance requirements. Evaluation of all these factors will lead to a sound selection by the process engineer. Goulds allows the process engineer to make the *choice,* the *best choice* for his company.

PUMPS offer maximum user benefits

THE GOULDS LINE ALLOWS A "CUSTOM FIT" STANDARDS PROGRAM FOR YOUR COMPANY

The minimum "AVS" offerings shown below may not always provide the best coverage or efficiency to meet *your* company's needs. Goulds, therefore, offers you a bonus of additional sizes. This allows you to custom tailor a select number of sizes that will give you both minimum parts inventory and maximum hydraulic efficiency . . . all within "AVS" dimensional standardization.

17½" STANDARD SIZES

23½" BASIC STANDARD SIZES

23½" BONUS STANDARD SIZES

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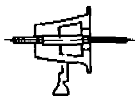
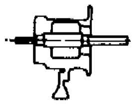
Dimensions	19-20





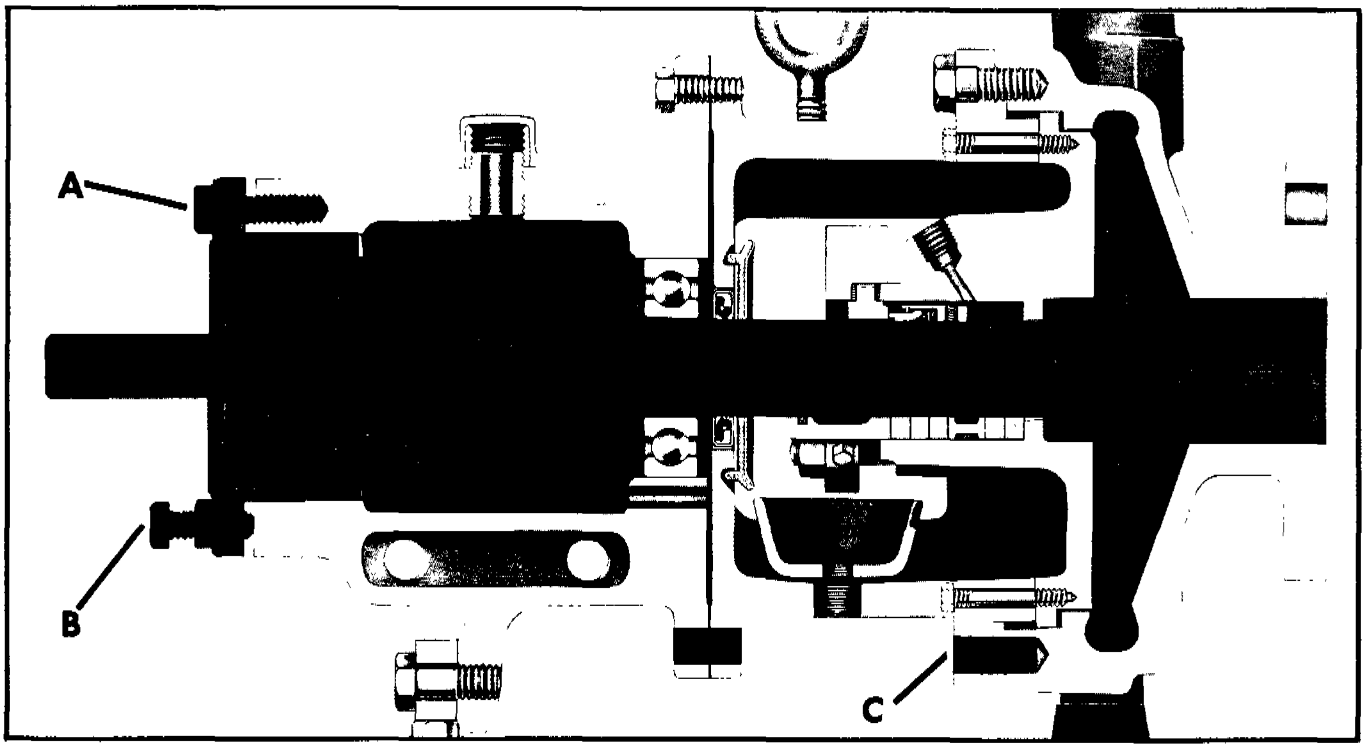
	3197-STD • 17½" Long	3196-STD • 23½" Long	BASIC AND BONUS 23½" SIZES FIT ONE BEARING FRAME/SHAFT
AA	1 x 1½-6		1 x 2-6
AB	1½ x 3-6		1½ x 3-6
A05		1 x 2-8	
A10		2 x 3-6	
A20		1½ x 3-13	
A30		2 x 3-13	
A40		3 x 4-13	
A50		1½ x 3-10	1½ x 3-8
A60		2 x 3-10	2 x 3-8
A70		3 x 4-10	3 x 4-8G 3 x 4-8
▲ A75		4 x 6-10	
▲ A80		4 x 6-13	

▲ Goulds recommendation for AVS adoption.

STANDARDIZE ON 23½" SIZES FOR OPTIMUM STANDARDIZATION

The American Voluntary Standards established eight 23½" and two 17½" pumps to cover the full range of temperature, head and pressure requirements. Goulds gives you the plus benefit of completely covering and far exceeding this range with sixteen 23½" sizes . . . one bearing-shaft unit to handle *all* sizes. This is the optimum in pump standardization that offers users maximum benefits.

THE PROVEN DESIGN FEATURES OF GOULDS MODEL STD



MAINTAIN CONSTANT EFFICIENCY WITH GOULDS EASY EXTERNAL ADJUSTMENT

You do not need to disassemble pump to renew running clearances.

Impeller clearance is set by telescoping thrust bearing housing into the frame through a precision fit. This is all you do . . . it's simply a matter of minutes:

1. Use a common open-end wrench to loosen bolt "A" (top). Ease impeller assembly (shown in blue above) forward until it contacts casing.
2. Turn jacking bolt, "B" 1 flat, which backs up impeller establishing the proper running clearance.

With Goulds Model 3196-STD this is all there is to maintaining the correct clearance for constant NPSH and pump performance. You don't disturb gaskets or run the risk of damaging oil seals. Also, with no disassembly, downtime is kept to a minimum.

When it is consistent with routine maintenance, impeller clearances can easily be set on the power end "on the bench."

This method of external adjustment has been a feature of pumps Goulds has supplied for process applications for more than 25 years.

MAINTAIN POSITIVE ALIGNMENT WITH GOULDS PRECISION ALIGNERS

Precision aligners (shown lt. blue) align bearing frame, frame adapter, and casing.

Aligners are minimum tolerance-interference fit components. They eliminate the inherent misalignment caused by an accumulation of machining tolerances in a series of lock fits.

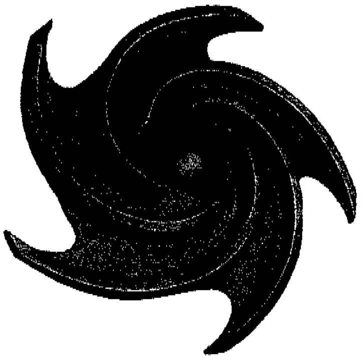
This is the same method of obtaining precision alignment that has long been used by the machine tool industry in the best grades of precision machinery . . . machines costing many thousands of dollars.

Aligner holes are bored and reamed in the same machine setup and at the same time as the critical bores in the part. Their position with respect to the bore is held to a tolerance of three-ten thousandths of an inch, and the diameter of the hole itself is held to within two-ten thousandths of an inch. The precision ground aligners are held to similar tolerances. There is never any question that any subsequent repair parts will always fit perfectly, and be in alignment.

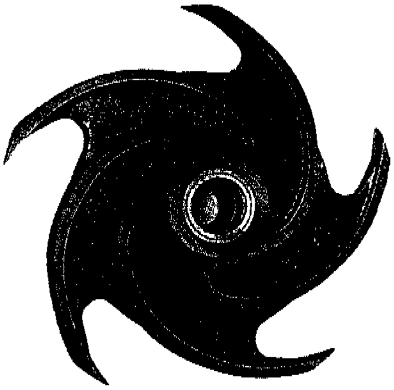
Aligners (C) are tapped for easy removal by standard cap screws.

Goulds precision aligners will save you time and money on pump disassembly and they assure "like new" alignment when you put a pump back in service after maintenance.

CCR 000008009



FULLY OPEN



THE IMPELLER DESIGN PROVEN BEST FOR CORROSIVE/ABRASIVE SERVICES

Impellers are fully open, with partial shrouds for maximum vane support. Large, smoothly contoured flow passages combine best slurry and solids handling ability, yet meet low NPSH requirements. The shearing action of the impeller vane on the casing wall prevents brakebanding.

Back pump-out vanes keep solids from behind the impeller and reduce pressure on the stuffing box.

This impeller design is first choice for corrosive/abrasive liquids because wear is distributed over the complete vane surfaces and the complete casing area swept by the impeller. Wear is not concentrated in a small close tolerance, high velocity area as it is with closed or semi-closed impellers. *Example:* A typical open impeller pump size $1\frac{1}{2}$ x 3- 10 will have a wear area of a 10 inch circle with a 3 inch circle out of the center on each side of the impeller.

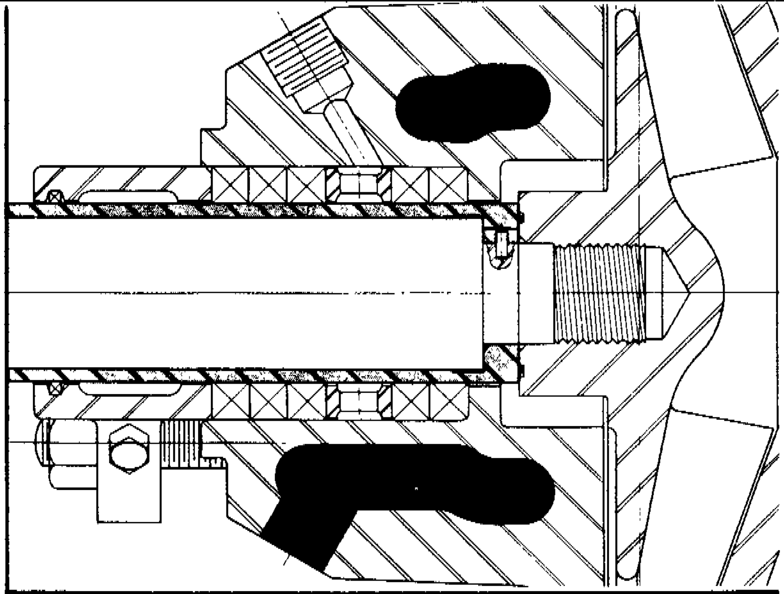
$$\textit{Area Formula} = \frac{II\,(D_1^2 - D_2^2)}{4}$$

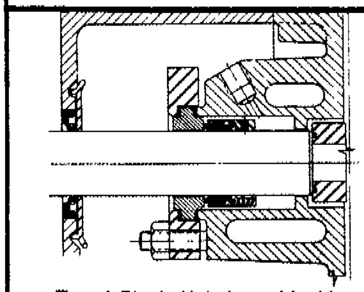
$$= .785\ (100\text{-}9)$$

$$= 71.5\ \text{in}^2\ \text{per side}$$

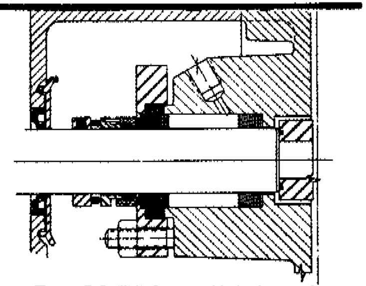
$$\text{Total Wear Area} = 143\ \text{in}^2$$

The same size closed impeller would have two 3 inch diameter wear rings or a total wear area of 28 in^2. The closed impeller would have approximately the same wear concentrated on $\frac{1}{5}$ the area. The open impeller, therefore, can take about 5 times more wear than a closed impeller before performance is reduced and NPSH requirements increased. Semi-open, or semi-closed, impellers with horizontal wear areas do not overcome the closed impeller design weakness of the close tolerance wear area.

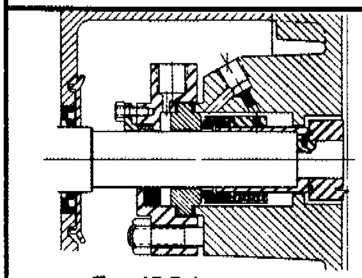




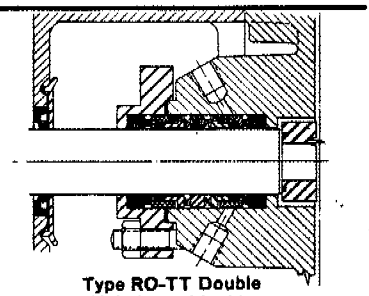
Type 9 Single Unbalanced Inside with Water Cooled Box



Type RO-TT Single Unbalanced Outside with Carbon Restricting Bushing



Type 9B Balanced Inside with Quench Style Gland



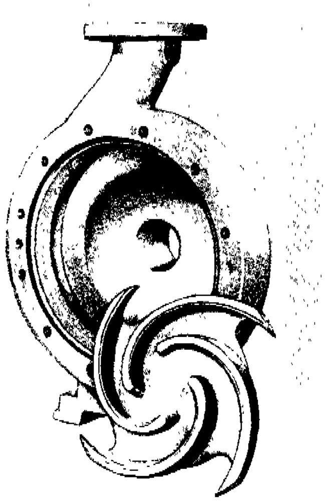
Type RO-TT Double Unbalanced Inside

OPTIMUM SHAFT SEALING AND COOLING ARRANGEMENT FLEXIBILITY

A wide variety of shaft sealing problems are encountered in practice. Many of these problems become apparent only after the pump is installed or after process changes are made. Therefore, a wide variety of sealing approaches must be available to the pump user. The following features show some of the flexibility available in Goulds model STD units.

1. Stuffing box fully machined and faced to accommodate either packing or mechanical seal. No machining required to convert in the field.
2. Jacketed box available for heating or cooling to maintain required stuffing box temperature.
3. Special shaft materials and hard facings for severe corrosion and abrasion problems.
4. Renewable hook-type shaft sleeve available. Sleeve can be supplied in special materials and inexpensively replaced. Stepped sleeve allows easy application of balanced seals.

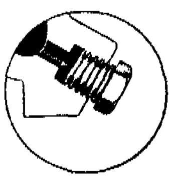
SPECIFICATIONS–GOULDS MODEL STD

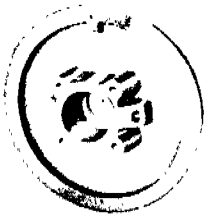


CASING AND IMPELLER

Top centerline discharge, self-venting casing, arranged for back pull-out. Fully confined gasket. Foot support under casing for maximum resistance to misalignment and distortion from pipe loads. ASA 150 lb. flanges standard, 300 lb. optional for working pressures to 375 PSI with ⅛″ corrosion allowance. For maximum corrosion-erosion resistance casing is supplied without tapped openings, but gage and gasketed drain plug openings are supplied when specified.

Impeller matched to casing for high efficiency and low NPSH. Fully open, has partial shrouds for maximum vane support without high thrust inherent in full shroud designs. Impeller is screwed on shaft, and threads are sealed by a Teflon O-ring. This eliminates projecting impeller nut and exposed threads from impeller eye. Smoothly contoured passages for good solids and slurry handling. All impellers statically balanced.





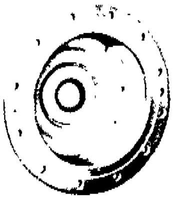
STUFFING BOX COVER

Stuffing box cover encloses back of casing, and contains stuffing box chamber. Cover is bolted to frame adapter so that a spare back pull out assembly can be stocked completely assembled. Cover can be supplied with jacket for cooling packing or seal in high temperature services. Jacket can also be used for heating when handling viscous or high freezing point liquids.

Packed box has 5 rings of packing and a lantern ring. Quench gland with quench water taps and an auxiliary ring of packing is standard. Gland is split, and can be completely removed for easy repacking. Tapped openings to the lantern ring permit "in and out" sealing, external flushing or lubrication as required.

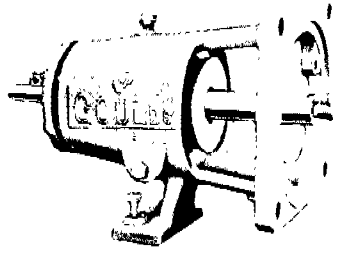
Stuffing box is completely machined for mechanical seal installation, either originally or as a field conversion. Inside, outside, double and balanced seals, with any required quench gland, restricting bushing and flushing line furnished to meet individual sealing problems. Gland completely confines stationary seat gasket.

Both packed box and mechanical seal can be used with either solid or sleeved shaft, depending upon application and user preference.

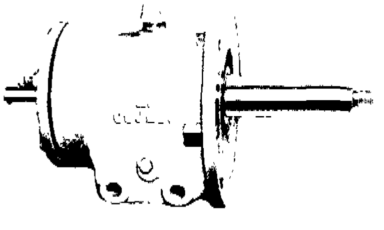


FRAME ADAPTER

Machined with precision aligners as reference, to keep bearing frame and casing in perfect alignment. Furnished with lifting eyebolt for ease in maintenance. Adapter houses stuffing box drip basin, non-sparking rotating deflector and inboard bearing oil seal. Either frame adapter or drip basin may be piped to drain. On Model 3197, adapter is integral with bearing frame.



Model 3197-STD



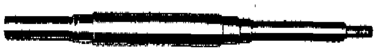
Model 3196-STD

BEARING FRAME, SHAFT AND BEARINGS

On Model 3196 the liquid end of the pump can be driven by any one of three pump shafts (1¼″, 1¾″, 2⅛″) with corresponding bearings (307, 309, 311) depending upon the severity of the process application. The over-all length of the pump (23½″) is the same for all combinations. The two sizes of Model 3197 have 1⅛″ shaft, and overall length of 17½″.

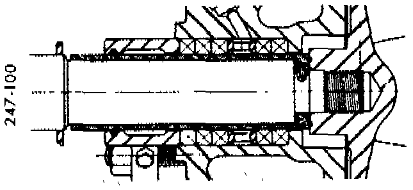
BEARING FRAME

Heavy cast iron construction with precision aligners to maintain alignment with frame adapter. Contains large oil reservoir, water jacketed. Oil level is maintained at proper level by means of a constant level oiler with visible oil supply. Oil breather vent fully protects oil from contamination while allowing for expansion or contraction of air caused by ambient temperature change. Model 3197 has frame adapter integral with frame, not water jacketed.



SHAFT AND SHAFT SLEEVES

Shaft is designed for .002″ maximum deflection at stuffing box face. All bearing and packing surfaces ground to less than 32 micro inches. Threads where shaft screws into impeller are sealed by Teflon O-ring. Choice of shaft with or without sleeve for utmost flexibility in solving sealing problems.



Renewable shaft sleeves are positively driven, hooktype with one end free to expand with temperature variations. Teflon O-ring prevents leakage under sleeve. The hooktype shaft sleeve permits application of inside balanced mechanical seals where required.

BEARINGS

Inboard bearing is pressed on shaft and is free to float axially in frame, to carry radial load only. Outboard bearing is shouldered and locked on shaft and in bearing housing to carry radial and any unbalanced thrust load. All bearing fits are precision bored.

Inboard bearing is single row, deep groove. Outboard bearing is double row, deep groove angular contact, as standard. As an option, a single row outboard bearing identical with the inboard bearing may be supplied.

Both radial and thrust bearings are sized for minimum two year life. See page 18.

CAST IRON R STRUCTURAL STEEL BEDPLATE

Each bedplate takes a range of NEMA frame motors. In most cases a larger motor can be added (or a larger pump) without changing bedplates. Four bedplates take any size motor required by any pump.

Cast iron bedplate has camber top to prevent liquids from being trapped on bedplate, and grout and vent holes for proper grouting to foundation. Steel bedplate has raised drip lip. Either type can be jackscrew (inline) or spring suspension mounted for lowest installation cost.

MATERIALS OF CONSTRUCTION

Goulds 3196 can be manufactured in any machinable alloy service conditions require. Goulds inventories units and parts in the following materials:

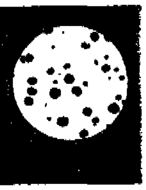
Ductile Iron, heat treated (ASTM 395-56T, Type 60-45-15)
Cast 316 Stainless Steel (ACI-CF-8M)
Gould-A-Loy 20 (ACI-CN-7MCU)
For detailed Materials of Construction Table see Page 9.

DUCTILE IRON . . . a standard material

Ductile Iron, sometimes referred to as Nodular Iron or Spheroidal Graphite Iron is produced under a licensed process of International Nickel Company. In this process the shape of the graphite particles, which are essential ingredients of iron, are changed from flat flakes to spheroids. The spheroid graphite particles have much larger areas of iron matrix between them, and since they have no sharp edges, ductile iron exhibits much greater tensile strength, yield strength, ductility, impact resistance, and resistance to thermal shock than gray cast iron. Ductile Iron approaches carbon steel in physical properties at appreciably less cost. The corrosion resistance of Ductile Iron is comparable to that of gray cast iron; thermal expansion comparable to carbon steel.

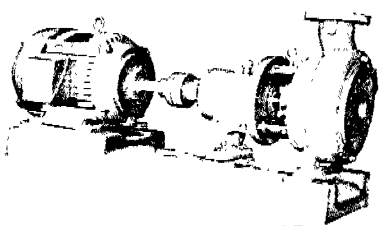
One hundred times photomicrographs show graphite formation and distribution for High Strength Gray Cast Iron and Full Ferritized Annealed Ductile Iron.

	Tensile Strength	Yield Strength	Elongation	Cost Ratio	Notes
Cast Iron A48-56	*30,000 PSI*	*0*	*0*	*1.0*	
Goulds Ductile Iron (ASTM A395-56T)	60,000 to 70,000 PSI	45,000 to 50,000 PSI	15-25%	1.1	As Heat Treated to Full Ferritized Anneal
Carbon Steel ASTM A-216-59T-WCB	70,000 PSI	36,000 PSI	22%	1.7	



STEAM JACKETED PUMPS AVAILABLE

The table at the right shows sizes of Model 3196 pump which can be supplied with a steam jacketed casing for handling liquids which solidify at ambient or above ambient temperatures. The jacketed casing is normally used with the jacketed stuffing box cover to provide a completely heated liquid end. This construction easily handles high melting liquids such as sulfur, naphthalene, tars and waxes.

