Application and Selection of Hydro Foil Pumps

I. Description:

A Hydro-Foil pump is a vertical, shaft-driven bottom suction pump. The pump may be of the mixed-flow, propeller, or HH turbine type. In general, a Hydro-Foil pump consists of four basic elements: (1) The pump bowl assembly, (2) the fabricated insert elbow with additional column as required, (3) the lineshaft with enclosing tube and (4) the pump drive.

(1) The pump bowl assembly normally has one stage. The stage consists of a top bowl, an impeller or propeller, an impeller shaft, a bell type suction manifold and the bowl bearings. The impeller is usually attached to the impeller shaft with thrust rings and key, except in smaller units. The impeller shaft bearings are lubricated by the fluid being pumped.

(2) The fabricated steel insert type elbow consists of one of three standard wall thicknesses, with discharge above or below the support plate from which the entire pump assembly is hung. Additional column of the same size and weight is added as required.

(3) The lineshaft, with enclosing tube, arranged for either oil or water flush lubrication, transmits energy from the driver to the impeller or propeller.

(4) The prime mover can be a vertical hollowshaft motor, vertical solid shaft motor, steam turbine, or a right angle gear drive.

II. Selection Data

The selection of a pump for any given job is dependent to a large extent on the user's requirements. A thorough knowledge of the pump application is necessary to be certain of making the proper selection. For any given condition, two or more bowl sizes and column sizes can be used. Depending on the users application, only one specific combination is correct. The user determines whether highest possible efficiency is important. He should indicate how much pump efficiency is worth in terms of additional cost. The user knows whether the pump is to be used on intermittent or continuous service. These and other factors, such as elbow wall thickness, lineshaft lubrication, and amount of submergence depend on the user's preference, application or facilities.

In order to properly select a Hydro-Foil pump the following data must be known:

1. The desired pump capacity.
2. The total head required.
3. The submergence available.
4. The driving power available and/or current to be used.

III. The required capacity.

The capacity is usually supplied by the user or the user's engineer.

In certain cases however, the pump capacity is determined by the pump supplier and the customer working together, to determine the job to be done and the method by which it is to be done.

IV. The total head required:

The total pump head is usually given by the user or the user's engineer. The total head consists of the following:

A. Static Head: The vertical distance in feet from the pumping level in the sump to either the center line of discharge or the surface of the pool into which the pump is discharging, whichever is greater.

B. Field Head: The sum of the distance in feet from the pumping level in the sump to the centerline of discharge (static head) plus the velocity head loss at the discharge, plus the hydraulic loss due to pipe friction, bends, valves, etc., in the discharge line beyond the elbow. If the discharge is submerged, the distance between the surface of the pool and the centerline of discharge must be included as part of the static head.

C. Laboratory head or bowl head: The sum of the field head, column loss and the discharge elbow loss. This is the head figure used to select a bowl from the sales curves.

V. The Sump:

The sump should provide for adequate submergence, proper side and bottom clearance for the pump suction and sufficient clearance and/or baffling between pumps in multiple pump installations. Trash racks or suitable screens should be provided at the sump

intake, to eliminate stringy material and solids larger than the pump will handle. Information on sump configuration and design along with pump submergence data is located in Vertical Turbine Section 133.

VI. Hydraulic Downthrust:

The pump driver bearings must be capable of carrying the hydraulic downthrust of the pump plus the weight of the rotating parts. If the pump is to be started, stopped or run at shut-off, it is important that the factory be made aware of this.

VII. Siphons:

It is occasionally possible to utilize the siphon effect to reduce the horsepower requirement of pump installations. The overall efficiency of a siphon installation cannot be guaranteed because of the many variables involved which are beyond the pump manufacturers control. Contemplated installations involving a siphon should be referred to the factory along with the following information: (1) a drawing of the proposed installation showing all dimensions (2) the capacity to be pumped (3) the altitude of the installation.

VIII. Column and Elbow sizes:

As a general rule, the Hydro-Foil elbows and column should be selected so that velocities in the column of from 5 to 10 feet per second are obtained. This has been found to be an economical range. The lower velocities of 5, 6, and 7 fps will result in more efficient pumping. Velocities around 10 fps are satisfactory for intermittent operation or where efficiency is not of prime importance.