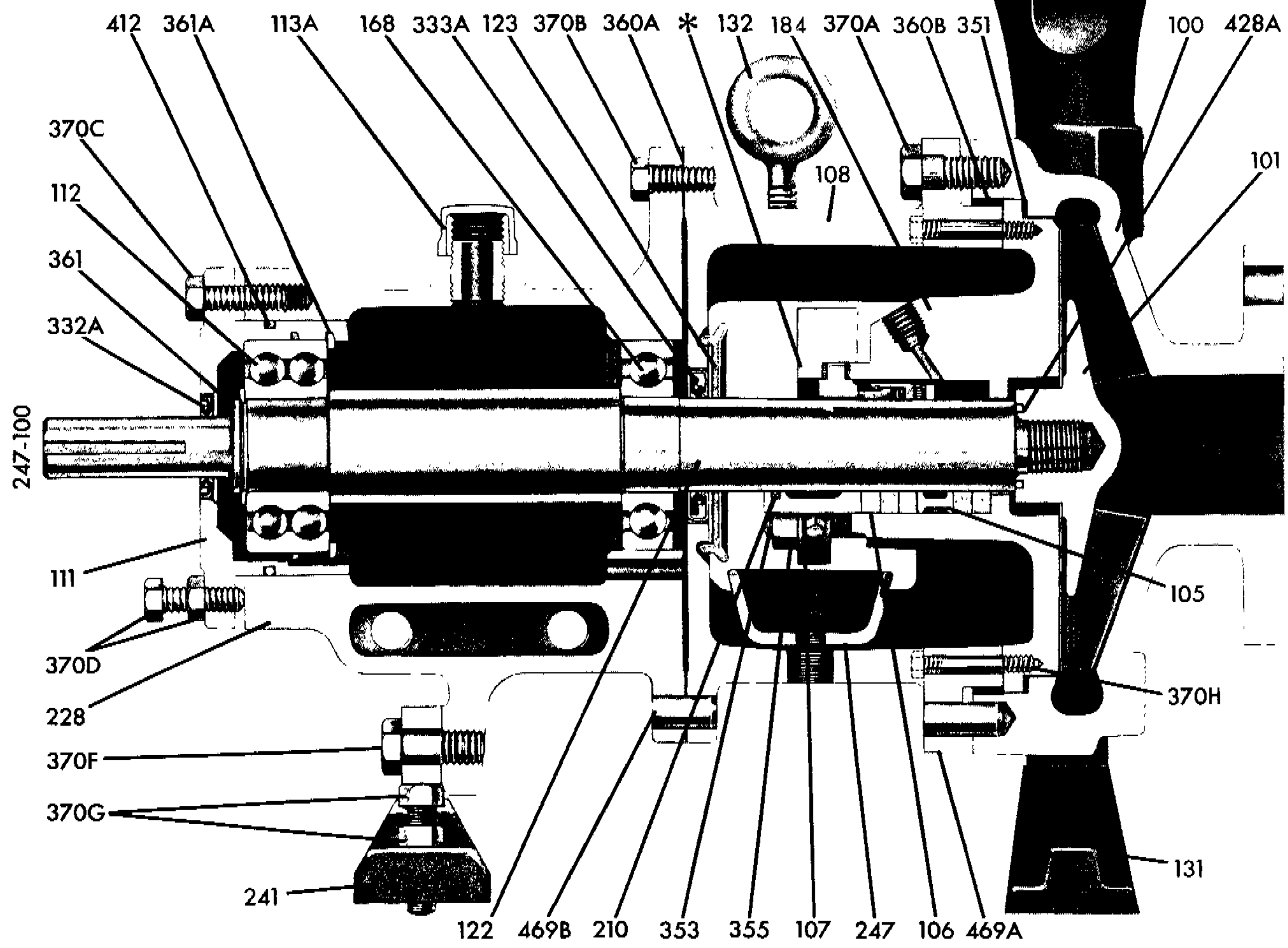


SIZES AVAILABLE

1 x 2-8	3 x 4-8	1½ x 3-10
2 x 3-6	2 x 3-13	2 x 3-10
1½ x 3-13	3 x 4-13	3 x 4-10
4x6-13		

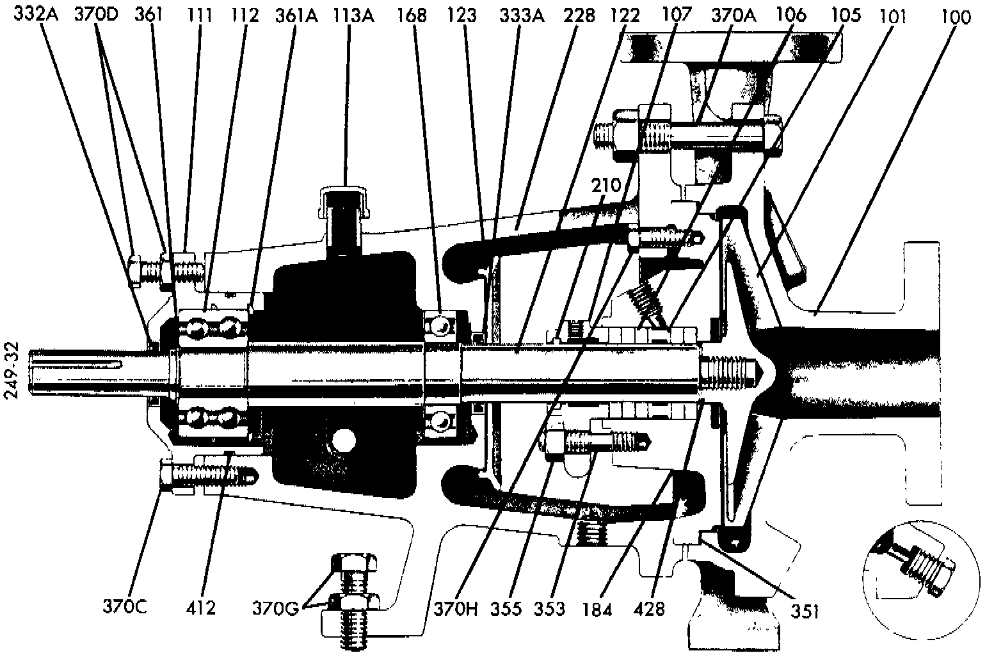
SECTION DRAWING

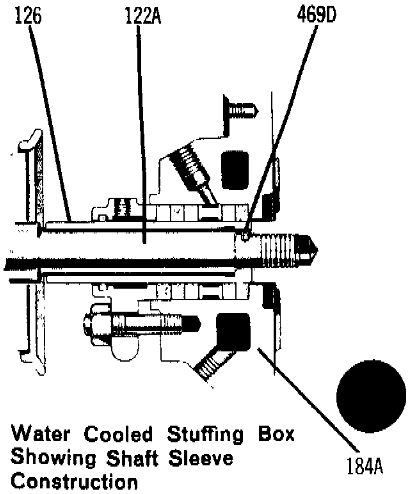
Model 3196-STD



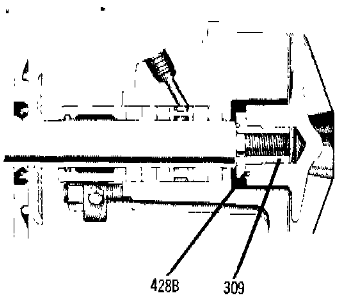
*Upper half of Stuffing Box shows Type 9 Unbalanced Mechanical Seal. Lower half shows Packing.

Model 3197-STD

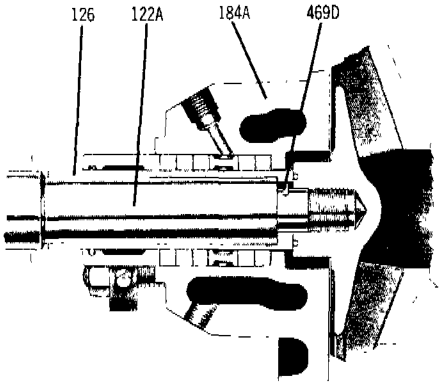




Water Cooled Stuffing Box Showing Shaft Sleeve Construction



Group "S" Construction Showing Non-Cooled Stuffing Box and Solid Shaft.



Water Cooled Stuffing Box Showing Shaft Sleeve Construction.

POWER END PARTS NUMBERS ON SECTIONAL VIEW SHOWN IN BLACK

Item No.	No. Req'd Per Pump	Part Name	STANDARD MATERIALS OF CONSTRUCTION								INTERCHANGEABILITY			
			All Ductile Iron	All Bronze	All 316 S.S.	All GA-20	All ISO-B	All ISO-C	All Monel	All Nickel	3197	3196		
												SFR	MFR	LFR
105	1	Lantern Ring	Glass Filled Teflon								T	S	M	L
106	1 Set	*Stuffing Box Packing*	*Blue African Asbestos*			*Teflon*					T	S	M	L
107	1	Gland—Packed Box	316			GA-20	ISO-B	ISO-C	Monel	Nickel	T	S	M	L
111	1	Bearing Housing	1000								T	S	M	L
112	1	Ball Bearing—Outboard	Steel								T	S	M	L
113-A	1	Bearing Frame Breather	Steel								S			
122	1	Pump Shaft (Less Sleeve)	2237	▲316		▲C-20	Hast-B	Hast-C	Monel	Nickel	T	S	M	L
122-A	1	Pump Shaft (With Sleeve)	2238				316				T	S	M	L
123	1	Deflector	Glass Reinforced Nylon								T	S	M	L
126○	1	Shaft Sleeve	420‡	316		C-20	Hast-B	Hast-C	Monel	Nickel	T	S	M	L
132	1	Eyebolt	Steel								—	S		
168	1	Ball Bearing—Inboard	Steel								T	S	M	L
210	1	Gland Packing	Blue African Asbestos								T	S	M	L
228	1	Bearing Frame	1000								T	S	M	L
247	1	Drip Basin	—	316							T	S		
251	1	Constant Level Oiler	Glass & Steel								T	S		
309	1	Shaft Bushing	316			C-20	Hast-B	Hast-C	Monel	Nickel	—	S	Not Req'd	
332-A	1	Oil Seal (Outboard)	Buna Rubber								T	S		
333-A	1	*Oil Seal (Inboard)*	*Buna Rubber*								T	S	M	L
353	2	Gland Stud	316				Monel				T	S		
355	2	Gland Stud Nut	304				Monel				T	S		
360-A	1	Gasket (Bearing Frame to Frame Adapter)	1/64" Vellumoid								①	S		
361	1	Retaining Ring (Shaft)	Steel								T	S	M	L
361-A	1	Retaining Ring (Bearing Housing).	Steel								T	S	M	L
370-A	4—12	Hex Head Mach. Bolt (Frame Adap. to Casing)	Steel	304*							T	S		
370-B	4	Hex. Head Mach. Bolt (Frame Adapter to Bearing Frame)	Steel								①	S		
370-C	3	Hex Head Tap Bolt (Bearing Housing)	Steel								S		M	
370-D	3	Hex Head Tap Bolt with Jam Nut (Impel. Adjust.)	Steel								S		M	
370-E	2	Hex Head Mach. Bolt with Lockwasher (Casing Foot to Casing) (Not Illus.)	Steel								②	S		
370-F	1	Dowel Bolt (Frame to Frame Foot)	Steel								①	S		
370-G	2	Hex Head Tap Bolt with Jam Nut (Bearing Frame Foot Adjustment)	Steel								S			
370-H	2	Hex Head Tap Bolt or Stud (Stuffing Box Cover to Frame or Frame Adapter)	Steel								T	S		
412	1	"O"-Ring (Bear'g Hous'g)	Buna Rubber								T	S	M	L
428	1	Impeller Gasket	Teflon								T	—		
428-A	1	"O"-Ring (Impeller)	Teflon								—	S		
428-B	1	"O"-Ring (Shaft Bushing)	Teflon								—	S	Not Req'd	
469-A	2	Precision Aligner (Frame Adapter to Casing)	Steel								—	S		
469-B	2	Precision Aligner (Bearing Frame to Frame Adapter)	Steel								—	S		
469-D	1	Roll Pin (Shaft Sleeve)	420								S			

⊙ Optional *SAE 4140 on Model 3197

▲ Material shown, butt welded to carbon steel and machined as a single piece.

PARTS LIST

CODE	MATERIAL AND SPECIFICATIONS
304	Wrought Stainless AISI type 304
316	Cast Stainless ACI-CF-8M
316	Wrought Stainless AISI type 316
420	Wrought Stainless AISI type 420
GA-20	Cast Goulds-A-Loy 20 ACI CN-7MCU
C 20	Wrought Carpenter 20
1000	Cast Iron ASTM A48 56
1012	Ductile Iron, Heat Treated ASTM A395 56T Type 60-45-15
1013	Ductile Iron As Cast ASTM A339 55 Type 80 60 03
1103	Anti-Acid Bronze
2237‡	Molybdenum Alloy Steel SAE 4150
2238	Steel SAE 4140 Hot Rolled Double Heat Treated
ISO-B	Cast ISO B ASTM B332 58T
Hast-B	Wrought Hastelloy B ASTM B335-58T
ISO C	Cast ISO-C ASTM B332-58T
Hast-C	Wrought Hastelloy C ASTM B336-58T
Monel	Cast (Goulds 1119)
Monel	Wrought
Nickel	Cast (Goulds 1601)
Nickel	Wrought

‡Flame hardened to 500 Brinnell through Stuffing Box.

PUMP END PARTS—NUMBERS ON SECTIONAL END SHOWN IN BLUE

Item No.	No. Req'd Per Pump	Part Name	STANDARD MATERIALS OF CONSTRUCTION								INTERCHANGEABILITY BY CASING CLASS																		
			All Ductile Iron	All Bronze	All 316 S.S.	All GA-20	All ISO-B	All ISO-C	All Monel	All Nickel	Model 3197		Model 3196															
											1x1½—6	1½x3—6	1x2—6	1½x3—6	2x3—6	1x2—8	1½x3—8	2x3—8	3x4—8	3x4—8G	1½x3—10	2x3—10	3x4—10	4x6—10	1½x3—13	2x3—13	3x4—13	4x6—13
100	1	Casing	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel																		
101	1	Impeller	1013	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel																		
108	1	Frame Adapter	1000								①		6			8					10				13			
131	1	Casing Foot	1000								②		6			8			10					11	13-A	13		③
184	1	Stuffing Box Cover, Standard, Model 3197	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	1		—			—					—				—			
184	1	Stuffing Box Cover, Standard, "S" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6S			8S					10S				—			
184	1	Stuffing Box Cover, Standard, "M" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6M			8M					10M				13M			
184	1	Stuffing Box Cover, Stand ard, "L" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6L			8L					10L				13L			
⊙ 184-A	1	Stuffing Box Cover, Water Jacketed, Model 3197	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	1-A		—			—					—				—			
⊙ 184-A	1	Stuffing Box Cover, Water Jacketed, "S" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6S-A			8S-A					10S-A				—			
⊙ 184-A	1	Stuffing Box Cover, Water Jacketed, "M" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6M-A			8M-A					10M-A				13M-A			
⊙ 184-A	1	Stuffing Box Cover, Water Jacketed, "L" Power End	1012	1103	316	GA-20	ISO-B	ISO-C	Monel	Nickel	—		6L-A			8L-A					10L-A				13L-A			
241	1	Bearing Frame Foot	1000								①		8												13			
351	1	Gasket (Casing)	1/16" Thick Blue African Asbestos								6		6			8					10				13			
360-B	1	Gasket (Frame Adapter to Stuffing Box Cover)	.006" Thick Manila Paper								Not Req'd		6			8					10				13			

① Frame Adapter and Frame Foot are Integral with Frame on Model 3197.
② Casing Foot is Integral with Casing on Model 3197.
③ Casing Foot is Integral with casing on 4x6—13.

MODEL STD CONSTRUCTION DETAILS

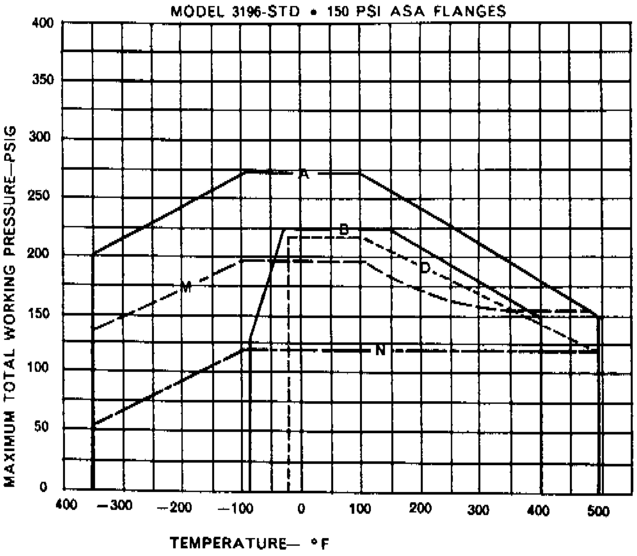
PUMP END

	Model 3197		Model 3196															
	1x1½—6	1½x3—6	1x2—6	1½x3—6	2x3—6	1x2—8	1½x3—8	2x3—8	3x4—8	3x4—8G	1½x3—10	2x3—10	3x4—10	4x6—10	1½x3—13	2x3—13	3x4—13	4x6—13
Minimum Casing Thickness	5/16"		3/8"	7/16"		3/8"	7/16"				½"					9/16"	5/8"	
Casing Corrosion Allowance	⅛"																	
Maximum Diameter Solids	5/16"	½"	5/16"	3/8"	3/8"	¼"	5/16"	½"	1⅛"	11/16"	7/32"	3/8"	5/8"	1"	7/32"	3/8"	5/8"	1"
Impeller Eye Area	See Individual Performance Curves, Pages 12-16																	
Working Pressure	150 PSIG		See Pressure-Temperature Chart Below															
Test Pressure	150% Of Maximum Working Pressure at 100°F.																	
Maximum Liquid Temp. (Without Cooling)	350°F																	
Maximum Liquid Temp. (With Cooling)	450°F		500°F															
Unit Weights	See Dimension Print, Pages 19 and 20																	

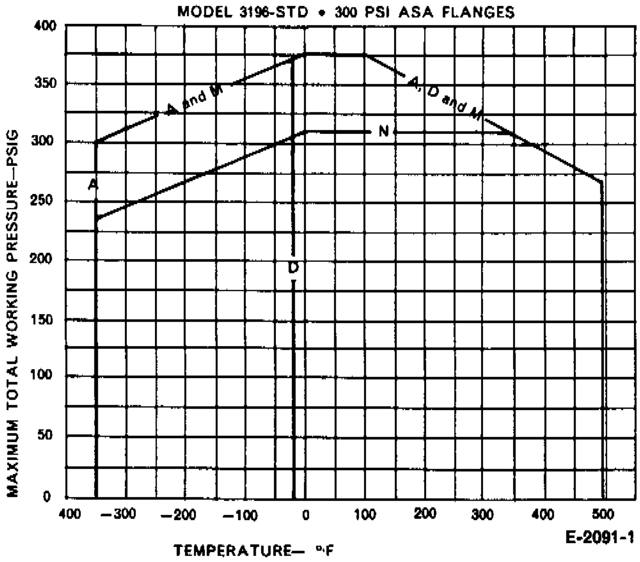
POWER END

		Model 3197	Model 3196		
			S	M	L
SHAFT DIAMETERS	At Impeller	5/8"	5/8"	1"	
	In Stuffing Box (Less Sleeve)	1⅛"	1¼"	1¾"	2⅛"
	In Stuffing Box (With Sleeve)	⅞"	1"	1½"	1⅞"
	Sleeve Outside Diameter	1⅛"	1¼"	1¾"	2⅛"
	Between Bearings	1¼"	1⅝"	2⅛"	2½"
	At Coupling	⅞"	1⅛"		
BEARINGS	Radial	206-S	307-S	309-S	311-S
	Coupling End (Single Row)	305-S	307-S	309-S	311-S
	(Double Row)	5305	5307	5309	5311
	Bearing Span (Single Row)	4 11/16"	7 5/16"	7"	6 13/16"
	(Double Row)	4½"	7 1/16"	6¾"	6 7/16"
	Shaft Overhang	5¾"	8¼"	8⅜"	
STUFFING BOX	Bore	1¾"	2"	2½"	2⅞"
	Depth	1 13/16"	2⅝"		
	Packing Size	5/16" x ¼"	⅜" x ⅜"		
	No. of Rings	5			
	Width of Lantern Ring	7/16"	5/8"		
	Distance—End of Box to Nearest Obstruction	2 1/16"	2 13/16"	3	

MODEL STD PRESSURE TEMPERATURE DATA



E-2092



E-2091-1

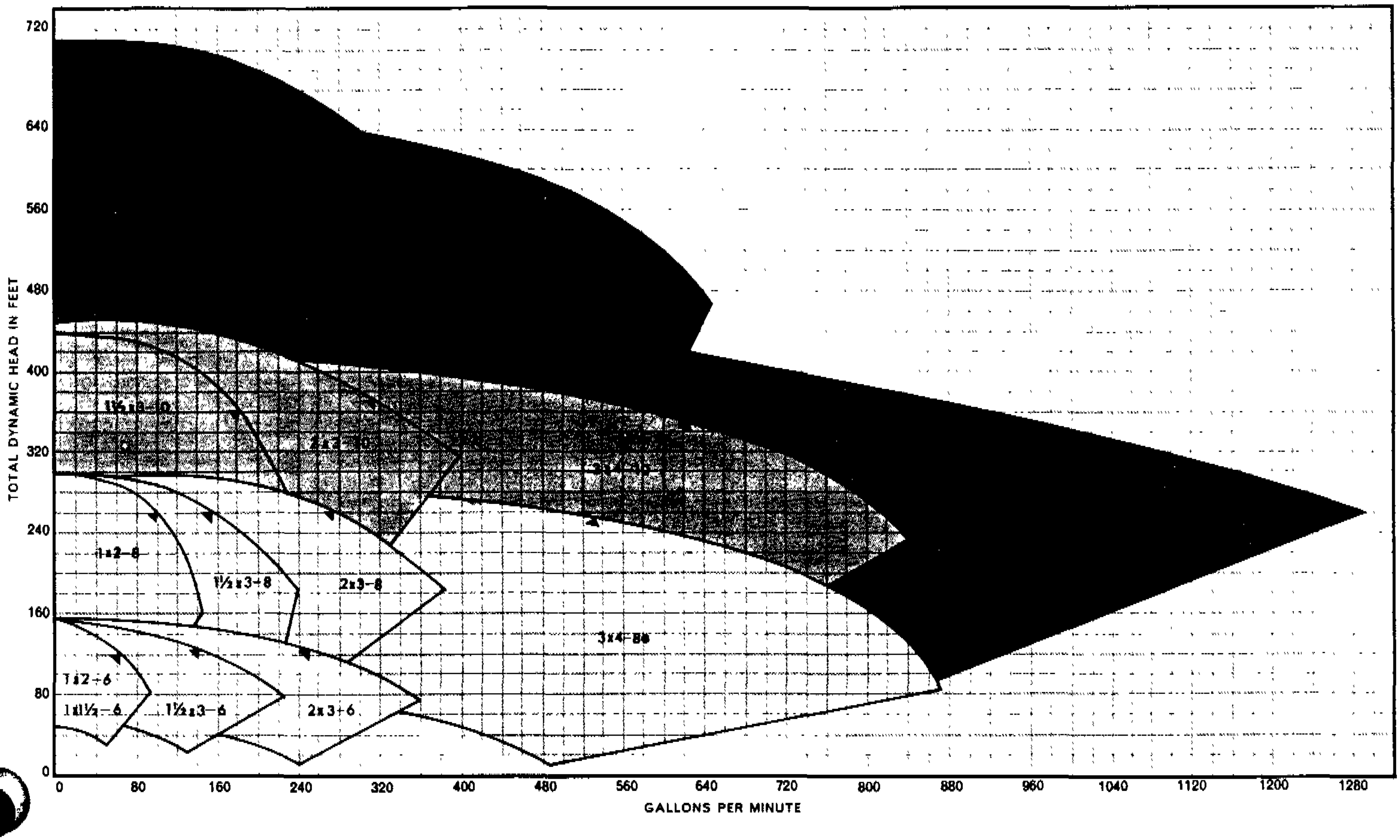
CODE FOR PRESSURE TEMPERATURE CHARTS

CODE A	CODE B	CODE D	CODE M	CODE N
316 (ASTM A296-60 CF-8M) GA-20 (ACI CN7MCU) ISO-B (ASTM B 332-58T) ISO-C (ASTM B 332-58T)	BRONZE (GOULDS 1103)	DUCTILE IRON (ASTM A395-56T)	MONEL (GOULDS 1119)	NICKEL (GOULDS 1601)

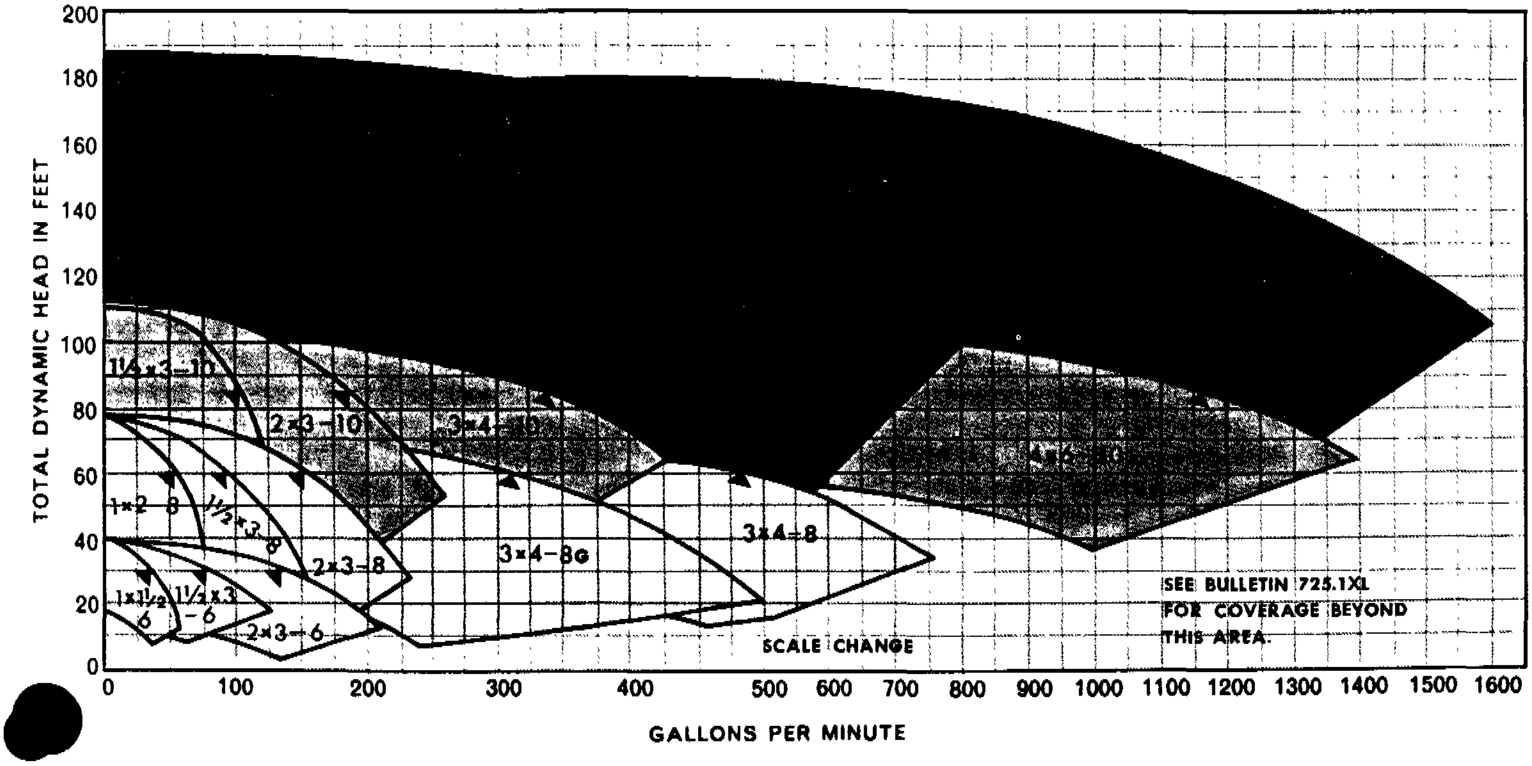
COMPOSITE RATING CHARTS

. For detailed hydraulic performance see individual performance curves.

3500 RPM PERFORMANCE



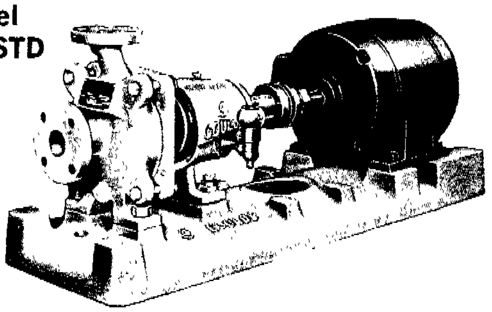
1750 RPM PERFORMANCE



HYDRAULIC COVERAGE

● Following are individual performance curves for all sizes of **GOULDS STD LINE** Curves are color coded by speed according to the index below.

Model 3197-STD

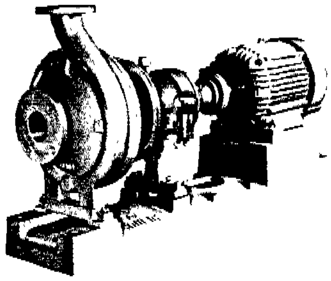


3500 RPM

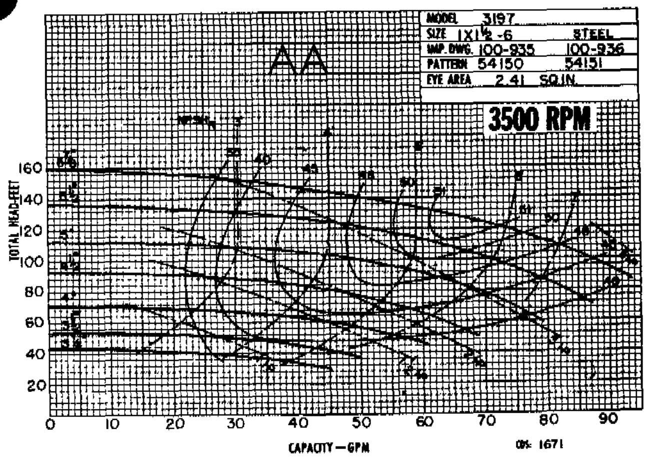
▨ 1750 RPM

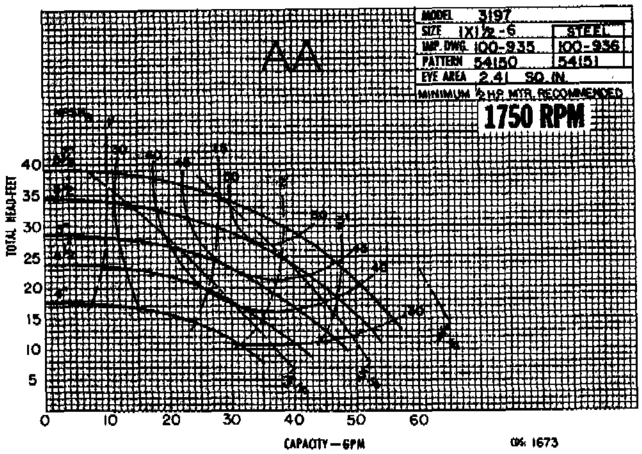
☐ 1150 RPM

Model 3196-STD



● PERFORMANCE CURVES MODEL 3197





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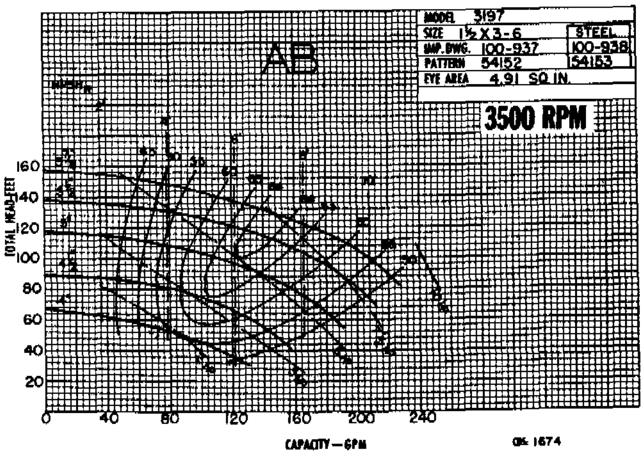
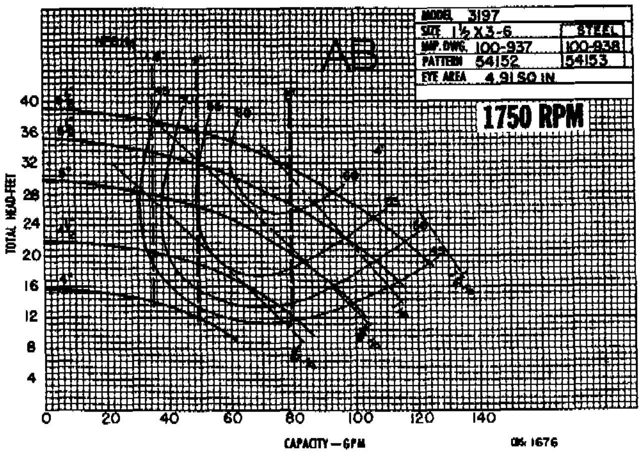
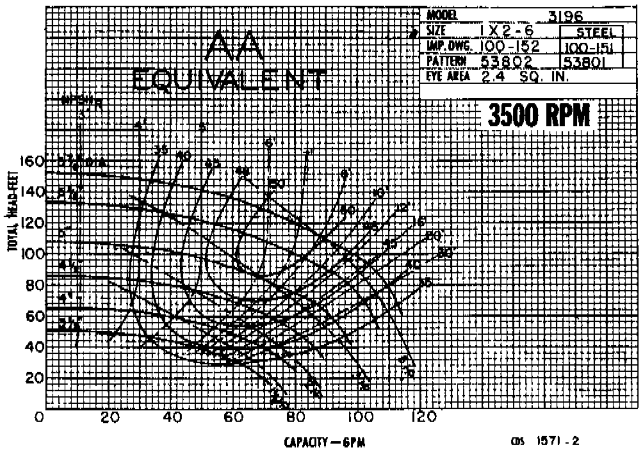
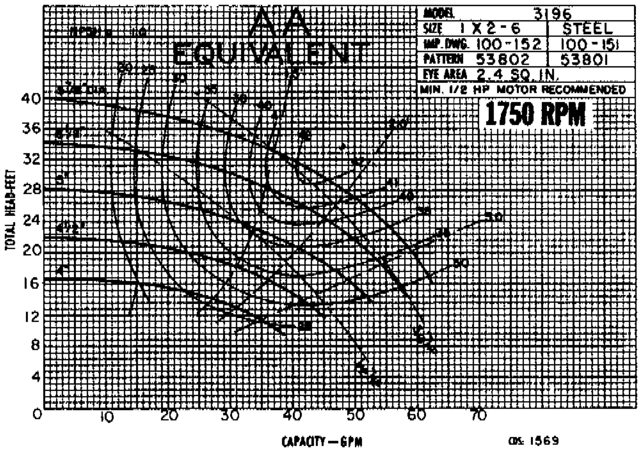




1½ x 3-6

PERFORMANCE CURVES MODEL 3196





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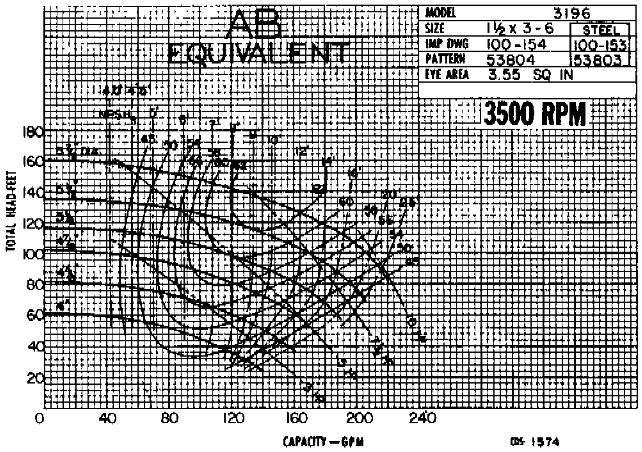

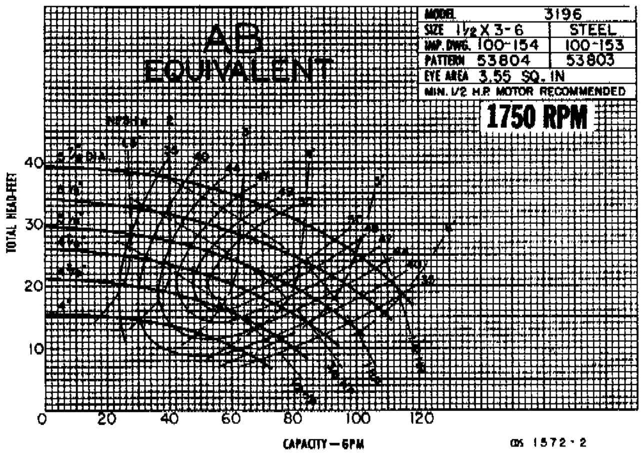

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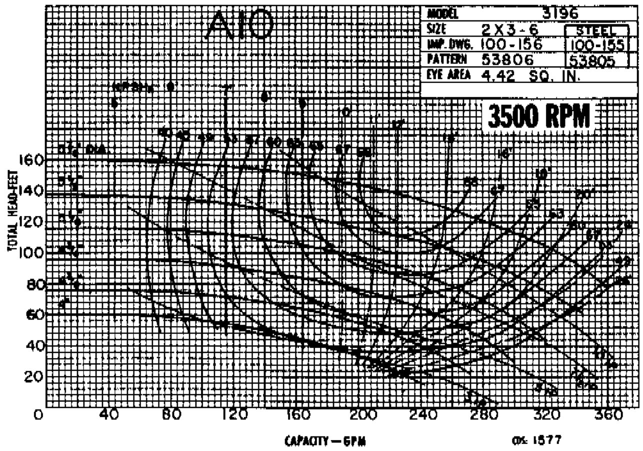

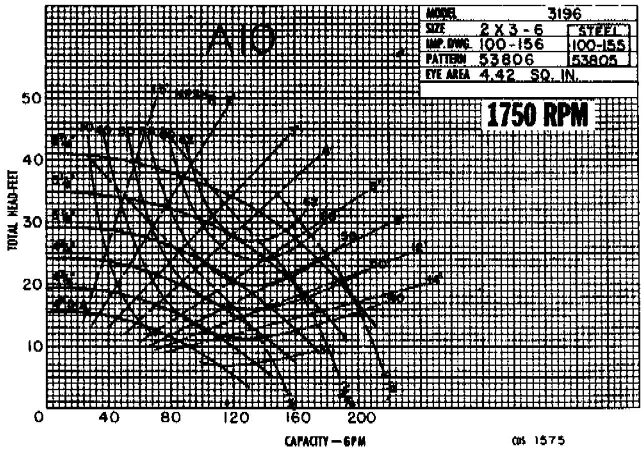

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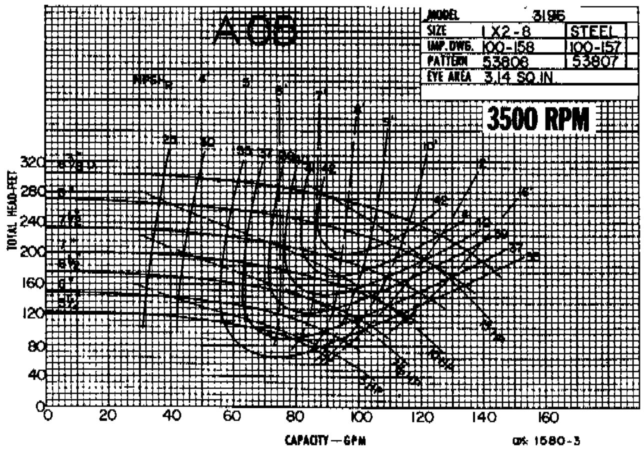
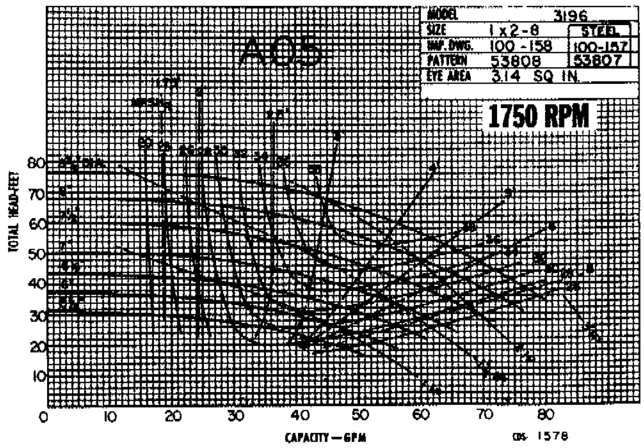
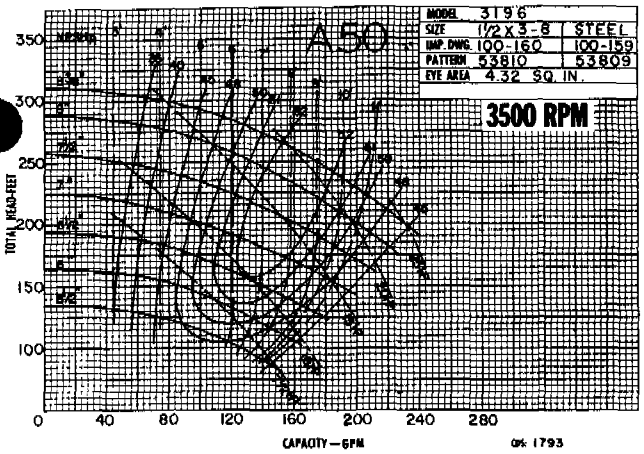
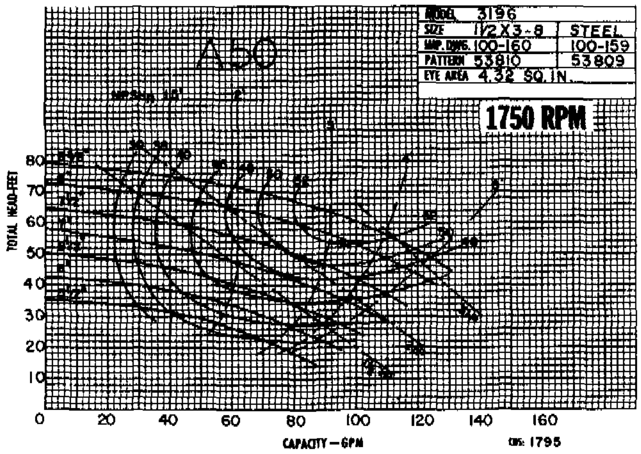




1 x 2-8

PERFORMANCE CURVES MODEL 3196





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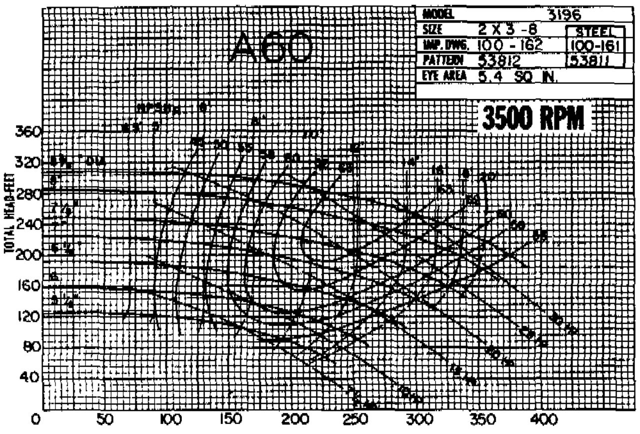

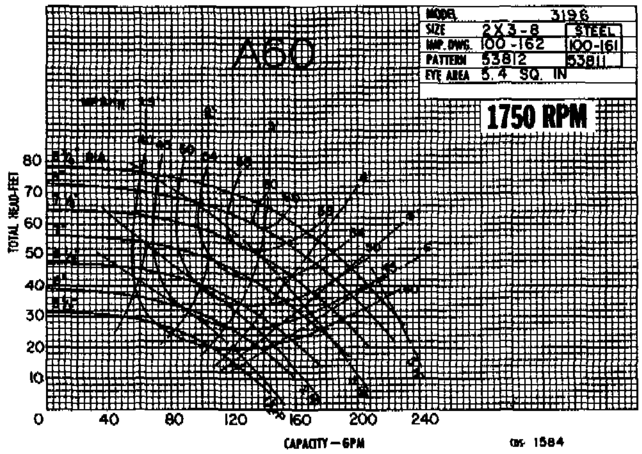

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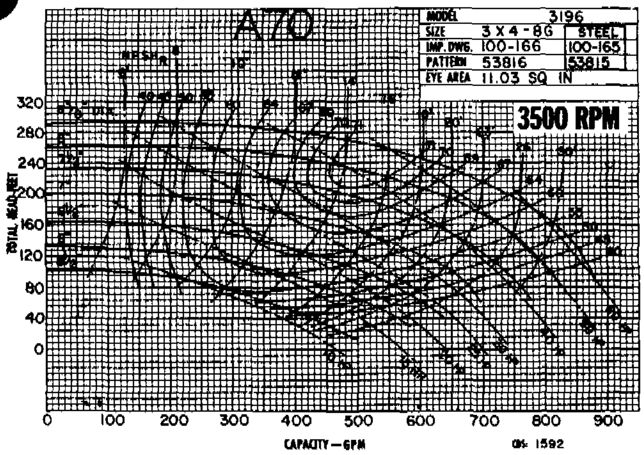

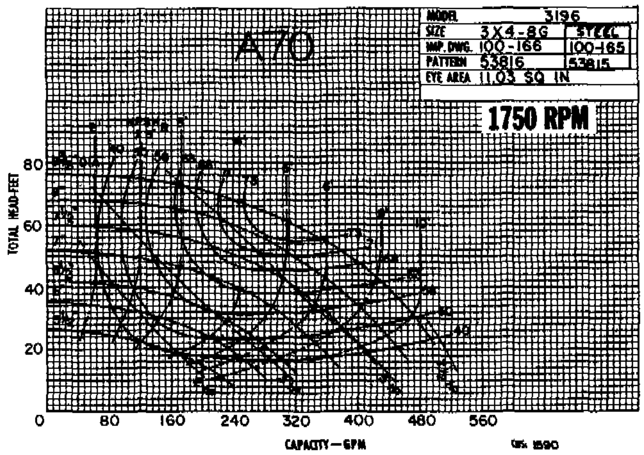

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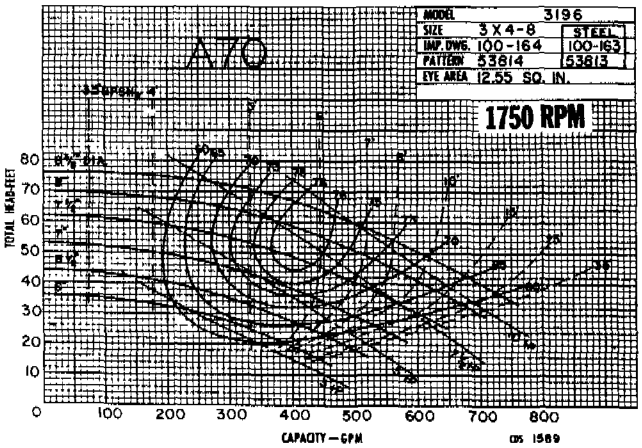

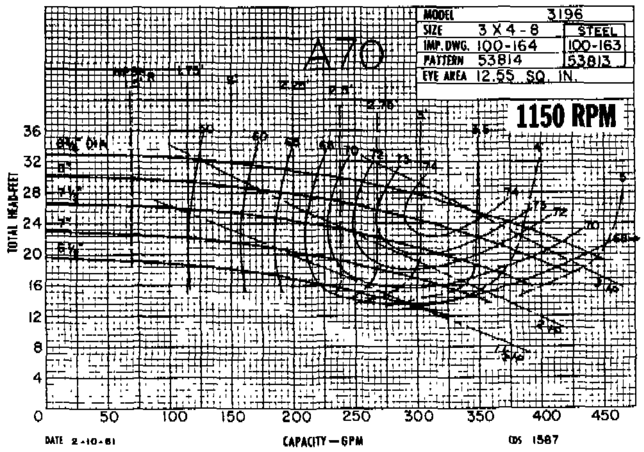

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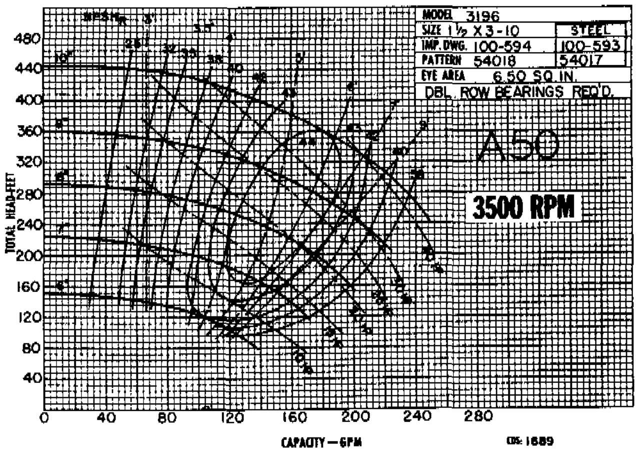

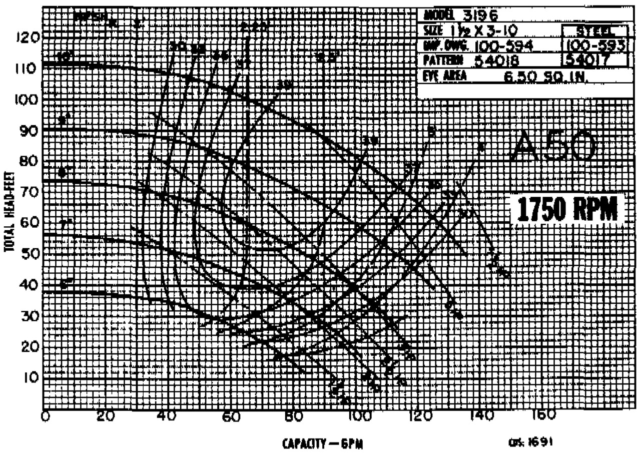

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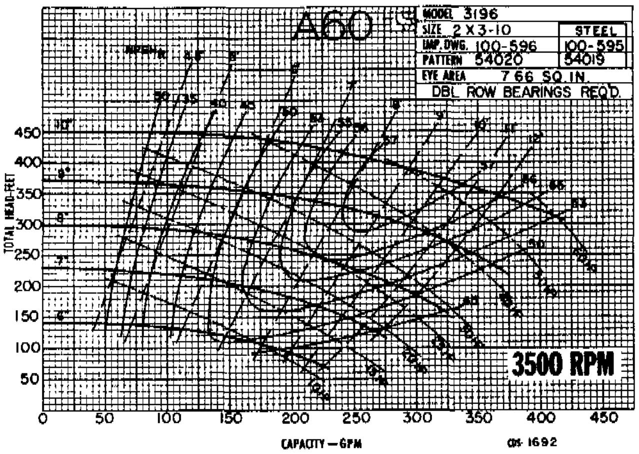

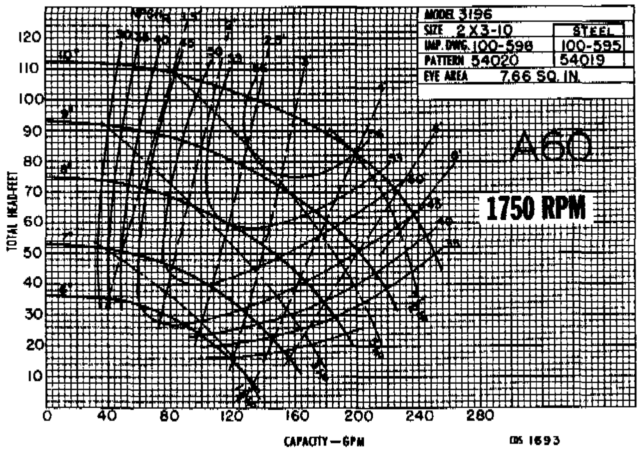

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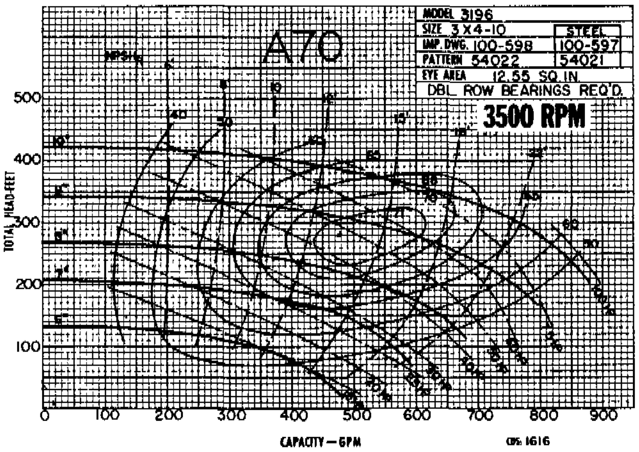