AN EXAMPLE FOR SELECTION:

For this example the unit will pump with free discharge from a river into a canal. The static head is 24 feet from the minimum water level in the river to the center line of discharge at the canal. The capacity of the pump is to be 10,000 gpm. The pump will utilize an electric motor drive. 440v 60 cyc power is available. The sump is 18 feet deep from the pump mounting support to the bottom. The minimum water level in the sump is 6 feet above the bottom. The pump will have an above base discharge.

First the proper bowl unit is selected. To obtain a unit with the lowest possible initial cost and the most economical pump operation, the speed of operation should be as high as possible without sacrifice of efficiency.

The performance curves are in three sections: the PL or propeller type, the MF or mixed flow type, and the HH or high capacity turbine type. In general the PL pumps have the highest capacity and lowest head, the MF pumps have medium capacity and medium head, and the HH pumps have the lowest capacity and the highest head.

STEP ONE (Tentative bowl selection)

A quick examination of the PL curves shows that at 10,000 gpm the pumps do not develop sufficient head and the HH pumps develop too much head. Curve 2845349 for the 24MF shows a performance of 10,000 gpm at 24 feet with an efficiency of 86.5%, and a brake horsepower (bhp) of approximately 70 at 870 rpm.

STEP TWO (Determination of elbow size)

Hydro-Foil pump curves show the laboratory performance of the bowl unit only. They do not include losses in the elbow or column. Referring to the velocity chart, we find that at 10,000 gpm, the velocity in a 24 inch elbow would be between 5 and 10 feet per second. This, for our example, we will assume is acceptable.

Capacities of column and elbows at 5 & 10 fps velocities

Column & Elbow Size	10	12	14	16	18	20	24
5 fps	1195	1705	2190	2820	3635	4500	6800
10 fps	2390	3410	4380	5640	7270	9000	13600

Column & Elbow Size	30	36	42	48	54	60
5 fps	10350	15100	20620	27820	35000	43260
10 fps	20700	30200	41250	55650	70000	86520

If lower efficiency is acceptable, a 20" elbow could have been chosen. If very efficient operation had been required, a 30" elbow would be chosen. Referring to the friction loss charts it is seen that the head loss in the 90° turn is 0.38 ft, and the head loss in 24" straight column is .1 ft per 10 ft.

To determine the pump length below the base, the clearance between the suction and the bottom of the sump ($\frac{D}{2}$), and the A dim of the bowl unit are subtracted from the sump depth.

$$18' - 1'1\tfrac{1}{4}'' - 2'1\tfrac{1}{2}'' = 14'9\tfrac{1}{4}''$$

To this we add dim E for figuring the total hydraulic loss:

$$14' 9\tfrac{1}{4}'' + 2' 2'' = 16' 11\tfrac{1}{4}''$$

The wall thickness is normally specified by the customer. Peerless offers three choices: standard wall for the normal job, heavy wall for long-lived industrial applications, and light wall for jobs where lowest possible initial cost is of prime importance.

STEP THREE (Tentative determination shaft size)

In step one, it was determined that the pump required approximately 70 bhp at 880 rpm. By referring to the horsepower ratings of C-1045 threaded lineshaft (Section 330, page 7), we determine that $1\frac{1}{2}''$ shaft is strong enough to transmit 87 hp at 870 rpm with a friction loss of .56 hp per 100 ft of shaft.

STEP FOUR (Final bowl selection)

The total pumping head to meet is 24 ft, plus hydraulic friction in the 90° turn, plus friction loss in the column.

$$24 + .4 + (.1 \times 1.7) = 24.57 \text{ ft}$$

The bowl performance is 10,000 gpm at 24.57 ft with an 86.5 efficiency. The resultant bhp is:

$$\frac{24.57 \times 10{,}000}{3960 \times 86.5} \times 1.0 = 71.7 \text{ bhp}$$

STEP FIVE (Final drive selection)

It is now apparent that the proper electric motor is a 75 hp, 870 rpm, 440 v, 60 cyc vertical hollow-shaft motor. This motor can be supplied with a $16\frac{1}{2}$, 20, or $24\frac{1}{2}''$ BD. Selection of the smallest BD is usually the most economical. However, in this example there is no price difference in the elbow. A price advantage does exist in some other sizes.

SUMMARY of the selection:

1. Motor: 75 hp, 870 rpm, 440 v, 60 cyc VHS
2. Elbow: 24 in, above base, standard wall
3. Inner Column: $1\frac{1}{2}''$ shaft with $2\frac{1}{2}''$ tube
4. Bowl Unit: 24 MF, Group A

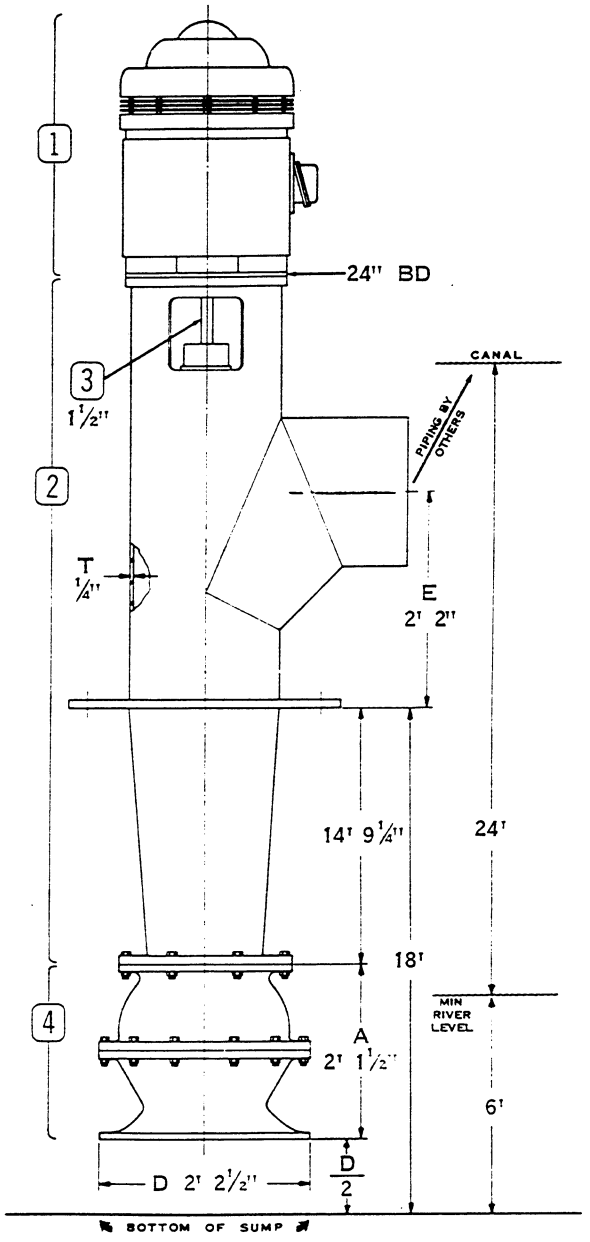
Various other features can be added. These are:

A choice of several column and elbow coatings, dresser coupling or discharge flange, water flushed tube bearings, various other bowl construction materials, basket strainer, and a wear ring. These features are used as required by the job specifications or the requirements of the application.

SHUT-OFF CONSIDERATIONS FOR LARGE HYDRO-FOIL PUMPS

In many cases large pumping units will be started and stopped against a closed valve. This can mean that larger shafts, couplings and tubes may be required because of the horsepower requirements of Hydro-Foil pumps at the shut-off condition (see Section 340, pages 2 and 3).

Further, when large synchronous motors are used, it is imperative that shut-off horsepower be given to the motor supplier if the pump is to be started at this condition. The pricing of the motor is partially based on the starting horsepower requirement.