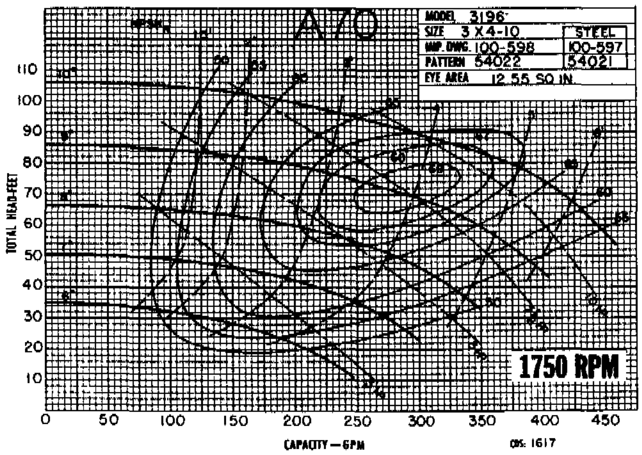

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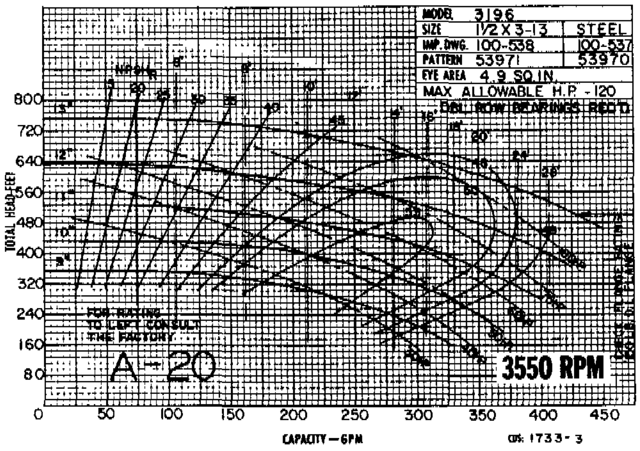
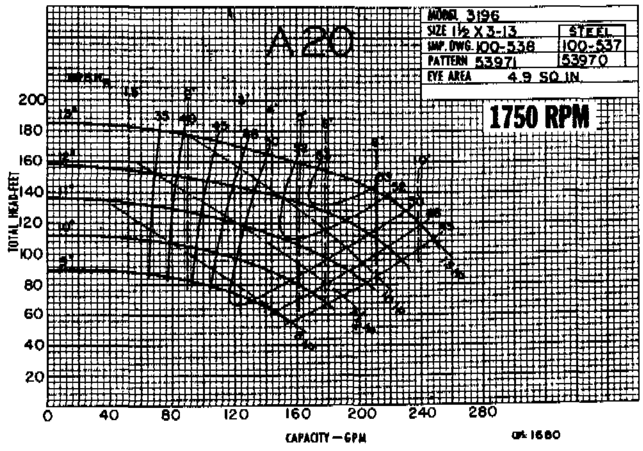
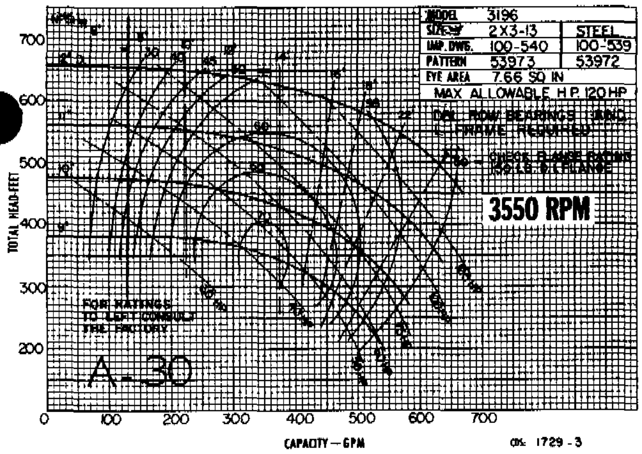
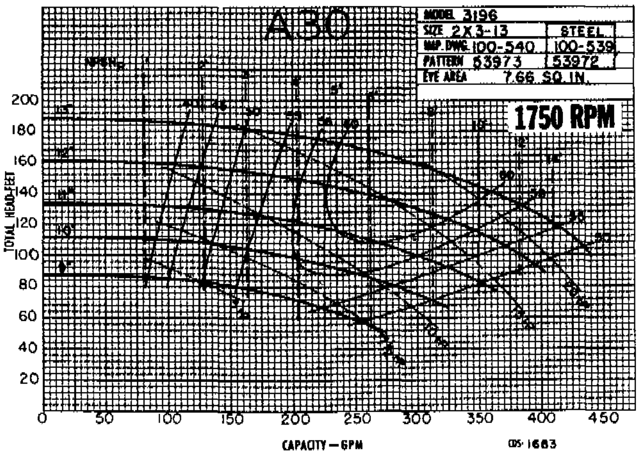




1½ x 3-13

PERFORMANCE CURVES MODEL 3196





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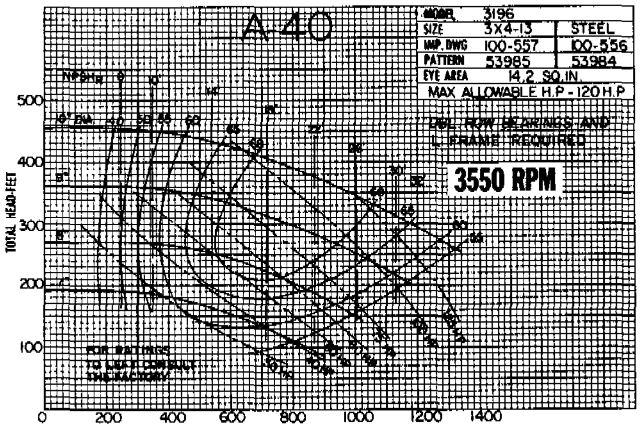

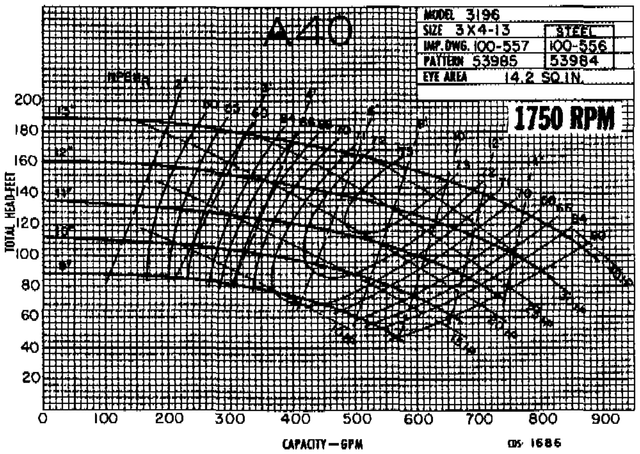

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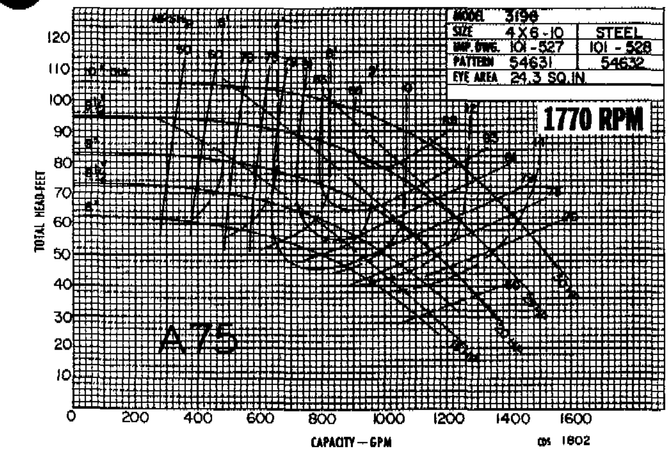
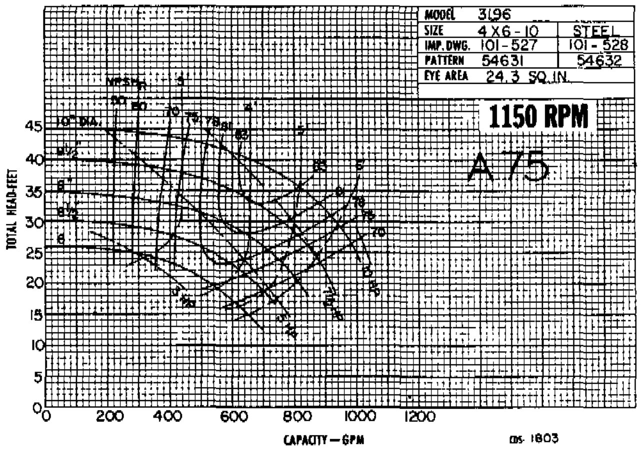
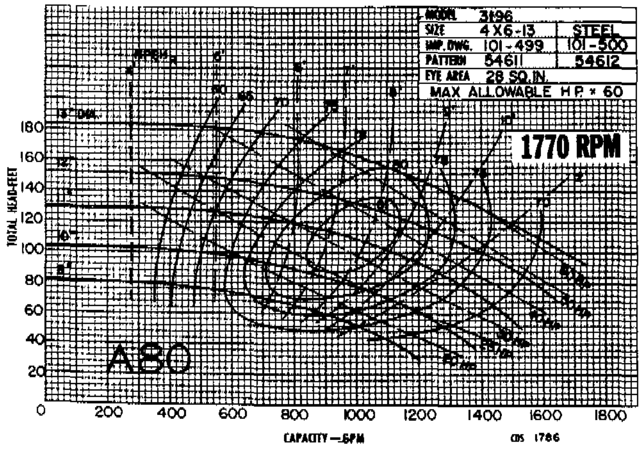
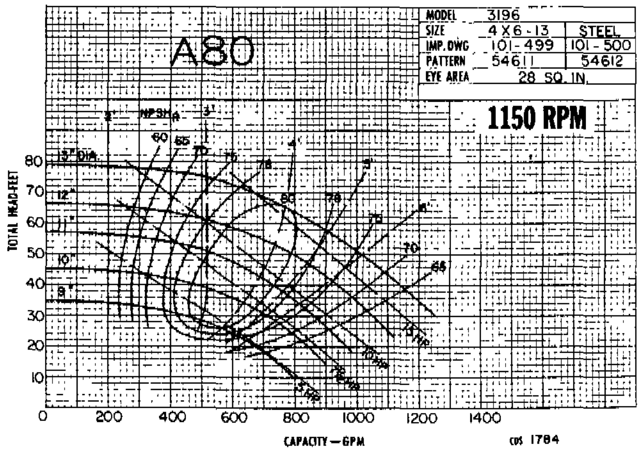




4 x 6-10

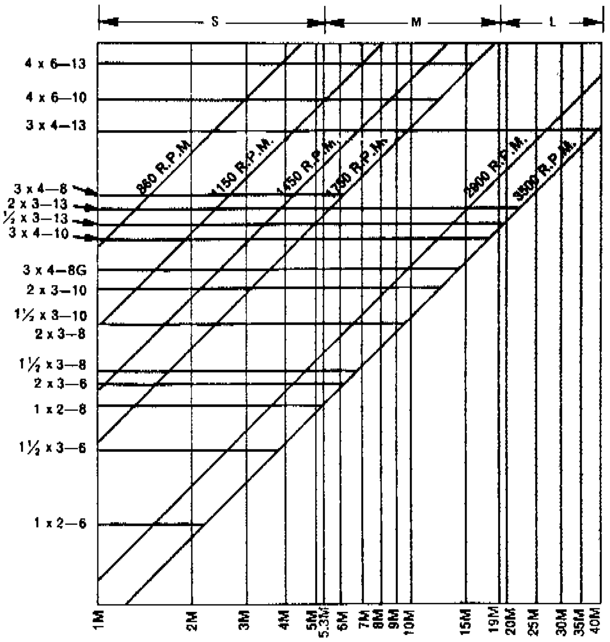




4 x 6-13

BEARING FRAME SELECTION

CHART A—FRAME SELECTION CHART—MODEL 3196



W—LOAD FACTOR

To select minimum bearing frame size:

1. Enter Chart A above for pump size required.
2. Read horizontally to intersection of operating RPM line. Scale at bottom of chart gives Frame Load Factor.
3. To correct load factor for liquid handled, multiply by specific gravity.
4. Then to correct load factor for actual impeller diameter being used, multiply by ratio of impeller diameter required to maximum diameter available.
5. Enter Table A with corrected load value to determine frame size.

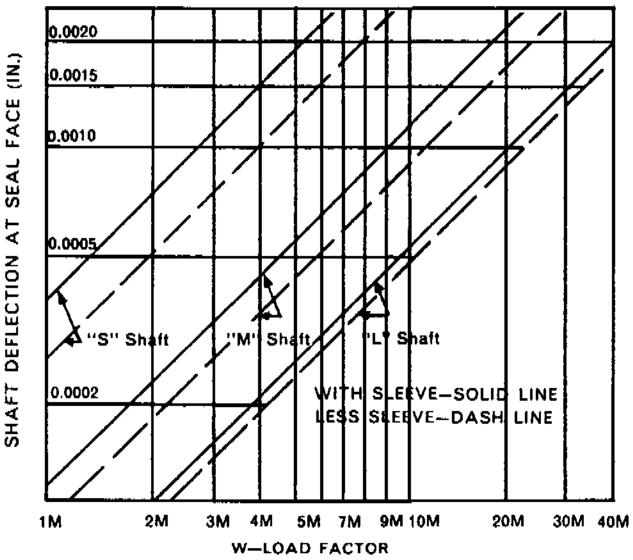
Table A

Frame	Max. Allow. Load
S	5.3M
M	19M
L	40M

6. A further limitation on frame size is B.H.P. for various R.P.M. shown in table at right.

SHAFT DEFLECTION

CHART B—SHAFT DEFLECTION AT SEAL FACES AT SHUT-OFF—MODEL 3196



W—LOAD FACTOR

Enter chart with frame load factor determined as at left. Reading to pump shaft used will give shaft deflection at mechanical seal face at shut-off.

The limit of .002″ is recommended as the maximum shaft deflection for good design practice.

B. H. P. LIMITS TABLE

Table below shows maximum allowable Brake Horsepower per frame size and R.P.M.

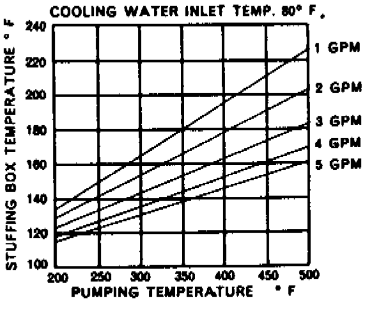
RPM Frame Size	3500	2900	1750	1450	1150	860
S	24	20	12	10	8	6
M	120	100	60	50	40	30
L	120	100	60	50	40	30

MATERIAL SPECIFICATIONS AND TYPICAL COMPOSITION

CODE	MATERIAL AND SPECIFICATIONS	CHEMICAL COMPOSITION PER CENT										
		Fe	Cr	Ni	C	Mo	Cu	Si	Mn	P Max.	S Max.	Other
304	Wrought Stainless AISI type 304	Bal	18-20	8-12	0.08 Max	—	—	1 00 Max	2.00 Max	0.04	0.03	—
316	Cast Stainless ACI-CF-8M	Bal	18-21	9-12	0 08 Max.	2.0-3.0	—	1 50 Max	1 50 Max	0,04	0 04	—
316	Wrought Stainless AISI type 316	Bal	16-18	10-14	0 08 Max.	2.0-2.0	—	1 00 Max.	2 00 Max.	0 04	0 03	—
420	Wrought Stainless AISI type 420	Bal	12-14	—	Over 0 15	—	—	1.00 Max	1.00 Max	0 04	0.03	—
GA-20	Cast Goulds-A-Loy 20 ACI CN-7MCU	Bal	20	29	0 07 Max	1 75 Min	3 00 Min	1 00 Max	1 50	0 04	0 04	—
C-20	Wrought Carpenter 20	Bal	20	29	0 07 Max.	2 00 Min.	3 00 Min.	1 00 Max.	0.75	—	—	—
1000	Cast Iron ASTM A48-56	Bal	—	—	3.4	—	—	2.2	0.5	0 3	0.15	—
1012	Ductile Iron, Heat Treated ASTM A395-56T Type 60-45-15	Bal	—	1 0	3 8	—	—	2 75	0 4	0 08	—	Mg 0 06 —
1013	Ductile Iron As Cast ASTM A339 55 Type 80-60-03	Bal	—	1.0	3 8	—	—	2.75	0 4	0 08	—	Mg 0.06
1103	Anti-Acid Bronze	—	—	0 5-1.0	—	—	86-88	—	—	—	—	Sn 5.5-6.5 Pb 3.5-5.5 Zn 1 0-2 5
2237‡	Molybdenum Alloy Steel SAE 4150	Bal	8-1.10	—	.45-55	.15-25	—	—	.6-9	0.04	0.05	—
2238	Steel SAE 4140 Hot Rolled Double Heat Treated	Bal	.80-1 10	—	35-.45	15-.25	—	—	0 60-0 90	0 04	0 05	—
ISO-B	Cast ISO-B ASTM B332-58T	4-6	1 0 Max	Bal	0 12 Max	26-30	—	1 0 Max	1 0 Max	0.04	0.03	Co 2.5 Max V 0 2-0 4
Hast-B	Wrought Hastelloy B ASTM B335-58T	4-6	1 0 Max.	Bal	0.05 Max.	26-30	—	1 0 Max.	1 0 Max.	0 025	0 03	Co 2 5 Max V 0 2-0 4
ISO-C	Cast ISO-C ASTM B332-58T	4 5-7 5	15 5-17 5	Bal	0.12 Max	16-18	—	1.0 Max	1 0 Max	0 04	0.03	Co 2.5 Max. W 3 75-5 25 V 0.2-0.4
Hast-C	Wrought Hastelloy C ASTM B336-58T	4-7	14 5-16.5	Bal	0 08 Max	15-17	—	1 0 Max	1 0 Max.	0 04	0 03	Co 2 5 Max W 3-4 5 V 0 35 Max
Monel	Cast (Goulds 1119)	2 0	—	62	0 2	—	31 5	1 5	0 8	—	—	Cb 1 4
Monel	Wrought	1.4	—	67	0 15	—	30	0 1	1.0	—	0 01	—
Nickel	Cast (Goulds 1601)	1.25 Max	—	97	—	1 0 Max	—	2.0 Max	1 5 Max	—	—	—
Nickel	Wrought	0 15	—	99 5	0 06	—	0 05	0 05	.25	—	—	—

‡Flame hardened to 500 Brinnell through Stuffing Box

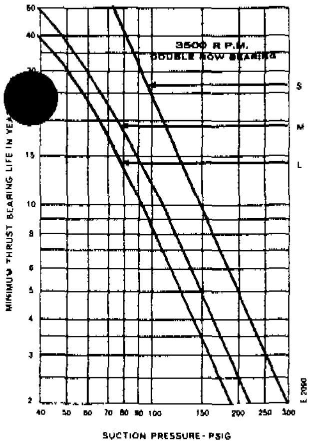
Temperature of liquid in pump stuffing box for various pumping temperatures

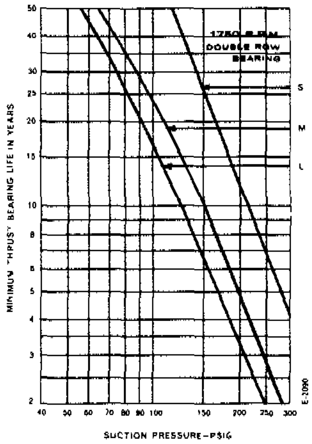


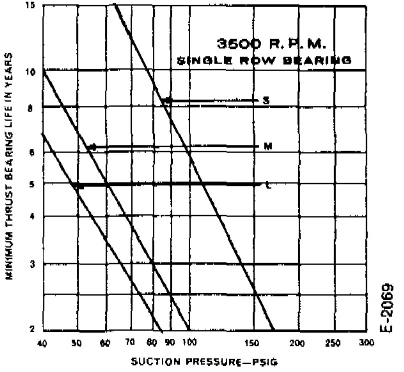
BEARING LIFE INFORMATION

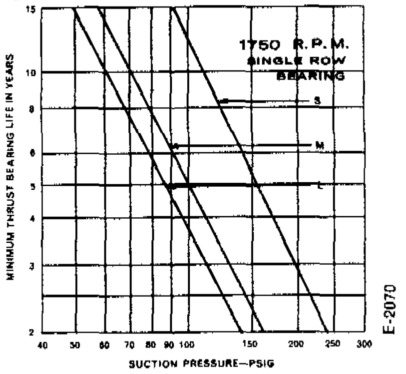
THRUST BEARING

The charts below show minimum thrust bearing life in years for various pump suction pressures.







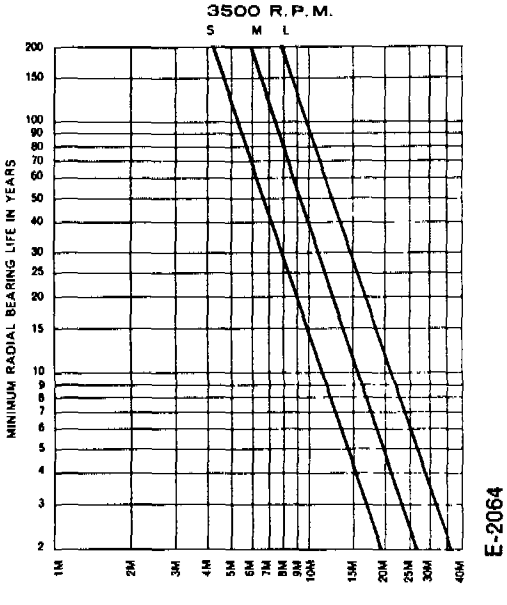


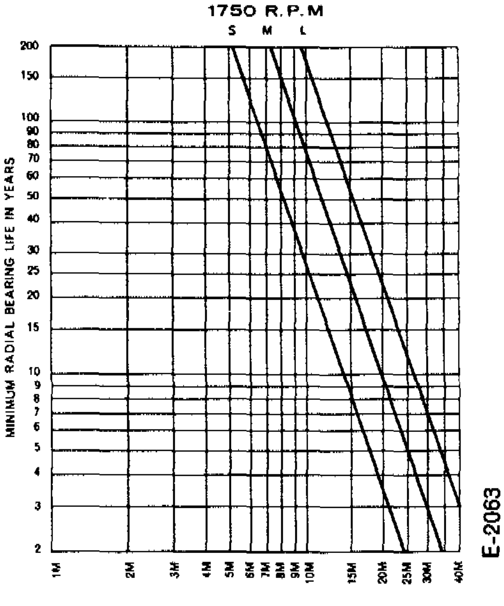
RADIAL BEARINGS

The inboard, or radial bearing is subject to radial load only. The two charts below show the minimum radial bearing life with the pump operating at zero flow and at rotative speeds indicated.

To find radial bearing life, proceed as follows:

1. Determine load factor "W" from chart "A" and steps 1 thru 4 on page 17.
2. Enter applicable chart below using load factor "W."
3. Read vertically up to the intersection with the required frame size.
4. Read horizontally to left to find the minimum radial bearing life in years.





BEARING LIFE CALCULATIONS

The design of the unit is such that under maximum load conditions, the calculated minimum bearing life will be not less than two years. Under average or minimum loads, the calculated minimum life of the bearings will be considerably greater.

Bearing manufacturers present data in the form of charts giving rated capacity in pounds at various RPM. This data makes it possible to calculate statistically the expected minimum life of the bearing. Minimum life is the service that 90% of a given size bearing will exceed for a given load condition. The life of 50% of the bearings will be five times the minimum life.

The minimum life of the bearing is calculated from:

$$\text{*Minimum life in years} = .057 \left(\frac{\text{rated capacity}}{\text{actual load}}\right)^3$$

For example, the maximum allowable load on the M frame radial bearing is 420 pounds. The radial bearing is a 309-S with a rated capacity of 1925 pounds at 3500 RPM.

The minimum life is:

$$M = .057 \left(\frac{1925}{420}\right)^3 = 5.5 \text{ years}$$

However, the load on the M frame radial bearing could go as low as 126 pounds and the minimum life would then be:

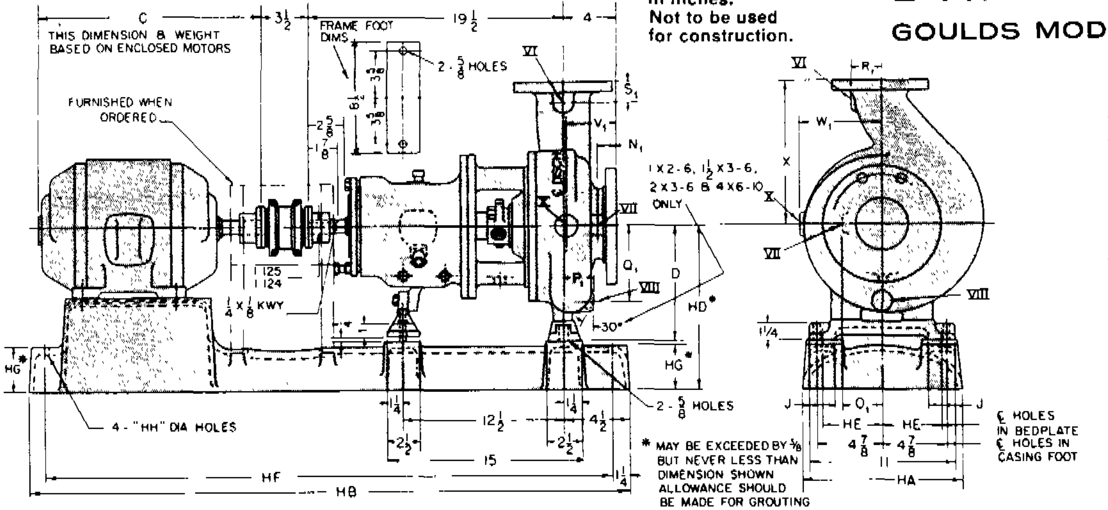
$$M = .057 \left(\frac{1925}{126}\right)^3 = 200 \text{ years}$$

*As defined by AFBMA

DIMENSIONS

GOULDS MODEL 3196-STD

All dimensions
in inches.
Not to be used
for construction.



* MAY BE EXCEEDED BY 1/8 BUT NEVER LESS THAN DIMENSION SHOWN ALLOWANCE SHOULD BE MADE FOR GROUTING AND BOLT LENGTH

150 LB FLANGE DIMENSIONS F F					
I D	O D	B C	THK	NO OF HOLES	SIZE OF HOLES
1	4 1/4	3 1/8	9/16	4	5/8
1 1/2	5	3 7/8	11/16	4	5/8
2	6	4 3/4	3/4	4	3/4
3	7 1/2	6	15/16	4	3/4
4	9	7 1/2	15/16	8	3/4
*6	11	9 1/2	1	8	7/8

* SUCTION FLANGE ON 4 X 6 10 & 4 X 6 13 HAS 8 3/4 10 NC TAPS

300 LB FLANGE DIMENSION F F					
I D	O D	B C	THK	NO OF HOLES	SIZE OF HOLES
1	4 7/8	3 1/2	11/16	4	3/4
1 1/2	6 1/8	4 1/2	13/16	4	7/8
2	6 1/2	5	7/8	8	3/4
3	8 1/4	6 5/8	1 1/8	8	7/8
△4	10	7 7/8	1 1/4	8	7/8
○6	12 1/2	10 5/8	1 7/16	12	7/8

△ SUCTION FLANGE ON 3 X 4 8 HAS 8 3/4 - 10 NC TAPS

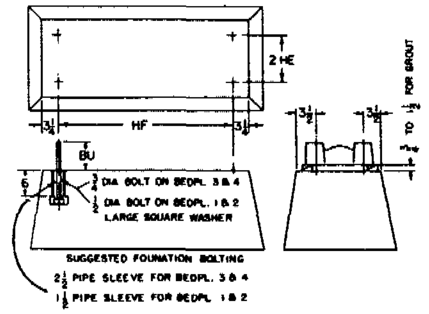
○ SUCTION FLANGE ON 4 X 6 10 & 4 X 6 13 HAS 12 3/4 - 10 NC TAPS

BED-PLATE NO	MOTOR FRAME	HA	HB	HD*		HE	HF	HG*	HH	C approx	APPROX WEIGHT OF BEDPLATE, CPLG, CPLG GUARD AND MOTOR
				6", 8" & 10" PUMPS +	11" & 13" PUMPS ‡						
1	143 T	12	45	12	13 3/4	4 1/2	42 1/2	3 3/4	3/4	12 1/2	155
	145 T	12	45			4 1/2	42 1/2	3 3/4	3/4	13 1/4	165
	182 182 T	12	45			4 1/2	42 1/2	3 3/4	3/4	14 5/8	175
	184 184 T	12	45			4 1/2	42 1/2	3 3/4	3/4	15 5/8	190
	213 213 T	12	45			4 1/2	42 1/2	3 3/4	3/4	17 3/4	240
	215 215 T	12	45			4 1/2	42 1/2	3 3/4	3/4	19 1/4	255
2	254 U 254 T	15	52	12 3/8	14 1/8	6	49 1/2	4 1/8	3/4	23 1/8	390
	256 U 256 T	15	52			6	49 1/2	4 1/8	3/4	25 1/8	430
	284 U 284 T	15	52			6	49 1/2	4 1/8	3/4	27	545
	284 TS	15	52			6	49 1/2	4 1/8	3/4	24 1/4	545
	286 U 286 T	15	52			6	49 1/2	4 1/8	3/4	29	555
	286 TS	15	52			6	49 1/2	4 1/8	3/4	25 3/4	555
3	324 U 324 T	18	58	13	14 3/4	7 1/2	55 1/2	4 3/4	1	30 3/8	700
	324 S 324 TS	18	58			7 1/2	55 1/2	4 3/4	1	27 5/8	700
	326 U 326 T	18	58			7 1/2	55 1/2	4 3/4	1	31 7/8	805
	326 S 326 TS	18	58			7 1/2	55 1/2	4 3/4	1	29 1/8	805
	364 U 364 T	18	58	14	14 3/4	7 1/2	55 1/2	4 3/4	1	33 5/8	940
	364 US 364 TS	18	58			7 1/2	55 1/2	4 3/4	1	31	940
	365 US 365 TS	18	58			7 1/2	55 1/2	4 3/4	1	32	995
4	404 US 404 TS	18	60	15	15	7 1/2	57 1/2	4 3/4	1	34 1/4	1220
	405 US 405 TS	18	60			7 1/2	57 1/2	4 3/4	1	35 3/4	1350
	444 US 444 TS	18	60	16	16	7	57 1/2	4 3/4	1	38 1/2	1535

‡ ALSO INCLUDES 4 X 6 - 10 + DOES NOT INCLUDE 4 X 6 - 10

C P NO	DISCH SIZE	SUCT SIZE	CAS CLASS	D	J	X	CASING PIPE TAP LOCATION								APPROX WEIGHT BARE PUMP USING VARIOUS FRAMES		
							N1	O1	P1	Q1	R1	S1	V1	W1	S	M	L
1	1	2	6	8 1/4	2 5/16	7	1 5/8	1 1/2	1 3/8	3 3/4	1	1 1/4	3 3/4	4 1/2	154	168	182
2	1 1/2	3	6			7 1/2	1 5/8	2	1 1/2	3 7/8	1 1/4	1 1/2	3 5/8	4 1/2	160	174	188
3	2	3	6			8 1/4	1 1/2	2	1 7/8	4	1 1/2	1 1/2	3 3/8	4 1/2	164	178	192
4	1	2	8		1 15/16	8 1/2	1 5/8	1 1/2	1 1/8	4 5/8	1	1 1/4	4	5 7/8	176	190	204
5	1 1/2	3	8			8 1/2	1 3/4	1 7/8	1 1/8	4 5/8	1 1/4	1 1/2	4	5 7/8	183	197	211
6	2	3	8			9 1/2	1 5/8	2	1 3/8	4 5/8	1 1/2	1 1/2	3 7/8	5 7/8	186	200	214
7	3	4	8G		2	11	1 5/8	2 5/8	1 7/8	5 1/4	2 1/8	1 3/4	3 3/4	5 7/8	206	220	234
8	3	4	8			11	1 3/8	2 3/4	2 3/8	5 7/8	2 1/8	1 3/4	3 3/8	6 1/8	206	220	234
15	1 1/2	3	10			8 1/2	1 5/8	2 1/8	1	5 3/8	1	1 3/8	4 1/4	6 3/4	203	217	231
16	2	3	10			9 1/2	1 5/8	2 1/8	1 1/8	5 5/8	1 3/8	1 3/8	4 1/8	6 3/4	216	230	244
17	3	4	10			11	1 5/8	2 5/8	1 1/2	5 7/8	1 3/4	1 7/8	4	6 3/4	250	264	278
	4	6	10	10	2 1/4	13 1/2	–	–	2 1/2	7 1/4	2 7/16	2 1/8	3 17/32	6 7/8		305	319
12	1 1/2	3	13		2	10 1/2	1 3/4	2 1/8	1	7	1 1/4	1 1/2	4 1/4	8 1/4		246	260
13	2	3	13		1 3/8	11 1/2	1 5/8	2 1/4	1 1/4	7 1/2	1 1/2	1 5/8	4 1/8	8 1/4		276	290
14	3	4	13		1 3/8	12 1/2	■1 3/8	■2 5/8	1 3/4	7 7/8	2 1/8	1 7/8	4	8 1/2		330	344
	4	6	13		3 1/2	13 1/2	–	–	2 3/8	8 3/8	2 1/2	2 1/8	3 7/8	8 11/16		405	419

SUGGESTED FOUNDATION



SUGGESTED FOUNATION BOLTING
2 1/2 PIPE SLEEVE FOR BEDPL. 3 & 4
1 1/2 PIPE SLEEVE FOR BEDPL. 1 & 2

BED-PLATE NO.	BU
1	6 1/4
2	6 5/8
3	7 1/2
4	7 1/2

NOTE
CASING SUPPLIED WITHOUT PIPE TAPS. TAPPED HOLE NOS VI, VII, VIII, & X CAN BE FURNISHED WHEN REQUIRED

▲ 3/8 - P TAP EXCEPT FOR SIZES 1 X 2 - 6 & 1 X 2 - 8 WHICH HAVE 1/4 P TAP

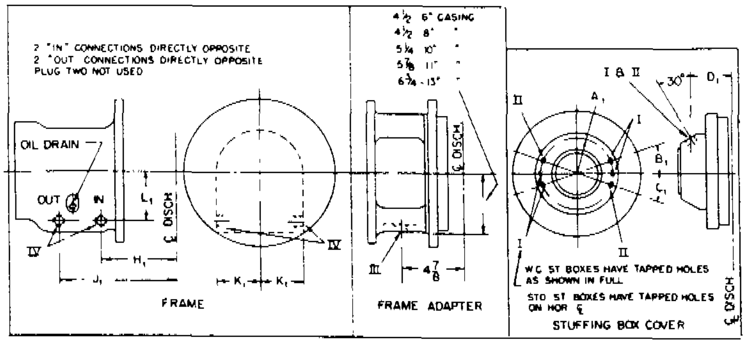
● 3/8 - P TAP EXCEPT SIZES 3 X 4 - 8 & 3 X 4 - 13 ARE 1/4 - P TAP 4 X 6 - 10 & 4 X 6 - 13 HAVE NO TAP

‡ 3/8 - P TAP - WHEN THIS HOLE IS FURNISHED IT IS DRILLED & TAPPED TO ACCOMMODATE SPECIAL GASKETED PIPE PLUG

■ SIZE 3 X 4 - 13 - 300# FLANGES N1 = 1 5/8 AND O1 = 3 1/4

NO	NO OF TAPS	PIPE TAP	PURPOSE
I	2	3/8	CONNECTION IN STUFFING BOX COVER FOR LANTERN RING OR MECH. SEAL FLUSHING - ALWAYS FURNISHED
II	2	3/8	CONNECTIONS FOR COOLING W.C ST BOX COV ONLY
III	1	1/2	FRAME ADAPTER DRAIN - ALWAYS FURNISHED
IV	4	1/2	FRAME COOLING - ALWAYS FURNISHED
V	2	1/4	QUENCH CONNECTION - PACKED STUFFING BOX GLAND
VI	1	▲	DISCHARGE NOZZLE GAUGE CONNECTION - WHEN SPECIFIED
VII	1	●	SUCTION NOZZLE GAUGE CONNECTION - WHEN SPECIFIED
VIII	1	‡	CASING DRAIN - WHEN SPECIFIED
IX	2	1/2	IN & OUT CONNECTION FOR MECHANICAL SEAL QUENCH GLAND - WHEN SPECIFIED
X	1	3/8	CONNECTION FOR STUFFING BOX CIRCULATING LINE - WHEN SPECIFIED.

	PIPE TAP LOCATION												
	STUFFING BOX COVER					GLAND PACKED BOX		FRAME				MECH SEAL QUENCH GLAND	
SHAFT SERIES	STD OR W C A1	STD 180° APART	W C 180° APART B1	W.C 180° APART C1	D1	E1	F1	H1	J1	K1	L1	T1	U1
S	2 3/8 RAD	HORIZ ℄	15°	15°	3 3/8	1 1/4	5	9 5/8	13 3/4	2 7/8	3 1/4	4 7/8	2 1/4
M	2 9/16 RAD	HORIZ ℄	20°	20°	3 1/4	1 1/2	4 7/8	9 7/8	13	3 1/8	3 1/2	4 5/8	2 1/2
L	2 9/16 RAD	HORIZ ℄	20°	20°	3 1/8	1 5/8	4 7/8	10	13 1/8	3 1/2	3 3/4	4 5/8	2 3/4

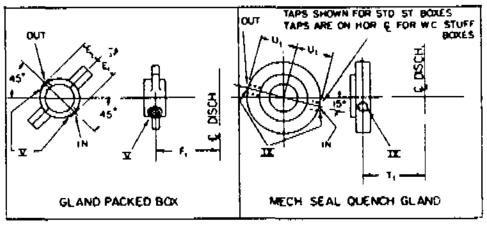


FRAME

FRAME ADAPTER

W C ST BOXES HAVE TAPPED HOLES AS SHOWN IN FULL
STD ST BOXES HAVE TAPPED HOLES ON HOR ℄

STUFFING BOX COVER



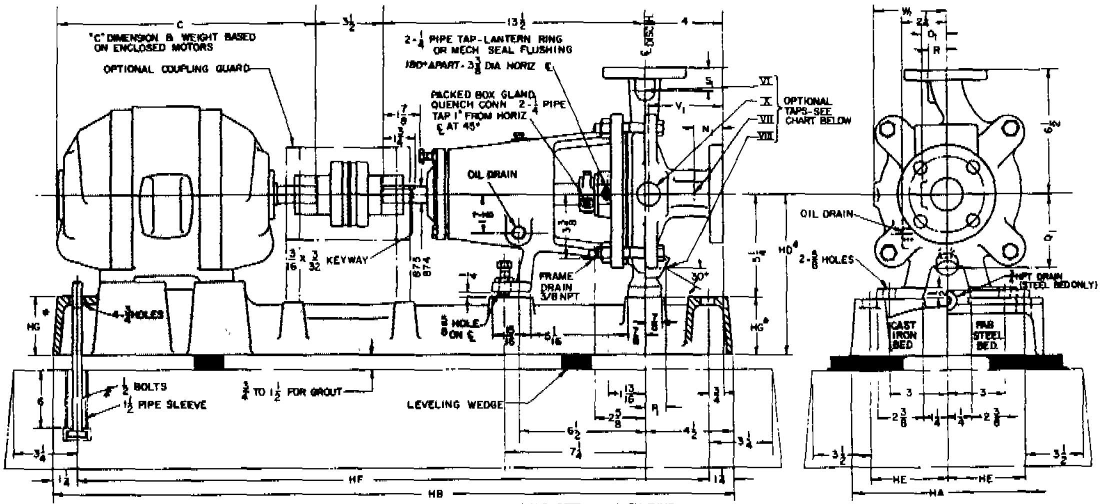
TAPS SHOWN FOR STD ST BOXES
TAPS ARE ON HOR ℄ FOR W C STUFF BOXES

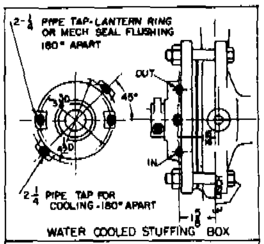
GLAND PACKED BOX

MECH SEAL QUENCH GLAND

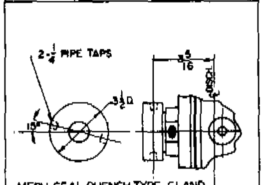
DIMENSIONS
GOULDS MODEL 3197-STD

All dimensions
in inches.
Not to be used
for construction.





WATER COOLED STUFFING BOX



MECH SEAL QUENCH TYPE GLAND

DIMENSIONS DETERMINED BY MOTOR & BEDPLATE

MOTOR FRAME SIZE	HA	HB	HD ●	HE	HF	HG ●	C	APPROX WGT OF BEDPLATE, CPLG CPLG GRD & MTR
56	10	36	8 1/4	4	32 1/2	3	11 7/8	125
143T							13	130
145T							13 1/2	130
182 182T							14 5/8	135
184							15 1/4	145
184T	12	39	8 1/2	4 1/2	36 1/2	3 1/4	16 3/8	155
213 213T							17 3/4	220
215 215T							19 1/4	235

DIMENSIONS DETERMINED BY PUMP

DISCH SIZE	SUCT SIZE	CASING CLASS	N1	O1	P1	Q1	R1	S1	V1	W1	A
1	1 1/2	6	1 5/8	1 3/8	1	3 3/4	1	1 1/4	4	3 3/4	60
1 1/2	3	6	1 5/8	2	1 3/8	3 7/8	1 1/8	1 1/2	3 7/8	3 7/8	70

● MAY BE EXCEEDED BY 3/8" BUT WILL NEVER BE LESS THAN DIMEN SHOWN ALLOWANCE FOR VARIANCE SHOULD BE MADE IN GROUTING AND FOUNDATION BOLT LENGTH.

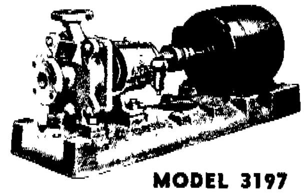
OPTIONAL CASING TAPS		
NO	SIZE	PURPOSE
VI	1/4	DISCHARGE GAGE
VII	1/4	SUCTION GAGE
VIII	3/8	CASING DRAIN
X	1/4	BY PASS TO S' BOX ℄

150 LB FLANGE DIMENSIONS (A S A STD EXCEPT FLAT FACED)

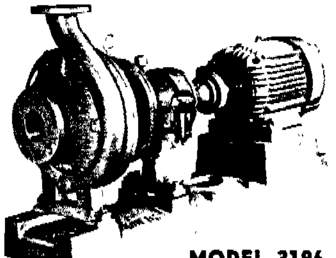
I D	O D	B C	THK	NO OF HOLES	SIZE OF HOLES
1	4 1/4	3 1/8	9/16	4	5/8
1 1/2	5	3 7/8	11/16	4	5/8
3	7 1/2	6	15/16	4	3/4

249-34

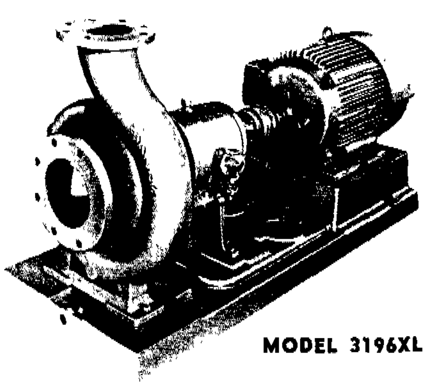
GOULDS COMPLETE LINE OF STANDARDIZED PROCESS PUMPS
Back Pull Out Design — Interchangeable Pump Dimensions



MODEL 3197



MODEL 3196



MODEL 3196XL

See Bulletin 725.1XL for model 3196XL coverage

GOULDS GP PUMPS

Goulds Pumps, Inc., Main Plant and Headquarters in Seneca Falls, N.Y. 13148

BRANCH SALES OFFICES: **ATLANTA**—1760 Tully Circle, N. E., Atlanta, Georgia 30329, **BATON ROUGE**—8520 Airway Drive., Baton Rouge, Louisiana 70806, **BOSTON**—1330 Beacon St., Brookline, Massachusetts 02146, **BUFFALO**—5554 Main St., Buffalo, New York 14221, **CHARLESTON**—1018 Kanawha Blvd E., Charleston, West Virginia 25301, **CHICAGO**—2439 Crescent Dr., Broadview, Illinois 60153, **CLEVELAND**—5061 West 161st Street, Cleveland, Ohio 44142, **DENVER**—2186 S. Holly St., Denver, Colorado 80222, **DETROIT**—15660 W. Ten Mile Rd., Southfield, Michigan 48075, **HOUSTON**—5828 Star Lane, Houston, Texas 77027, **LOS ANGELES**—3951 Capitol Ave., City of Industry, Calif 91747, **MONROE**—205 S. Stanley St., Monroe, Louisiana 71201, **NEW YORK**—341 Broad St., Clifton, N. J. 07013, **PHILADELPHIA**—354 Lancaster Ave., Haverford, Pennsylvania 19041, **PITTSBURGH**—223 Fourth Ave., Pittsburgh, Pennsylvania 15222, **RICHMOND**—5928 Nine Mile Rd., Richmond, Virginia 23223, **ST. LOUIS**—1401 S. Brentwood Blvd., St. Louis, Missouri 63144, **SAN FRANCISCO**—1043 Stuart St., LaFayette, California 94549, **TULSA**—4580 East 50th St., Tulsa, Oklahoma 74135, **PACIFIC NORTHWEST**—Goulds Pumps Western, Inc., 1919 N. W. Thurman St., Portland, Oregon 97209, **CANADA**—Beloit Goulds Division, Beloit Sorel Ltd., Quebec, Canada. **INTERNATIONAL SALES**—Export Dept., Seneca Falls, New York 13148.

CCR 000008025

FORM 8486-EL SUP. 7999-EL 10M FLP

PRINTED IN U.S.A.

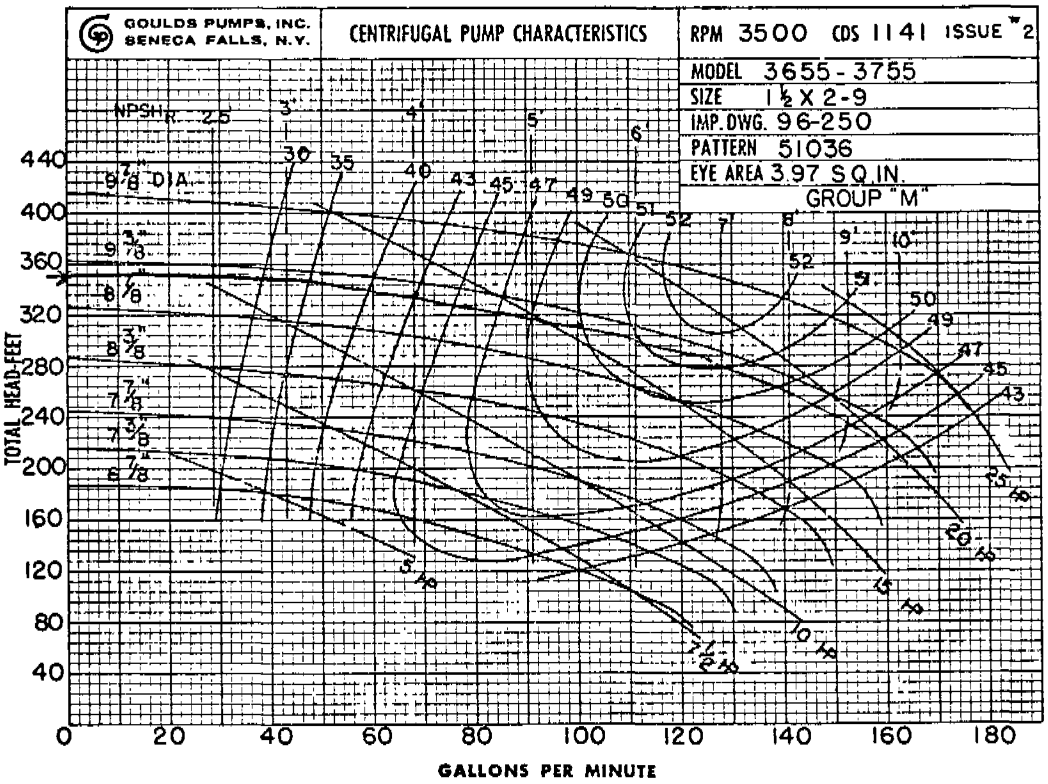
GOULDS MODEL 3655-3755 PERFORMANCE CURVES 60 Cycle Speeds

710.1C6

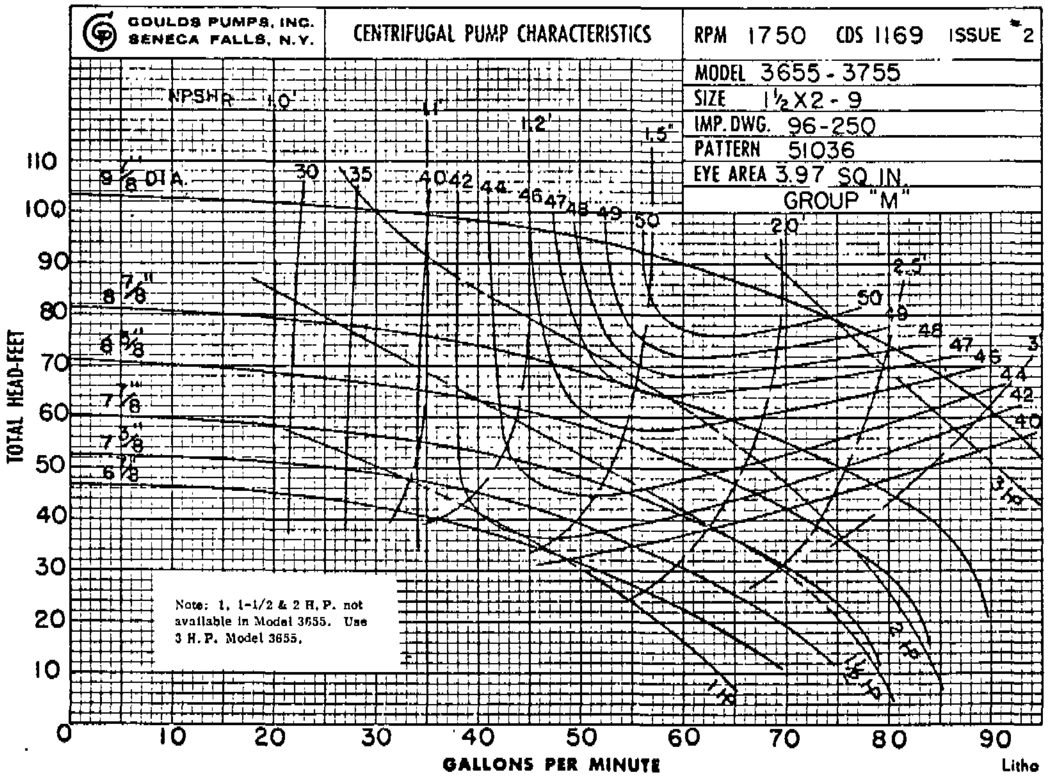
August 26, 1968
(Sup. 710.1C6 of 5/14/68)

CUSTOMER ....