HYDRO-FOIL PUMPS

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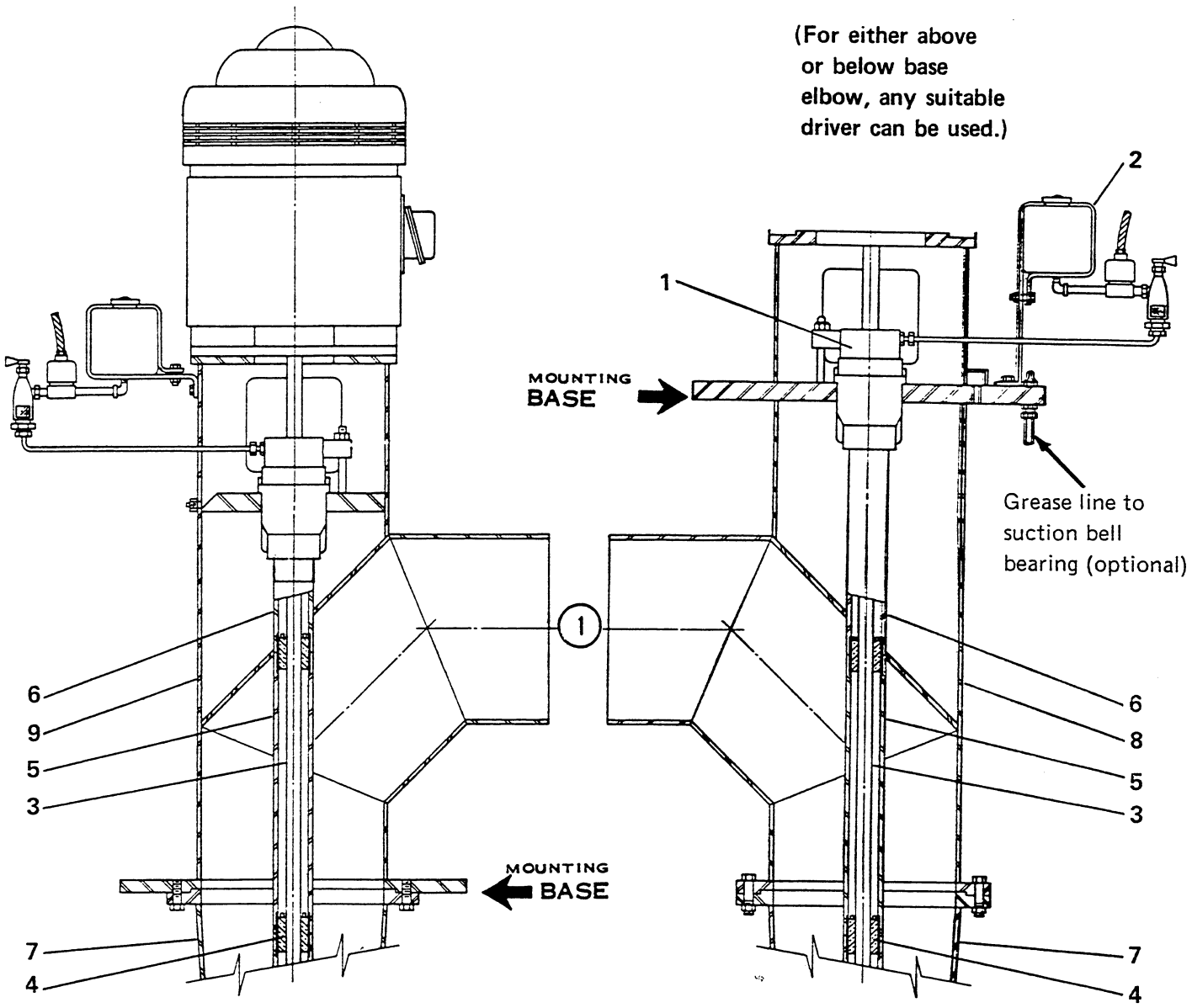
ABOVE BASE ELBOW

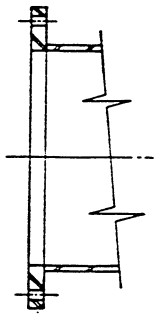
BELOW BASE ELBOW

(For either above or below base elbow, any suitable driver can be used.)