ITEM ....
SERVICE ....
GPM ....
HEAD ....
EFFICIENCY ....
RPM ....
....



3500 R.P.M.



Note: 1, 1-1/2 & 2 H.P. not available in Model 3655. Use 3 H.P. Model 3655.

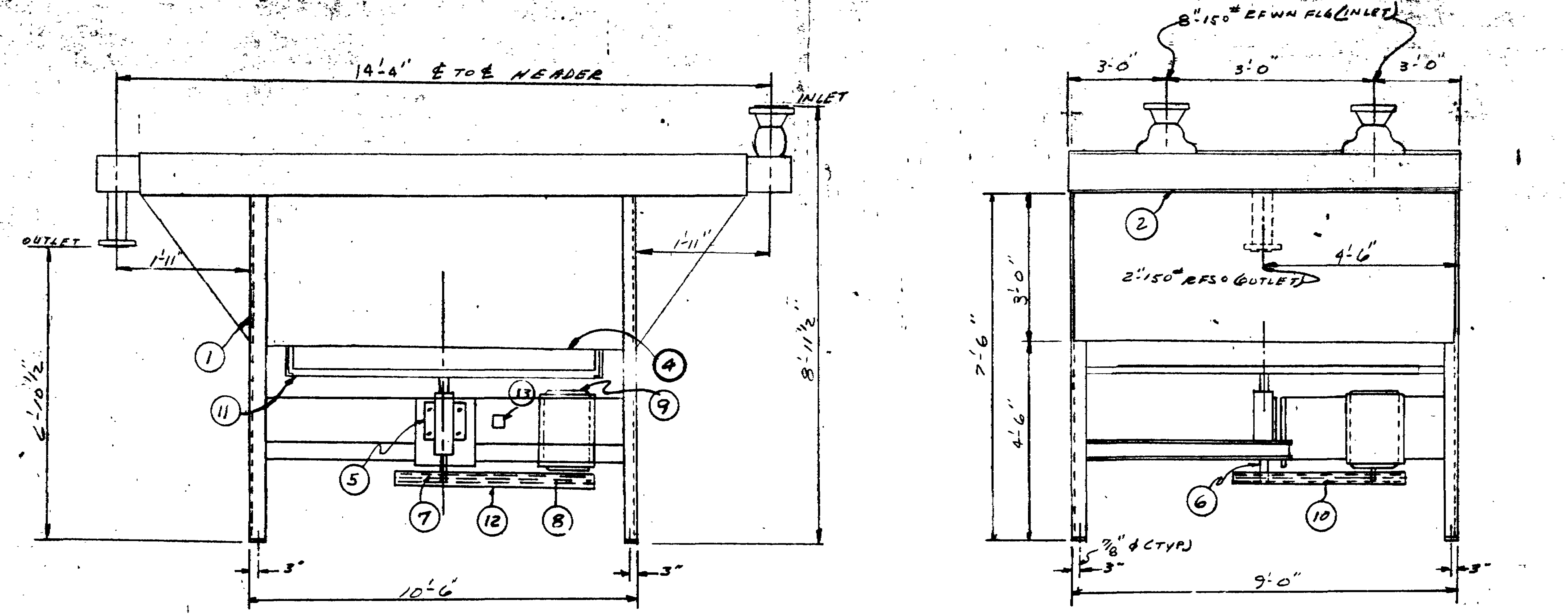
1750 R.P.M.

CCR 00008026

GOULDS PUMPS INC.

Seneca Falls,
New York, U.S.A.

Litho in U. S. A.



BILL OF MATERIALS

MARK	REQ'D	MAKE	DESCRIPTION
1	1	CON-RAD	STRUCTURE:
2	1	CON-RAD	SECTION 2(8"-150# RF INLET) 1(2"-150# RF OUTLET)
3			
4	1	CHECO	FAN: 8' DIA 4BL RH ROTATION
5	1	DODGE	BEARING: 2 3/16"ɸ F&B PILLOW BLOCK
6	1	CON-RAD	SHAFT: 2 3/16"ɸ
7	1		FAN SHEAVE 19" DIA. 3V 3 GROOVE
8	1		MOTOR SHEAVE 5" DIA. 3V 3 GROOVE
9	1		MOTOR 15.0 HP. 1800 RPM 480/3/60 TEFC.
10	1 SET OF 3		BELTS 3V900
11	1	CON-RAD	FAN GUARD 1½ #13 EXP. MTL.
12	1	CON-RAD	BELT GUARD 1½ #13 EXP. MTL.
13	1	NELSON	VIBRATION SWITCH 7ANMCA
14			

ALL DIM ± 1/8"

ONE REQ'D.

DWN R.J.
CKD DB
J.W. Raynolds 12-12-9
JOB 6835
PO 7036 L
DATE 12-9-69

MODEL 1BF 914S8

FOR Continental Oil Co.

CON-RAD
division of U S INDUSTRIES, INC.

DWG B-6835-A

LOW PRESSURE CONDENSER (ASSUME S-502 ALL CONDENSATE AT 150# for Btu VALUE)

1/

39,558 #/HR — 13,472,976 Btu/HR

$$\begin{cases} x + y = 39{,}558 \\ 1150.+x + 180.07y = 13{,}472{,}976 \end{cases}$$

x 970.33 = 6349840

$$x = \frac{13{,}472{,}976 - 180.07(39558)}{970.33} = 6544 \text{ lbs vapor/HR}$$

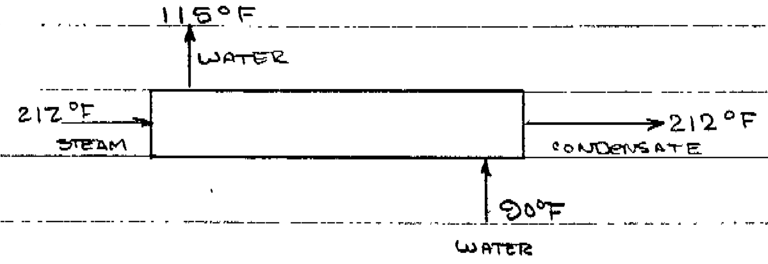
$$\left(\text{FRACTION VAPOR} = \frac{6544}{39558} = 0.165\right)$$

Add 10% 7200 lbs vapor/HR

CONDENSER Duty 7200 lbs/HR x 970.33 Btu/lb = 6,986,376 Btu/HR

~ 7,000,000 Btu/HR

WATER



$$\text{LMTD} = \frac{(212-90)-(212-115)}{\ln\frac{122}{97}} = \frac{25}{\ln 1.26} = 108.23$$

$\Delta T_{LM} = 108$

NOTE: ASSUMING 25° TEMP rise IN WATER AND U = 100

$$\text{AREA} = \frac{7{,}000{,}000}{(100)(108)} = 648 — 650 \text{ ft}^2$$

WATER (CONT.)

WATER NECESSARY

$$Q = WC_p\Delta T$$

$$W = \frac{7,000,000}{(1)(25)} = 280,000 \text{ lbs}/_{HR}$$

$$gpm = \frac{280,000 \text{ lbs}}{hr} \times \frac{1 \text{ hr}}{60 \text{ MIN}} \times 0.01610 \frac{ft^3}{lb} \times 7.48 \frac{gal}{ft^3}$$

$$= 562 \text{ gpm} \qquad (4'' \rightarrow)$$

(33720gph)

METHODS
I - CHURNS
II - NPGSA
III - AIMEO

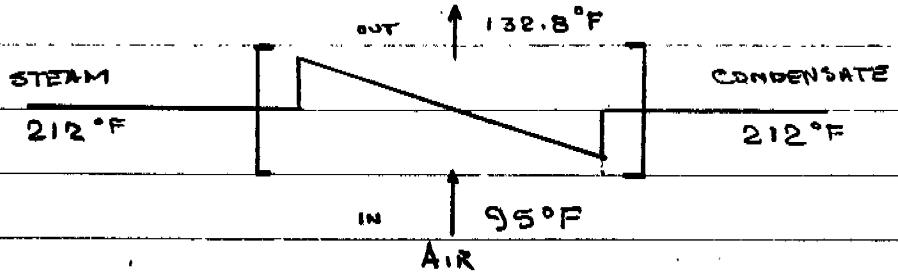
AIR TEMP - 95° F

AIR CONDENSER

METHOD I

$$\text{AIR RISE} = 0.328\,(\text{PROCESS AVERAGE} - \text{AIR TEMP})$$

$$= 0.323(212 - 95) = 37.79$$



$$LMTD = \frac{(212-95) - (212-132.8)}{\ln \frac{117}{79.2}} = \frac{37.8}{0.392} = 96.43$$

* from AIMCO

Use A $U = 4.25$

$$\text{FINNED AREA} = \frac{Q}{U\,\Delta T} = \frac{7,000,000}{4.25 \times 96.4}$$

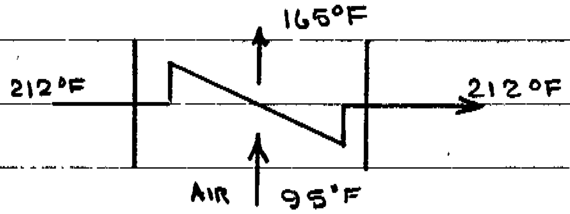
$A_{FINNED} = 17,086\ Ft^2$ *$\sim \$ = 7470$

$$A_{Bare} = \frac{17,086}{15} = 1139\ Ft^2$$

* $HP = 0.7\,(17.086) = 11.96$

METHOD II AIR RISE = 70°F

$U_{BARETUBE} = 135$



$$LMTD = \frac{(212-95)-(212-165)}{\ln\frac{117}{47}} = \frac{70}{\ln 2.49} = 76.67$$

$$A_{Bare} = \frac{7,000,000}{(135)(76.67)} = 676.3\ Ft^2$$

$A_{FINNED} = 676.3 \times 15 = 10,145\ Ft^2$

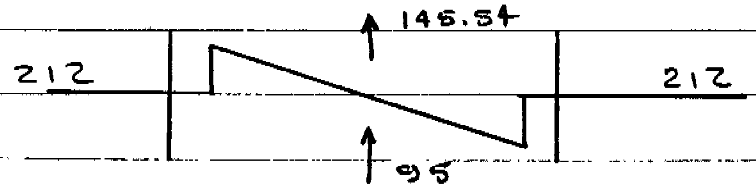
* $\sim \$ = 0.56 \times 10,145 = \$5681$

* $H.P. = 0.7\,(10,145) = 7.1$

METHOD III $U = 4.5$ (STM + NON COND.)

$$\text{AIR RISE} = 0.096 \times U \times (\text{PROCESS } \overset{\text{TEMP}}{\text{AVERAGE}} - \text{AIR } \overset{\text{TOMP}}{\text{INLET}})$$

$$\text{AIR RISE} = 50.54$$



$$\text{LMTD} = \frac{50.54}{\ln \frac{117}{66.5}} \doteq 89.45$$

$$\text{FINNED AREA} = \frac{7{,}000{,}000}{(4.5)(89.45)} = 17{,}390 \ ft^2$$

$$\text{BARE AREA} = 17{,}390/15 = 1159 \ ft^2$$

* Price = 0.43 (17390) = \$7478

* H.P. = 17.39 × .7 = 12.2 H.P.

CONDENSER SPECIFICATIONS

CONDENSER NO.:

SERVICE: LOW PRESSURE STEAM CONDENSER

STREAM	SHELL	TUBE
MATERIAL:	LOW PRESSURE STEAM	WATER
RATE (lbs/HR):	11,730	
°API:		
WEIGHT % VAPOR IN/OUT:	100 / 0	0 / 0
VISCOSITY (cp) IN/OUT:		
DENSITY (lbs/ft³) IN/OUT:		
PRESSURE (PSIG) OUT:		
MAXIMUM PRESSURE DROP (PSI):		
DESIGN PRESSURE (PSIG):	16	
DESIGN TEMPERATURE (°F):	300	
NOZZLE SIZES (IN) IN/OUT:	6 / 3	
LMTD (°F):	108	
COEFFICIENT (Btu/Hr ft² °F):	100	
DUTY (M Btu/HR):	11,410,000	
SURFACE AREA (ft²):	1060	
EXCHANGER TYPE:	SHELL AND TUBE	
TUBE BUNDLE TYPE:		
TUBE SIZE:		
TUBE GAUGE:		
TUBE PITCH:		
MATERIAL OF CONSTRIKTION		
TUBES:	CS	
TUBESHEET:	CS	
SHELL:	CS	
BAFFLES:	CS	
CORROSION ALLOWANCE:	1/8	

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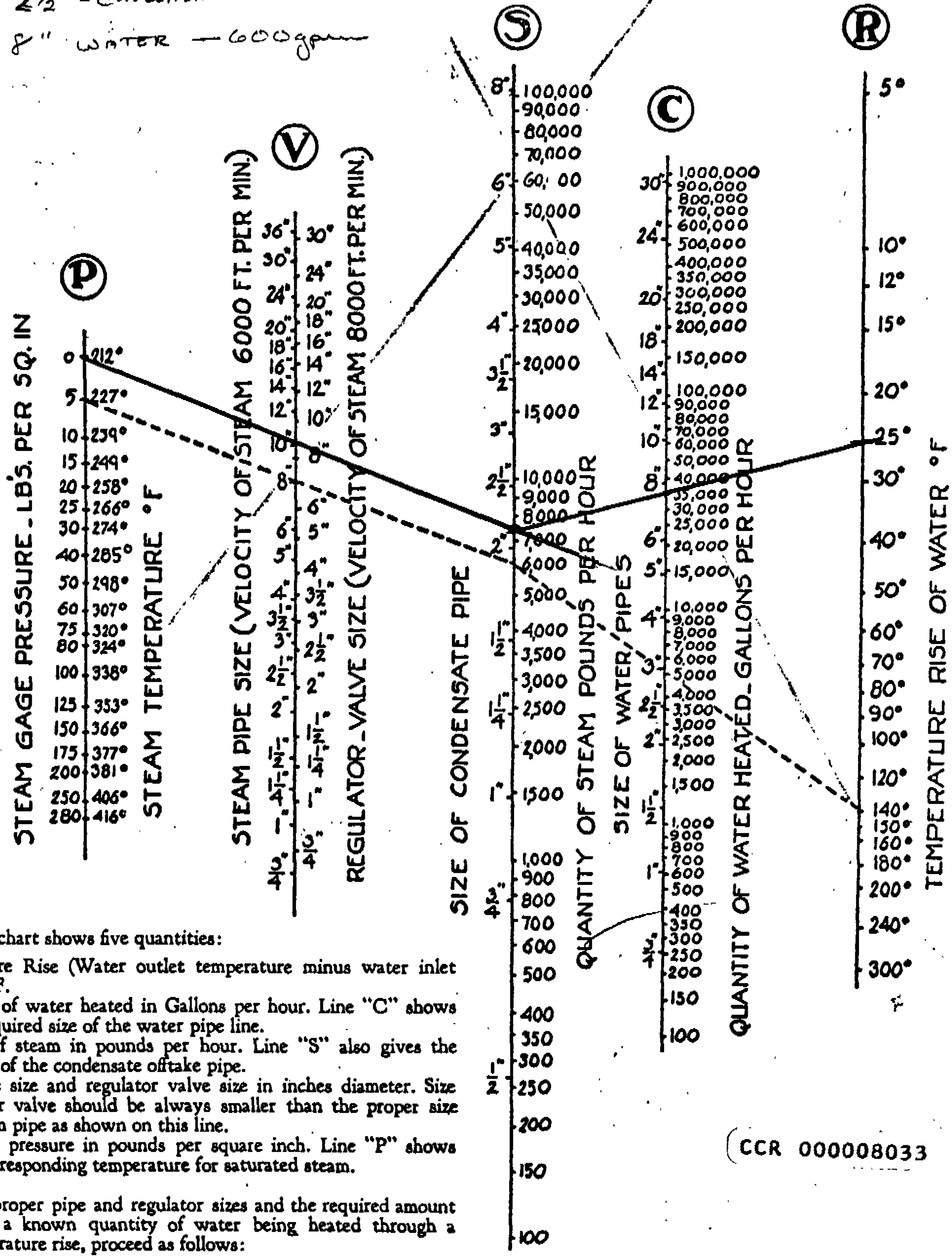
13-231-PB

7200# ATM STEAM
10" STEAM NOZZLE
2½" - CONDENSATE NOZZLE
8" WATER — 600gpm



The above chart shows five quantities:

R—Temperature Rise (Water outlet temperature minus water inlet temp.) in °F.

C—Quantities of water heated in Gallons per hour. Line "C" shows also the required size of the water pipe line.

S—Quantity of steam in pounds per hour. Line "S" also gives the proper size of the condensate offtake pipe.

V—Steam pipe size and regulator valve size in inches diameter. Size of regulator valve should be always smaller than the proper size of the steam pipe as shown on this line.

P—Steam gage pressure in pounds per square inch. Line "P" shows also the corresponding temperature for saturated steam.

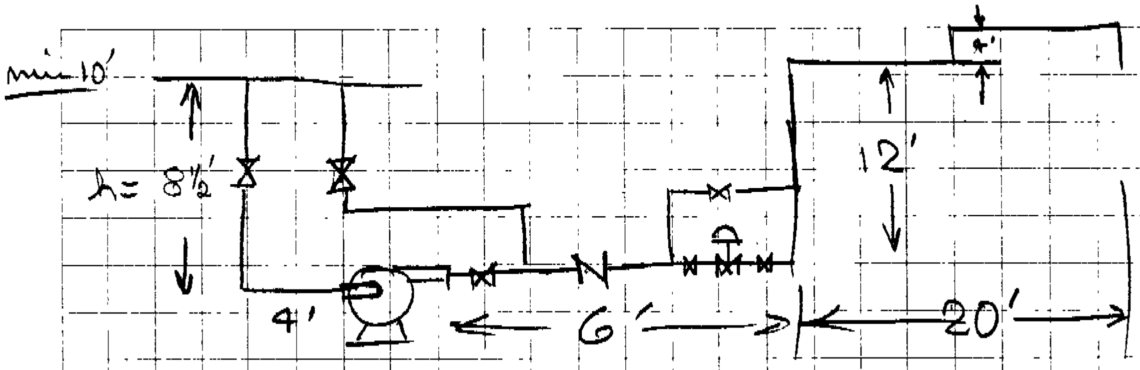
To find the proper pipe and regulator sizes and the required amount of steam for a known quantity of water being heated through a desired temperature rise, proceed as follows:

Connect with a straight edge lines "R" and "S" intersecting "R" at the desired temperature range and "C" at the known quantity of water being heated; read on "C" the required water pipe size and on "S" the steam consumption and required condensate pipe size; connect lines "S" and "P" with a straight edge intersecting "S" at the found quantity of steam and "P" at the known steam gage pressure or its corresponding temperature, read on line "V" the required steam pipe and regulator valve size.

The example indicated by the dotted line shows that 5,000 Gallons of water heated from 40 to 180 Degrees F., with steam at 5# Gage pressure require 6,000# of steam per hour, that the steam pipe should be 8", the regulator valve 6", the condensate piping 2" and the water inlet and outlet piping 3".

*C.R. BERNSTROM, INC.

100 gpm Condensate pump



Assume 3" pipe h = 8½

{100 gpm design
 85 gpm normal

$\mu = 0.3\text{cp} @ 212°F$

$\rho = 59.81 \text{ lbs/ft}^3$

$d = 3.068 \text{ in}$

$Q = 100 \text{ gpm}$

$$Re = 50.6 \frac{Q\rho}{d\mu}$$

$$Re_{100} = \frac{50.6(100)(59.81)}{(3.068)(0.3)} = 3.28 \times 10^5 \qquad f = 0.0185$$

$$Re_{85} = 2.8 \times 10^5 \qquad f = 0.019$$

$$\Delta P_{100} = \frac{0.0216 f \rho Q^2}{d^5} \qquad d^5 = 271.8$$

$(\Delta P_{100} = 0.879)_{100\text{gpm}}$

$(\Delta P_{100} = 0.652)_{85\text{gpm}}$

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	L/
12½' pipe	12.50
1 elbow (L/D = 30)	7.67
1 valve (L/D = 13)	3.32
	23.5

(Suction) $\Delta P_{100 gpm} = 0.21$ $h = \frac{0.21(144)}{59.81} = 0.51$

$\Delta P_{85 gpm} = 0.153$ $h = \frac{0.153(144)}{59.81} = 0.37$

$NPSH_{100 gpm} = 8.50 - 0.51 = 7.99$

$NPSH_{85 gpm} = 8.50 - 0.37 = 8.13$

Suction pressures

100 gpm = 3.32 psig

85 gpm = 3.38 psig

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Discharge line pressure 110 psig (265')

3" line

50' pipe	50'
5 elbows (L/D = 30)	38.4'
3 tees (L/D = 20)	15.4'
~~3~~ valves L/D = 13	10.0
1 CK Valve	35
1 control valve (ΔP = 10 psig)	24'
	173'

$\Delta P_{100gpm} = 1.52$ psig 3.53 ft

$\Delta P_{85gpm} = 1.13$ psig 2.63 ft

Discharge pressure @ 100gpm

$h_{D_{100gpm}} = 265 + 3.53 + 7.99 + 16 + 24 = 316.52$

$\Delta P = 131.47$

$h_{D_{85gpm}} = 265 + 2.63 + 8.13 + 16 + 24 = 315.76$

$\Delta P = 131.15$

pump $\Delta P_{100} = 131.47 - 3.32 = 128.15$ } 128 psig

pump $\Delta P_{85} = 131.15 - 3.38 = 127.77$

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! Pump Sizing

pump ΔP = 130 psig

	Normal	Design
NPSH	8.13	7.99
$\Delta P_{\text{suction}}$	3.38	3.32
$\Delta P_{\text{discharge}}$	131.15	131.47

Pump

100 gpm

130 psi ΔP = 313 ft

NPSH available 7'

Temp. 212

Cast Iron

Max. Suction pressure 6 psig – 14'

Max. impeller not acceptable

Water Horsepower = $QH\rho \div 247{,}000$

$= 100(313)(59.81) \div (247{,}000) = \underline{7.58}$

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September 8, 1969

Mr. George Furgeson
Placement Director
Louisiana State University
College of Engineering
Baton Rouge, Louisiana

Sir:

The enclosed project entitled "Low Pressure Condensate System" has been successfully completed by Mr. John C. Lunn, Jr. during his employment at the VCM Plant of Continental Oil Company. The project has been reviewed by the plant management and is now approved for construction. It is expected that work on this project will start in late October and, hopefully, will be completed by the end of 1969.

We consider the report to be a good, complete study and design project and recommend that it be accepted as proof of completion of Chris' Engineering Practice Number 149 course.

Very truly yours,

JDM

John D. Minatt
Sr. Process Engineer
Continental VCM Plant

JDM-MC
cc: Mr. R. H. Gerlach
Attachment

low pressure condensate system

Design:

1) all piping sized assuming total condensate at equipment pressure flashed to atmospheric pressure.

2) all lines assumed horizontal (gives greater pressure drop)

3) condensate rate assumed 10% greater than Design rate (process P+I) for each equipment source

OPERATING PRESSURES — LOW PRESSURE CONDENSATE SYSTEM

'69	TIME	EDC TS S104A/B	VINYL TS S208A/B	OXY VENT HEATER	HCl REB. H-205	HCl (OXY) PREHEAT H-309	FINISHING REAC. FEED HEATER H304	ETHYLENE (OXY) PREHEAT H308
7/30	1230	45	5		10	17		23
	1500	7	5		16	20	36	26
	1630	4	7		20	18	39	27
7/31	0800	45	8		20	18	38	23
	1000	45	8		20	17	38	21
	1115	45	8		20	17	38½	25
	1230	45	8		20	17	38½	21
	1330	45	8		20	17	38½	26
	1600	5	5		22	17	38	26
8/1	0800	40	8		19	18	49	9
	1000	35	7		26	17	43	22
	1230	40	7		23	17	48	24
	1430	38	7		23	17	47½	13
	1600	38	7		24	17	44½	23
8/2	0800	42	10		29	18	46½	34
	1000	42	11		29	17	48	34
	1230	45 avg	15		29	17	48	34

28

16

130#

96

145

(120)

48 30

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$1 ft\ H_2O = 0.434\ psi$

OPERATING PRESSURES

LOW PRESSURE CONDENSATE RECOVERY

[illegible]	[illegible] 9104 A/B	VINYL [illegible] 9208 A/B	HCL [illegible] H-208	ETH. PREHEAT H-308	HCL PREHEAT H-309	FINISHING [illegible] S-309	FINISHING [illegible] HEATER H-304	OXY UNIT HEATER H-310	OXY [illegible] S301-5	150 lb STM S-502	[illegible]
	35	5	14	18	66	15	48				
)	5	5	15	18	73	15	49				
:0	5	5	16	3	70	15	49				
25	5	5	14	18	58	15	49				
00	5	5	5	3	49	15	49				
20	5	3	15	18	46	15	49				
00	28	5	15	18	47	15	49				
45	32	5	16	17	36	16	49				
:45	32	5	15	17	36	15	49				
.00	34	5	17	17	36	10	49				
00	20	8	15	18	64	15	48				
100			15	17	72	15	49				
'30	26	5	15	18	73	15	48				
1:00	15	0	15	17	68	15	[illegible]				
5:00	25	5	14	18	45	15	48				
0:15	22	5	15	18	60	15	49				
1:15	22	6	16	18	46	20	49				
4:15	30	5	15	17	42	15	49				
8:00	28	8	17	17	62	15	49				
10:45	28	8	15	17	69	15	49				
1:01	0		16	17	34	15	49				
3/5	30		15	17	22	15	48				

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CALCULATION SHEET

TITLE Operating Pressures

Low Pressure Condensate Recovery

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JOB NO.

FIELD VCM

STATE

LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION △1

W = 20228 lbs/HR W + 10%W = 22250 lbs/HR

ω = 5.62 lbs/SEC ω + 10%ω = 6.18 lbs/SEC

Q = 10,989,279 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 20228 \\ 1150.4x + 180.07y = 10,989,279 \end{cases}$$

$$x = \frac{(10,989,279) - (20,228)\,180.07}{970.33}$$

VOLUME

$x = \underline{7571} \times 26.8 \qquad = 202903$

$y = \underline{12657} \times 0.01672 \qquad = \underline{212}$

TOTAL = 203115 } = LVF = 0.001

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
4"	12.3×10^4	0.0048	2.7×10^6	0.0041
6"	8.2×10^4	0.0050	1.79×10^6	0.0038

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JOB NO.

* TWOPHASE FLOW – METHOD OF CHENOWETH AND MARTIN PET. REF FIELD OCT-1955

STATE

1

③	PIPE DIAMETER	4"		6"			
	LENGTH 65'	L/D = 194		L/D = 129		L/D =	
	K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
1	GATE VALVES L/D=13	0.21	4.36	0.19	6.57		
	ELBOWS (90°) L/D= 30						
2	TEE (RUN) L/D=20	0.62	13.42	0.6	20.24		
1	TEE (BRANCH) L/D=60	1.0	20.13	0.9	30.32		
	OTHER						
1	ENTRANCE	0.5	8.74	0.5	12.6		
	TOTAL	2.33	46.75	2.19	69.73		
	TOTAL + EQ. LENGTH		112		135		

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△

④ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{F L}{D} + \Sigma K\right]$$

FROM GRAPH

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	$\Delta P_{TP}/\Delta P_L^*$
4	ψ_G	(0.0041)(194) + 2.33 =	3.13	x 1603 =	1539	490
	ψ_L	(0.0048)(194) + 2.33 =	3.26			
6	ψ_G	(0.0038)(129) + 2.19 =	2.68	x 1603 =	1513	490
	ψ_L	(0.0050)(129) + 2.19 =	2.84			
	ψ_G	( )( ) + =		x 1603 =		
	ψ_L	( )( ) + =				

⑤ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*		$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
	$\frac{2.25\times10^{-7}(0.0048)(112)(22250)^2}{(1058)}$ =	0.056	x	490	=	27.4
	$\frac{2.25\times10^{-7}(0.0050)(135)(22250)^2}{(8206)}$ =	0.0092	x	490	=	4.49
	$\frac{2.25\times10^{-7}(\quad)(\quad)(\quad)^2}{(\quad)}$ =		x		=	

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CALCULATION SHEET

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LOW PRESSURE C NDENSATE SYSTEM*

PIPE SECTION △2

W = 6570 lbs/HR   W + 10%W = 7227 lbs/HR

ω = 1.83 lbs/SEC   ω + 10%ω = 2.01 lbs/SEC

Q = 6,171,975 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 6570 \\ 1150.4x + 180.07y = 6,171,975 \end{cases}$$

$$x = \frac{(6,171,975) - (6570)180.07}{970.33}$$

VOLUME

$x = 5141 \times 26.8 = 137,791$

$y = 1429 \times 0.01672 = 24$

TOTAL = 137,814 } = LVF = 0.00017

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
3"	5.25×10^4	0.0053	7.46×10^5	0.0044
4"	4.0×10^4	0.0055	8.74×10^5	0.0042

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* TWOPHASE FLOW — METHOD OF CHENOWETH AND MARTIN PET. REF. OCT-1955

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2

③ PIPE DIAMETER	3"		4"			
LENGTH 30'	L/D = 133		L/D = 89.4		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALVES L/D = 13						
1 ELBOWS (90°) L/D = 30	0.62	7.67	0.50	10.07		
1 TEE (RUN) L/D = 20	0.35	5.11	0.32	6.71		
1 TEE (BRANCH) L/D = 60	1.10	15.34	1.0	20.13		
OTHER						
TOTAL	1.97	28.12	1.82	36.91		
TOTAL + EQ. LENGTH		58		67		

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△2

CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER	ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
3″	ψ_G (0.0044)(133) + 1.97 =	$\frac{2.56}{2.67}$	x 1603 =	1534	1800
	ψ_L (0.0053)(133) + 1.97 =				
4″	ψ_G (0.0042)(89.4) + 1.82 =	$\frac{2.20}{2.31}$	x 1603 =	1524	1800
	ψ_L (0.0055)(89.4) + 1.82 =				
	ψ_G ( )( ) + =		x 1603 =		
	ψ_L ( )( ) + =				

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000{,}000{,}225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
3″	$\frac{2.25 \times 10^{-7} (0.0053)(58)(7227)^2}{(271.8)}$ =	0.013	x 1800	=	24
4″	$\frac{2.25 \times 10^{-7} (0.0055)(67)(7227)^2}{(1058)}$ =	0.0041	x 1800	=	7.37
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)}$ =		x	=	

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~ 90' pipe

PE SECTION $\triangle 3$

W
5000 lbs/HR

W + 10%
5500 lbs/HR
ω = 1.53 lbs/sec

	d	Re
2"	2.067	5.93×10^4
3"	3.068	4×10^4

	F	d^5
2"	0.023	37.72
3"	0.0235	271.8

$$\Delta P = 0.00000336 \frac{f L W^2 \bar{V}}{d^5}$$

$$\textcircled{3''} \quad \Delta P = \frac{3.36 \times 10^{-6} (0.0235)(90)(5500)^2(26.8)}{271.8} = 21$$

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CONTINENTAL OIL COMPANY
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TITLE

FIELD

OF

STATE

LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION 4

$W = 8950$ lbs / HR $W + 10\%W = 9845$ lbs / HR

$\omega = 2.50$ lbs / SEC $\omega + 10\%\omega = 2.73$ lbs / SEC

$Q = 2{,}403{,}073$ Btu / HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 8950 \\ 1150.4\,x + 180.07\,y = 2{,}403{,}073 \end{cases}$$

$$x = \frac{(2403073) - (8950)\,180.07}{970.33}$$

VOLUME

$$x = 816 \times 26.8 = 21859$$

$$y = 8134 \times 0.01672 = 136$$

$$\text{TOTAL} = 21995$$

$$\text{LVF} = 0.0062$$

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\, A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
3"	7.14×10^4	0.0051	1.01×10^6	0.0043
4"	5.43×10^4	0.0052	1.19×10^6	0.0041

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* TWOPHASE FLOW – METHOD OF CHENOWETH AND MARTIN PET. REFFIELD OCT-1955

△4

③ PIPE DIAMETER	3"		4"			
LENGTH 90'	L/D = 352		L/D = 268		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALVES L/D=13						
ELBOWS (90°) L/D= 30						
TEE (RUN) L/D = 20						
4 TEE (BRANCH) L/D= 60	4.40	61.36	4.0	80.52		
OTHER						
TOTAL	4.40	61.86	4.0	80.52		
TOTAL + EQ. LENGTH		151		171		

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Δ

CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{F L}{D} + \Sigma K\right]$$

Pipe Diameter		ψ		$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
3"	ψ_G	$(0.0043)(352) + 4.4 =$	$\left.\frac{5.91}{6.195}\right\} \times 1603 =$	1530	80
	ψ_L	$(0.0051)(352) + 4.4 =$			
4"	ψ_G	$(0.0041)(268) + 4.0 =$	$\left.\frac{5.10}{5.39}\right\} \times 1603 =$	1516	80
	ψ_L	$(0.0052)(268) + 4.0 =$			
	ψ_G	$(\quad)(\quad) + \quad =$	$\left.\frac{\quad}{\quad}\right\} \times 1603 =$		
	ψ_L	$(\quad)(\quad) + \quad =$			

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F

L_{eq} - EQUIVALENT LENGTH

Pipe Diameter		ΔP_L^*		$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
3"	$\frac{2.25\times10^{-7}(0.0051)(151)(5845)^2}{(271.8)} =$	0.062	x	80	=	4.94
4"	$\frac{2.25\times10^{-7}(0.0052)(171)(5845)^2}{(1058)} =$	0.016	x	80	=	1.29
	$\frac{2.25\times10^{-7}(\quad)(\quad)(\quad)^2}{(\quad)} =$		x		=	

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION △S

W = 2800 lbs/HR W + 10%W = 3080 lbs/HR

ω = 0.78 lbs/SEC ω + 10%ω = 0.86 lbs/SEC

Q = 947800 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 2800 \\ 1150.4x + 180.07y = 947{,}800 \end{cases}$$

$$x = \frac{(947{,}800) - (2800)\,180.07}{970.33}$$

			VOLUME
$x = 457$	× 26.8	=	12,252
$y = 2343$	× 0.01672	=	39
		TOTAL =	12291

} = LVF = 0.0031

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\ A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
3"	2.25×10^4	0.0063	3.19×10^5	0.0045
4"	1.71×10^4	0.0068	3.74×10^5	0.0043

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③ PIPE DIAMETER	3"		4"			
LENGTH 75'	L/D = 293		L/D = 224		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALUES L/D = 13						
ELBOWS (90°) L/D = 30						
TEE (RUN) L/D = 20						
1 TEE (BRANCH) L/D = 60	1.10	15.34	1.0	20.13		
OTHER						
3×4 SW.	0.15	2				
TOTAL	1.25	17.34	1.0	20.13		
TOTAL + EQ. LENGTH		92		95		

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△5

[illegible] CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER	ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
3"	ψ_G (0.0045)(293) + 1.25 =	2.57	x 1603 =	1330	150
	ψ_L (0.0063)(293) + 1.25 =	3.10			
4"	ψ_G (0.0043)(224) + 1.0 =	1.96	x 1603 =	1250	150
	ψ_L (0.0068)(224) + 1.0 =	2.52			
	ψ_G ( )( ) + =		x1603 =		
	ψ_L ( )( ) + =				

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*		$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
3"	$\frac{2.25\times10^{-7}(0.0063)(92)(3080)^2}{(271.8)}$ =	0.0045	X	150	=	0.68
4"	$\frac{2.25\times10^{-7}(0.0068)(95)(3080)^2}{(1068)}$ =	0.013	X	150	=	0.20
	$\frac{2.25\times10^{-7}(\quad)(\quad)(\quad)^2}{(\quad)}$ =		X		=	

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION $\triangle$6

W = 1400 lbs/HR   W + 10% W = 1540 lbs/HR

ω = 0.39 lbs/SEC   ω + 10% ω = 0.43 lbs/SEC

Q = 473,900 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1400 \\ 1150.4\,x + 180.07\,y = 473{,}900 \end{cases}$$

$$x = \frac{(473\,900) - (1400)\,180.07}{970.33}$$

			VOLUME
$x = 228.6$	× 26.8	=	6126
$y = 1171$	× 0.01672	=	19.6
		TOTAL =	6145.6

$\} = \text{LVF} = 0.0032$

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\,A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
2"	1.67×10^4	0.0070	3.64×10^5	0.0050
3"	1.12×10^4	0.0075	1.6×10^5	0.0047

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6

③ PIPE DIAMETER	2"		3"			
LENGTH 320	L/D = 1858		L/D = 1251		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT (ft) LENGTH
GATE VALUES L/D = 13						
7 ELBOWS (90°) L/D = 30	3.64	53.7	3.50	70.5		
TEE (RUN) L/D = 20						
TEE (BRANCH) L/D = 60						
OTHER						
SW 2×3	0.30	2				
TOTAL	3.94	55.7	3.50	70.5		
TOTAL + EQ. LENGTH		376		391		

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⑥

Ⓐ CALCULATION OF $\Delta P_{TP} / \Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K \right]$$

PIPE DIAMETER	ψ				$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP} / \Delta P_L^*$
2"	ψ_G	$(0.0050)(1858) + 3.94 =$	13.23	$\times 1603 =$	1255	140
	ψ_L	$(0.0070)(1858) + 3.94 =$	16.9			
3"	ψ_G	$(0.0047)(1251) + 3.5 =$	9.38	$\times 1603 =$	1167	140
	ψ_L	$(0.0075)(1251) + 3.5 =$	12.88			
	ψ_G	$(\quad)(\quad) + \quad =$		$\times 1603 =$		
	ψ_L	$(\quad)(\quad) + \quad =$				

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000{,}000{,}225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP} / \Delta P_L^*$	ΔP_{TP}
2"	$\frac{2.25 \times 10^{-7} (0.007)(376)(1540)^2}{(37.72)} =$	0.037	× 140 =	5.18
USE → 3"	$\frac{2.25 \times 10^{-7} (0.0075)(391)(1540)^2}{(271.8)} =$	0.0058	× 140 =	0.81
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		× =	

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION △7

W = 2350 lbs/HR   W + 10%W = 2593 lbs/HR

ω = 0.65 lbs/SEC   ω + 10%ω = 0.72 lbs/SEC

Q = 795,475 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 2350 \\ 1150.4x + 180.07y = 795475 \end{cases}$$

$$x = \frac{(795475) - (2350)180.07}{970.33}$$

VOLUME

$x = 384 \times 26.8 = 10,283$

$y = 1966 \times 0.01672 = 33$

TOTAL = 10316

$\} = \text{LVF} = 0.0032$

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1 1/2"	3.64×10^4	0.0065	7.8×10^5	0.0053
2"	2.79×10^4	0.0062	6.1×10^5	0.0048

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△7

③ PIPE DIAMETER	1½"		2"			
LENGTH 115	L/D = 857		L/D = 668		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
2 GATE VALVES L/D=13	0.54	3.48	0.5	4.48		
5 ELBOWS (90°) L/D = 30	3.0	20.15	2.85	25.6		
TEE (RUN) L/D = 20						
1 TEE (BRANCH) L/D = 60	1.25	8.05	1.20	10.33		
OTHER						
ENTRANCE	0.5	3.0	0.5	3.5		
TOTAL	5.29	34.68	5.05	43.91		
TOTAL + EQ. LENGTH		150		159		

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△7

④ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{F L}{D} + \Sigma K\right]$$

PIPE DIAMETER	ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
	ψ_G (0.0053)(857) + 5.29 = ψ_L (0.0065)(857) + 5.29 =	$\frac{9.83}{10.86}$	x 1603 =	1450	140
	ψ_G (0.0048)(668) + 5.05 = ψ_L (0.0062)(668) + 5.05 =	$\frac{8.26}{9.19}$	x 1603 =	1440	140
	ψ_G ( )( ) + = ψ_L ( )( ) + =		x 1603 =		

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*		$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
$1\frac{1}{2}$"	$\frac{2.25 \times 10^{-7} (0.0065)(150)(2593)^2}{(10.82)}$ =	0.136	x	140	=	19.1
2"	$\frac{2.25 \times 10^{-7} (0.0062)(159)(2593)^2}{(37.72)}$ =	0.04	x	140	=	5.53
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)}$ =		x		=	

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PIPE SECTION B

W = 1308 lbs/HR   W + 10%   1440 lbs/hr

EQUATION 3-10 CRANE

$$\Delta P = 0.000,000,0363 \; \frac{d+3.6}{d^6} \; W^2 L \bar{V}$$

L = 22 ft

$\bar{V}$ = 26.8

6" d = 6.065

$$\Delta P = 0.000,000,0363 \left(\frac{9.665}{(6.065)^6} \right) (1440)^2 (22)(26.8)$$

$$\Delta P = 3.63 \times 10^{-8} \left(\frac{9.665}{49771} \right) (1440)^2 (22)(26.8) = 0.009$$

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LOW PRESSURE C NDENSATE SYSTEM *

PIPE SECTION (9)

W = 1570 lbs/HR　　W + 10%W = 1727 lbs/HR

ω = 0.44 lbs/SEC　　ω + 10%ω = 0.48 lbs/SEC

Q = 419,975 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1570 \\ 1150.4x + 180.07y = 419{,}975 \end{cases}$$

$$x = \frac{(419975) - (1570)180.07}{970.33}$$

VOLUME

$x = 141 \times 26.8 = 3791$

$y = 1429 \times 0.01672 = 24$

TOTAL = 3815

$\}$ = LVF = 0.0062

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu \; A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1 1/2"	2.43×10^4	0.0069	5.2×10^5	0.0054
2"	1.86×10^4	0.0068	4.1×10^5	0.0048

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2

③	PIPE DIAMETER	1 1/2		2"			
	LENGTH 45'	L/D = 335		L/D = 261		L/D =	
	K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
1.	GATE VALVES L/D=13	0.27	1.74	0.25	2.24		
5	ELBOWS (90°) L/D= 30	3.0	20.15	2.85	25.85		
	TEE (RUN) L/D = 20						
1	TEE (BRANCH) L/D= 60	1.25	8.05	1.20	10.33		
	OTHER						
	TOTAL	4.52	29.94	4.30	38.42		
	TOTAL + EQ. LENGTH		75		83		

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Ⓐ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER		ψ		$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
1 1/2	ψ_G	$(0.0054)(335) + 4.52 =$	$\frac{6.33}{6.83}$ x 1603 =	1485	80
	ψ_L	$(0.0069)(335) + 4.52 =$			
2	ψ_G	$(0.0048)(261) + 4.3 =$	$\frac{5.55}{6.08}$ x 1603 =	1463	80
	ψ_L	$(0.0068)(261) + 4.3 =$			
	ψ_G	( )( ) + =	x 1603 =		
	ψ_L	( )( ) + =			

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
1 1/2	$\frac{2.25 \times 10^{-7} (0.0069)(75)(1727)^2}{(10.82)} =$	0.032	x 80 =	2.56
2	$\frac{2.25 \times 10^{-7} (0.0068)(83)(1727)^2}{(37.72)} =$	0.01	x 80 =	0.80
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		x =	

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LOW PRESSURE CONDENSATE SYSTEM

PIPE SECTION △10

W = 1200 lbs/HR — W + 10%W = 1320 lbs/HR

ω = 0.33 lbs/SEC — ω + 10%ω = 0.37 lbs/SEC

Q = 321000 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1200 \\ 1150.4x + 180.07y = 321000 \end{cases}$$

$$x = \frac{(321000) - (1200)180.07}{970.33}$$

$$\begin{array}{lllll} & & & & \text{VOLUME} \\ x = & 108 & \times 26.8 & = & 2898 \\ y = & & \times 0.01672 & = & 18 \\ & & & \text{TOTAL} = & 2916 \end{array} \Bigg\} = \text{LVF} = 0.0062$$

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu \; A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1 1/2"	1.87×10^4	0.0073	4×10^5	0.0054
2"	1.43×10^4	0.0071	3.1×10^5	0.0050

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△10

③ PIPE DIAMETER						
LENGTH 35'	L/D = 261		L/D = 203		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT (ft) LENGTH
2 GATE VALVES L/D=13	~~0.54~~	~~3.48~~	~~0.50~~	~~4.48~~		
4 ELBOWS (90°) L/D=30	2.40	16.12	2.28	20.68		
TEE (RUN) L/D=20						
1 TEE (BRANCH) L/D=60	1.25	8.05	1.20	10.33		
OTHER						
ENTRANCE	0.5	2.3	0.5	3.03		
EXIT	1.0	4.6	1.0	6.06		
TOTAL	5.69	34.55	5.48	44.58		
TOTAL + EQ. LENGTH		70		80		

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Ⓐ CALCULATION OF $\Delta P_{TP} / \Delta P_L^*$

$$\psi = \left[\frac{F L}{D} + \Sigma K \right]$$

FROM GRAPH

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L} \frac{\rho_L}{\rho_G}$	$\Delta P_{TP}/\Delta P_L^*$
	ψ_G	$(0.0054)(261)+5.69 =$	7.10	x 1603 =	1497	80
	ψ_L	$(0.0073)(261)+5.69 =$	7.60			
	ψ_G	$(0.0050)(203)+5.48 =$	6.50	x 1603 =	1504	80
	ψ_L	$(0.0071)(203)+5.48 =$	6.92			
	ψ_G	$(\quad)(\quad)+\quad =$		x 1603 =		
	ψ_L	$(\quad)(\quad)+\quad =$				

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F

L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
1 1/2"	$\frac{2.25 \times 10^{-7} (0.0073)(70)(1320)^2}{(10.82)} =$	0.0185 x	80 =	1.48
2"	$\frac{2.25 \times 10^{-7} (0.0071)(80)(1320)^2}{(37.72)} =$	0.0059 x	80 =	0.47
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$	x	=	

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CONTINENTAL OIL COMPANY
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TITLE

JOB NO. CCR 000008067

FIELD

STATE

LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION $\triangle$11

W = 3900 lbs/HR   W + 10% W = 4290 lbs/HR

ω = 1.08 lbs/SEC ω + 10% ω = 1.19 lbs/SEC

Q = 853,398 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 3900 \\ 1150.4x + 180.07y = 853{,}398 \end{cases}$$

$$x = \frac{(853{,}398) - (3900)\,180.07}{970.33}$$

VOLUME

$x = 156 \times 26.8 = 4174$

$y = 3744 \times 0.01672 = 63$

TOTAL = 4237

} = LVF = 0.015

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\, A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
3"	3.11×10^4	0.0059	4.4×10^5	0.0045
4"	2.37×10^4	0.0062	5.2×10^5	0.0043

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JOB No.
TITLE * TWOPHASE FLOW — METHOD OF CHENOWETH AND MARTIN
PET. REF FIELD OCT-1955
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13-231-PS

△11

③ PIPE DIAMETER	3"		4"			
LENGTH 35'	L/D = 137		L/D = 104		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT (ft) LENGTH
2 GATE VALVES L/D = 13	0.46	6.64	0.42	8.72		
2 ELBOWS (90°) L/D = 30	1.04	14.34	1.0	20.14		
TEE (RUN) L/D = 20						
1 TEE (BRANCH) L/D = 60	1.10	15.34	1.0	20.13		
OTHER						
TOTAL	2.6	36.32	2.42	48.99		
TOTAL + EQ. LENGTH		71		84		

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CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
3"	ψ_G	$(0.0045)(137)+2.6=$	3.22	x 1603 =	1510	38
	ψ_L	$(0.0059)(137)+2.6=$	3.41			
4"	ψ_G	$(0.0043)(104)+2.42=$	2.87	x 1603 =	1500	38
	ψ_L	$(0.0062)(104)+2.42=$	3.065			
	ψ_G	$(\quad)(\quad)+\quad=$		x 1603 =		
	ψ_L	$(\quad)(\quad)+\quad=$				

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*		$\Delta P_{TP}/\Delta P_L^*$		ΔP_{TP}
3"	$\frac{2.25\times10^{-7}(0.0059)(74)(4290)^2}{(271.8)}=$	0.0066	x	38	=	0.25
4"	$\frac{2.25\times10^{-7}(0.0062)(84)(4290)^2}{(1058)}=$	0.002	x	38	=	0.076
	$\frac{2.25\times10^{-7}(\quad)(\quad)(\quad)^2}{(\quad)}=$		x		=	

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JOB NO.

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LOW PRESSURE C NDENSATE SYSTEM*

PIPE SECTION △ 12

$W = 1050$ lbs/HR $W + 10\%W = 1155$ lbs/HR

$\omega = 0.29$ lbs/SEC $\omega + 10\%\omega = 0.32$ lbs/SEC

$Q = 280,875$ Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1050 \\ 1150.4x + 180.07y = 280,875 \end{cases}$$

$$x = \frac{(280,875) - (1050)\,180.07}{970.33}$$

VOLUME

$$x = 94.6 \times 26.8 = 2536$$

$$y = 955 \times 0.01672 = 16$$

TOTAL = 2562 } = LVF = 0.0062

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu \, A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1½"	1.62×10^4	0.0075	3.49×10^5	0.0054
2"	1.24×10^4	0.0072	2.7×10^6	0.0044

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* TWO PHASE FLOW — METHOD OF CHENOWETH AND MARTIN PET. REF. OCT-1955

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③ PIPE DIAMETER	1 1/2"		2"			
LENGTH 54'	L/D = 402		L/D = 314		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
1. GATE VALUES L/D = 13	0.27	1.74	0.25	2.24		
4 ELBOWS (90°) L/D = 30	2.4	16.12	2.28	20.68		
TEE (RUN) L/D = 20						
1 TEE (BRANCH) L/D = 60	1.25	8.05	1.20	10.33		
OTHER						
TOTAL	3.92	25.91	3.73	33.25		
TOTAL + EQ. LENGTH		80		87		

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△2

⑦ CALCULATION OF $\Delta P_{TP} / \Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K \right]$$

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L} \frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP} / \Delta P_L^*$
1 1/2	ψ_G	(0.0054)(402) + 3.92 =	6.09	} x 1603 =	1550	80
	ψ_L	(0.0075)(402) + 3.92 =	6.28			
2"	ψ_G	(0.0044)(314) + 3.73 =	5.11	} x 1603 =	1370	80
	ψ_L	(0.0072)(314) + 3.73 =	5.99			
	ψ_G	( )( ) + =		} x 1603 =		
	ψ_L	( )( ) + =				

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP} / \Delta P_L^*$	ΔP_{TP}
1 1/2	$\frac{2.25 \times 10^{-7} (0.0075)(80)(1155)^2}{(10.82)} =$	0.017	x 80	= 1.33
2"	$\frac{2.25 \times 10^{-7} (0.0072)(87)(1155)^2}{(37.72)} =$	0.0049	x 80	= 0.39
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		x	=

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LOW PRESSURE CONDENSATE SYSTEM

PIPE SECTION $\triangle$ 13

W = 1400 lbs/HR W + 10% W = 1540 lbs/HR

ω = 0.39 lbs/SEC ω + 10% ω = 0.43 lbs/SEC

Q = 473,900 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1400 \\ 1150.4x + 180.07y = 473,900 \end{cases}$$

$$x = \frac{(473,900) - (1400)180.07}{970.33}$$

VOLUME

$x = 228.6 \times 26.8 = 6126$

$y = 1171 \times 0.01672 = 19.6$

TOTAL = 6145.6 } = LVF = 0.0032

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1"	1.68×10^{4}	0.0076	3.67×10^{5}	0.0058
2"	1.67×10^{4}	0.0070	3.64×10^{5}	0.0050

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* TWOPHASE FLOW – METHOD F
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PET. REF FIELD OCT-1955

3

	Ⓐ		Ⓑ			
③ PIPE DIAMETER	1"		1"		2"	
LENGTH	(8) L/D = 92		(21) L/D = 240		(54) L/D = 314	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALVES L/D = 13	① 0.3	1.14	① 0.3	1.14	① 0.25	2.24
ELBOWS (90°) L/D = 30	② 1.36	5.24	③ 2.04	7.86	⑥ 3.42	31.07
TEE (RUN) L/D = 20	② .90	3.50	③ 1.35	5.25		
TEE (BRANCH) L/D = 60	① 1.40	5.24	3.42		① 1.20	10.33
OTHER						
Check Values (L/D = 135)	3.0	11.80	3.0	11.80		
TOTAL	6.96	26.92	10.11	26.05	4.87	43.59
TOTAL + EQ. LENGTH		35		47		98

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Ⓐ CALCULATION OF $\Delta P_{TP} / \Delta P_L^*$

$$\psi = \left[\frac{F L}{D} + \Sigma K \right]$$

FROM GRAPH

PIPE DIAMETER		ψ			$\frac{\psi_G}{\psi_L} \frac{\rho_L}{\rho_G}$	$\Delta P_{TP} / \Delta P_L^*$
Ⓐ 1"	ψ_G	(0.0058)(92) + 6.96 =	7.49	x 1603 =	1580	140
	ψ_L	(0.0069)(92) + 6.96 =	7.595			
Ⓑ 1"	ψ_G	(0.0058)(240) + 10.11 =	11.50	x 1603 =	1570	140
	ψ_L	(0.0069)(240) + 10.11 =	11.77			
Ⓒ 2"	ψ_G	(0.0050)(313) + 4.87 =	6.435	x 1603 =	1470	140
	ψ_L	(0.0070)(313) + 4.87 =	7.01			

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*		$\Delta P_{TP} / \Delta P_L^*$		ΔP_{TP}
Ⓐ 1"	$\frac{2.25 \times 10^{-7} (0.0076)(35)(770)^2}{(1.27)} =$	0.027	x	140	=	3.85
Ⓑ 1"	$\frac{2.25 \times 10^{-7} (0.0076)(47)(770)^2}{(1.27)} =$	0.0374	x	140	=	5.24
2"	$\frac{2.25 \times 10^{-7} (0.0070)(98)(1540)^2}{(37.72)} =$	0.0102	x	140	=	1.43

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION △14

$W =$ 1400 lbs/HR $W + 10\%W =$ 1540 lbs/HR

$\omega =$ 0.39 lbs/SEC $\omega + 10\%\omega =$ 0.43 lbs/SEC

$Q =$ 473,900 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 1400 \\ 1150.4x + 180.07y = 473{,}900 \end{cases}$$

$$x = \frac{(473{,}900) - (1400)\,180.07}{970.33}$$

VOLUME

$x = 228.6 \times 26.8 = 6126$

$y = 1171 \times 0.01672 = 19.6$

TOTAL $= 6145.6$ } = LVF = 0.0032

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\ A}$$

	PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
0.22	1''	1.68×10^4	0.0076	3.67×10^5	0.0058
	$1\frac{1}{2}$''	2.17×10^4	0.0070	4.69×10^5	0.0057

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△

	(A)		(B)			
③ PIPE DIAMETER	1"		1"		1 1/2	
LENGTH	(10) L/D = 114		(25) L/D = 286		(32) L/D = 238	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
GATE VALVES L/D = 13	① 0.3	1.14	① 0.3	1.14	① 0.27	1.74
ELBOWS (90°) L/D = 30	① 0.68	2.62	③ 2.04	7.86	⑤ 3.0	20.15
TEE (RUN) L/D = 20	① 0.45	1.75				
TEE (BRANCH) L/D = 60	① 1.40	5.24	② 2.80	10.48		
OTHER						
TOTAL	2.83	10.75	5.14	19.48	3.27	21.89
TOTAL + EQ. LENGTH		21		45		54

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CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

PIPE DIAMETER		ψ		$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	FROM GRAPH $\Delta P_{TP}/\Delta P_L^*$
Ⓐ 1"	ψ_G	$(0.0058)(114) + 2.83 =$	$\frac{3.49}{3.696}$ x 1603 =	1510	150
	ψ_L	$(0.0076)(114) + 2.83 =$			
Ⓑ 1"	ψ_G	$(0.0058)(286) + 5.14 =$	$\frac{6.80}{7.31}$ x 1603 =	1490	150
	ψ_L	$(0.0076)(286) + 5.14 =$			
1 1/2	ψ_G	$(0.0054)(238) + 3.27 =$	$\frac{4.56}{4.94}$ x 1603 =	1480	150
	ψ_L	$(0.0070)(238) + 3.27 =$			

Ⓑ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
Ⓐ 1"	$\frac{2.25\times10^{-7}(0.0076)(21)(770)^2}{(1.27)} =$	0.0167	x 150 =	2.51
Ⓐ 1"	$\frac{2.25\times10^{-7}(0.0076)(45)(770)^2}{(1.27)} =$	0.036	x 150 =	5.39
1 1/2"	$\frac{2.25\times10^{-7}(0.0070)(54)(1540)^2}{(10.82)} =$	0.019	x 150 =	2.79

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION △B

W = 16980 lbs/HR　　　W + 10%W = 18678 lbs/HR

ω = 4.72 lbs/SEC　　　ω + 10%ω = 5.19 lbs/SEC

Q = 5,747,730 Btu/HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 16980 \\ 1150.4\,x + 180.07\,y = 5,747,730 \end{cases}$$

$$x = \frac{(5,747,730) - (16980)\,180.07}{970.33}$$

VOLUME

$$x = 2772 \times 26.8 = 74300$$

$$y = 14208 \times 0.01672 = 238$$

TOTAL = 74538 } = LVF = 0.0032

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu\,A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
2"	2.01×10^5	0.005	4.40×10^6	0.0047
3"	1.36×10^5	0.0047	1.93×10^6	0.0044

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③ PIPE DIAMETER	2"					
LENGTH	70' L/D = 522		L/D =		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
4 GATE VALUES L/D = 13	1.70	8.96				
7 ELBOWS (90°) L/D = 30	3.99	36.19				
2 TEE (RUN) L/D = 20	0.76	6.88				
TEE (BRANCH) L/D = 60						
OTHER						
2 entrances K = 0.5	1.0	6.71				
1 exit K = 1.0	1.0	6.71				
TOTAL	7.75	65.45				
TOTAL + EQ. LENGTH		135				

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$\triangle\!\!\!\!\!\!\;5$

⑦ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

FROM GRAPH

PIPE DIAMETER	ψ	$\frac{\psi_G}{\psi_L}\frac{\rho_L}{\rho_G}$	$\Delta P_{TP}/\Delta P_L^*$
2''	ψ_G (0.0047)(522) + 7.75 = 10.2 ψ_L (0.005)(522) + 7.75 = 10.36 } x 1603 =	1580	145
	ψ_G ( )( ) + = ψ_L ( )( ) + = } x 1603 =		
	ψ_G ( )( ) + = ψ_L ( )( ) + = } x 1603 =		

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
2''	$\frac{2.25\times10^{-7}(0.005)(135)(18678)^2}{(37.72)}$ =	1.4	x 145 =	203
	$\frac{2.25\times10^{-7}(\ \ )(\ \ )(\ \ )^2}{(\ \ )}$ =		x =	
	$\frac{2.25\times10^{-7}(\ \ )(\ \ )(\ \ )^2}{(\ \ )}$ =		x =	

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LOW PRESSURE CONDENSATE SYSTEM*

PIPE SECTION $\triangle$ 16

W = 3400 lbs / HR W + 10% W = 3740 lbs / HR

ω = 0.944 lbs / SEC ω + 10% ω = 1.04 lbs / SEC

Q = 909500 Btu / HR

① CALCULATION OF LIQUID VOLUME FRACTION (LVF)

$$\begin{cases} x + y = 3400 \\ 1150.4x + 180.07y = 909500 \end{cases}$$

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$$x = \frac{(909500) - (3400)180.07}{970.33}$$

VOLUME

x = 306.5 × 26.8 = 8214

y = 3093 × 0.01672 = 52

TOTAL = 8268

} = LVF = 0.0063

② CALCULATION OF REYNOLDS NUMBER AND FRICTION FACTOR (PERRY 5-20)

$$Re = \frac{D(\omega_L + \omega_G)}{\mu \, A}$$

PIPE DIAMETER	Re_L	F_L^*	Re_G	F_G^*
1 ½"	5.26×10^4	0.0062	1.13×10^6	0.0052

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PIPE DIAMETER	1 1/2"					
LENGTH (20)	L/D = 116		L/D =		L/D =	
K-FACTORS	K	EQUIVALENT LENGTH (ft)	K	EQUIVALENT LENGTH (ft)	K	(ft) EQUIVALENT LENGTH
① GATE VALUES L/D=13	0.27	1.74				
② ELBOWS (90°) L/D= 30	1.20	8.06				
TEE (RUN) L/D = 20						
① TEE (BRANCH) L/D=60	1.25	8.05				
OTHER						
TOTAL	2.72	17.85				
TOTAL + EQ. LENGTH		37.85				

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⑦ CALCULATION OF $\Delta P_{TP}/\Delta P_L^*$

$$\psi = \left[\frac{FL}{D} + \Sigma K\right]$$

FROM GRAPH

PIPE DIAMETER		ψ	$\frac{\psi_G}{\psi_L}\frac{P_L}{P_G}$	$\Delta P_{TP}/\Delta P_L^*$
	ψ_G	(0.0052)(116) +2.72 = 3.323 } x 1603 =	1548	80
	ψ_L	(0.0062)(116) +2.72 = 3.439		
	ψ_G	( )( ) + = } x 1603 =		
	ψ_L	( )( ) + =		
	ψ_G	( )( ) + = } x 1603 =		
	ψ_L	( )( ) + =		

⑧ CALCULATION OF ΔP_L^*

CRANE 3-2

$$\Delta P_L^* = 0.00000336 \frac{F L W^2 \bar{V}}{d^5}$$

$$\Delta P_L^* = 0.000000225 \frac{F W^2 L_{eq}}{d^5}$$

FANNING F
L_{eq} - EQUIVALENT LENGTH

PIPE DIAMETER		ΔP_L^*	$\Delta P_{TP}/\Delta P_L^*$	ΔP_{TP}
	$\frac{2.25 \times 10^{-7} (0.0062)(37.85)(3740)^2}{(10.82)} =$	0.068	x 80 =	5.46 4.3
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		x =	
	$\frac{2.25 \times 10^{-7} (\quad)(\quad)(\quad)^2}{(\quad)} =$		x =	

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		NO.	LABOR $/UNIT	TOTAL LABOR	MATERIAL $/UNIT	TOTAL MATERIAL	INSULATION LABOR $/UNIT	INSULATION MATERIAL $/UNIT	TOTAL	
PIPE	6"	82	1.50	123	1.50	123	164	106	270	
	4"	115	1.00	115	1.21	139	195	115	310	
	3"	500	0.80	400	0.89	445	900	522	1422	
	2"	70	0.50	35	0.50	35	91	54	145	
	1½"	230	0.50	115	0.50	115	265	150	415	
WELDS	6"	4	1250	50.00						
	4"	5	12.50	62.50						
	3"	30	10.00	300.00						
	2"	4	7.00	28.00						
	1½"	11	7.00	77.00						
/ALUES	6"	1	20	20	200	200				
	3"	6	14	84	100	600				
	2"	3	12	36	70	210				
	1½"	5	12	60	70	350				
LLS	6"	3	25	75	3.50	10.50				
	3"	19	20	380	1.50	28.50				
	2"	2	14	28	0.90	1.80				
	1½	15	14	210	0.90	13.50				
ELLS	6"	1	35	35	20	20				
	4"	3	30	90	15	45				
	3"	6	25	150	12	72				
LANGES	6"	2	20	40	6.00	62.00				
	3"	12	14.50	174	3.57	216.84				
	2"	6	11.00	66	2.55	81.30				
	1½"	10	11.00	110	2.55	135.50				
				2863.50		2903.94	1615	997	2562	8329.44
			x1.18	3380 500		3427 500	1900	1120		

CONTINENTAL OIL COMPANY
CALCULATION SHEET

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OF
JOB NO. CCR 000008086
FIELD
STATE

8/19/69

Restriction Orifice sizing

ΔP — 130 psig

Flowrate — 10% of 100 gpm

ρ = 53.81 lbs/cu ft

μ = 0.28 cp

Re = 60,000

assume d_o/D = 0.1

d_o = 0.2

C = 0.58

RESTRICTION ORIFICE ~ 1/4"

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Low pressure condensate system

Down time
3 days

EQUIPMENT COST ESTIMATE

PUMP + BASE PLATE	778
CONDENSER W/O SUPPORTS	4600
PIPING	7000
INSULATION	3000
TANK	3000
COND. PROBE	2000
LEVEL CONTROL	1500
	21878
STRUCTURES	4000
	25878
+10%	28465.8

1428

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RESTRICTION ORIFICE (PUMP RECYCLE)

pump $NPSH_R$ 7

$NPSH_A$ 8.1

$P_1 + \frac{NPSH_A - NPSH_R}{2.31} = P_2$

$HP_o = 30$

$h_L = 313$

$P_1 = 18.04$ T =

$P_2 = 18.5$ T = 224°

$R = T_1 - T = 224 - 212 = 12°F$

BYPASS GPM

$$Q = \frac{HP_o \times 5.1}{R \times SG \times S} = \frac{30 \times 5.1}{12 \times 0.96} = 13.26 \sim 14 \text{ gpm}$$

$$Q = 19.65\, d_o^2\, C \sqrt{h_L}$$

$$d_o^2 = \frac{14}{19.65(\sqrt{313})(0.6)}$$

$$d_o^2 = 0.0671$$

$$d_o = 0.259$$

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pump - 3196 1½ × 3-10 20 H.P.

7.1 × 0.43

$$HP_o = \frac{\overset{7.4}{gpm} \times \overset{31.30}{head} \times 8.33}{33000}$$

$$\text{Temp. Rise °F/}_{MIN} = \frac{HP_o \times 5.1}{\text{GALLONS} \times SG. \times S} = \frac{HP_o \times 5.1}{\text{GALLONS}}$$

CASING CAPACITY

$$\text{lbs/}_{MIN} \text{ By Pass} = \frac{HP_o \times 33000}{778 \times R \times S}$$

$$P_1 = 8.1 \times 0.43 = 3.48 \times 0.96 = \frac{\overset{14.7}{3.34}}{18.04} + 14.7 = 18.04$$

$$P_2 = 18.04 + \frac{(8.1 - 7)}{2.31} \times 0.96 = 18.5 \quad T = 224$$

$$R = T_1 - T = 224 - 212 = 12°$$

$$\text{lbs/}_{MIN} \text{ By Pass} = \frac{30 \times 33000}{778 \times 12 \times 0.96} = 110 \text{ lbs/}_{MIN}$$

$$\frac{110}{8.33 \times 0.96} = 14 \text{ gpm By pass}$$

orifice No. - 11

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annin Catolog 1500E , page 46

CONTROL VALVE

$$C_v = \frac{Q\sqrt{G}}{\sqrt{\Delta P}} = \frac{100\,\text{gpm}\,\sqrt{0.96}}{\sqrt{10}} = 31$$

pressure drop for dump valve 1

$$C_v = \frac{100\sqrt{.96}}{\sqrt{2}} = \frac{98}{1.414} = 69$$

CONDENSATE Drum 4' × 10' 942 gal.

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CONDENEATE DRUM 5 MINUTES HOLDING time (2 x VOLUME)

$$43,514 \text{ lbs}/\text{HR} \times \frac{2}{12} \times 0.01672 = 122 \text{ ft}^3$$

OR 913 gallons

$\left\{ \begin{array}{l} 5' \times 6'\text{-}0 \\ 4' \times 10' \end{array} \right.$

CONDENSATE Pump

$43514 \times 0.01672 \times 7.48052 =$ 5442 gph or 90.7 gpm

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piping estimate

		LABOR COST $/UNIT	TOTAL LABOR	MAT'L COST $/UNIT	TOTAL MAT'L COST	TOTAL	1½ INSULAT LAB	 MAT'L
PIPE	82 6"	② 1.50	123	1.50	123	246	164	106
	115 4"	1.00	115	1.21	139.15	254.150	115	115
	580 3"	0.80	464	0.89	516.20	980.20	300	522
	70 2"	0.50	35	0.47	32.90	67.90	31	52.5
	230 1½	0.50	115	0.47	108.10	223.10	264.5	191.
	(1077 ft)					1771.35	1614.5	945
							2559.5	
WELDS								
	4 6"	12.50	50.00			50.00		
	5 4"	12.50	62.50			62.50		
	30 3"	10.00	300.00			300.00		
	4 2"	7.00	28.00			28.00		
	11 1½"	7.00	77.00			77.00		
						517.50		
VALVES	1 - 6"	20	20	200	200	220.00		
	6 - 3"	14	84	100	600	684.00		
	3 - 2"	12	36	70	210	246.00		
	5 - 1½"	12	60	70	350	410.00		
						1560		
Ellbows	3 - 6"	25	75	3.50	10.50	85.50		
	19 - 3"	20	380	1.50	28.50	408.50		
	2 - 2"	14	28	0.90	1.80	29.80		
	15 - 1½"	14	210	0.90	13.50	223.50		
						747.30		
[illegible]	1 - 6"	35	35	20	20	55.00		
	3 - 4"	30	90	15	45	135.00		
	6 - 3"	25	150	12	72	122.00		
						312		

[illegible]

Sub
4908.15

flanges

2 - 6"	20.00	40	6.00	12	62.00	
12 - 3"	14.50	174	3.57	42.84	216.84	
6 - 2"	11.00	66	2.55	15.30	81.30	
10 - 1½"	11.00	110	2.55	25.5	135.50	
					495.64	
					Total Piping	$5403.88
					insulation $1.50/ft	1615.50
						$7019.29

piping	$8000	10,000
condenser	9000	3000
pump	1500	1800
L-controls	1500	1500
conduit.	2000	1500
drum	3000	2700
	25,000	26,500
+ 10%	$27500	$3,000

5404
3020
8424

10,000

5404

MATERIAL AND ENERGY BALANCE
LOW PRESSURE CONDENSATE
SYSTEM

EQUIPMENT	STEAM Pressure	Btu/lb	DESIGN LOADS	
			lbs/HR. (1)	BTU/HR (2)
EDC TAR STILLS S-104 A/B	150	338.5	1400	473,900
VINYL TAR STILLS S-208 A/B	150		1400	473,900
R-4 STEAM DRUM S-304	15	218.82	3900	853,398
R-4 FEED HEATER H-304	50	267.5	1050	280,875
OXY VENT HEATER H-310	50		1200	321,000
ETHYLENE HEATER H-308	50		1570	419,975
OXY BLOWDOWN S-311	ATM		1308 (VAPOR)	1,504,723 (VAPOR)
HCl REBOILER H-205	150		16980	5,747,730
HCl FEED HEATER H-309	150		2350	795,475
HCl EVAPORATORS S-210 A/B	50		3400	909,500
TOTALS W/O S-502			34558 lbs/HR	11,780,476 Btu/hr
150# STEAM DRUM S-502	150		5000	1,692,500
TOTALS WITH S-502			39558 lbs/hr	13,472,976 Btu/hr

(1) FROM P AND I DRAWINGS
(2) ALL CONDENSATE AT STEAM PRESSURE

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PIPE DATA [illegible] STEEL [illegible]

PIPE SIZE (NOMINAL)	D (ft)	d^5 (in)	A (ft²)	ϵ/D	D/A	$\frac{D}{A\mu_L}$
1	0.0874	1.270	0.00600	0.0018	14.567	7.658 ×10^4
1½	0.1342	10.82	0.01414	0.00125	9.491	[illegible] ×10^4
2	0.172[illegible]	37.72	0.02330	[illegible]	7.391	[illegible] ×10^4
3	0.2[illegible]7	271.8	0.05130	0.0006	4.984	2.614 ×10^4
4	0.33[illegible]	1055.	0.08840	0.00045	3.795	1.9[illegible] ×10^4
6	0.5054	81[illegible]	[illegible]006	0.0003	2.519	1.321 ×10^4

STEAM DATA

	h_f	h_{fg}	h_g	V_f	V_g
165 psia	338.[illegible]	[illegible]	1195.[illegible]		
65 psia	2[illegible]	911.[illegible]	1[illegible]		
30 psia	218.82	945.3	1164.1		
ATM	180.07	970.3	1150.4	0.01672	26.80

DENSITIES $\begin{cases} \rho_L = 59.8 \text{ lbs/ft}^3 \\ \rho_g = 0.0373 \text{ lbs/ft}^3 \end{cases}$ $\rho_L/\rho_g = 1603$

VISCOSITY $\begin{cases} \mu_L = 0.2838 \text{ Cp.} \times 6.72\times10^{-4} = 1.907 \times 10^{-4} \text{ lb/ft-sec} \\ \mu_g = 0.013 \times 6.72 \times 10^{-4} = 8.7[illegible] \times 10^{-6} \text{ lb/ft-sec} \end{cases}$

RESISTANCE FACTOR, K,

	1"	1½"	2"	3"	4"	6"
GATE VALVES						
L/D = 13	0.30	0.27	0.25	0.23	0.21	0.19
L=	(1.14)	(1.74)	(2.24)	(3.32)	(4.36)	(6.57)
ELBOWS (90°						
L/D = 30	0.5[illegible]	[illegible].6[illegible]	0.57	0.53	0.50	0.4[illegible]
L=	(2.62)	(4.03)	(5.[illegible])	(7.67)	(10.07)	(15.16)
STANDARD TEE						
[illegible]						
L/D = 2[illegible]	0.4[illegible]	0.40	0.38		0.3[illegible]	[illegible]
L=	(1.75)	(2.68)	(3.44)	(5.11)	(6.71)	(10.12)
[illegible]						
60	1.40	1.25	1.1[illegible]	1.1	1.0	[illegible]
L=	(5.24)	(8.05)	(10.33)	(15.34)	(20.13)	(30.38)

ENTR[illegible] K = 0.5