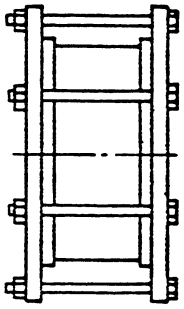


Above Base elbow shown with Style AB - 1 motor mounting.

Below Base elbow shown with Style BB - 2 integral yoke. Note: use either Style BB - 2 or BB - 3; Style BB - 1 is discontinued.



(1) Plain end pipe discharge is standard. Available options include Dresser coupling or discharge flange.

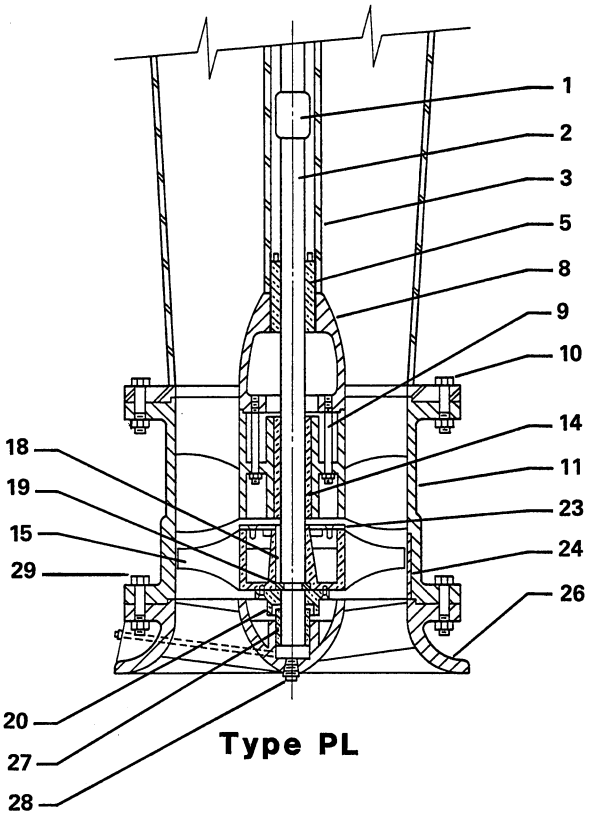


Item	Description
1	Tube nut assembly
2	Oiler assembly
3	Lineshaft
4	Tube bearing
5	Intermediate tube
6	Top tube
7	Additional column
8	Below base elbow
9	Above base elbow

Hydro-Foil Bowl Units

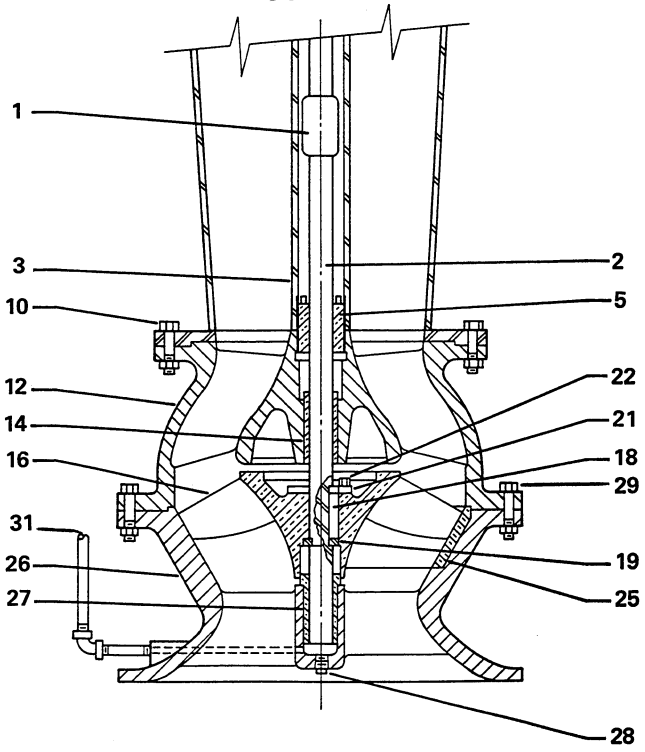
Type PL (propeller or axial impeller), Type MF (mixed flow) or Type HH (turbine) bowl units are used with the Hydro-Foil elbows shown on Section 310, page 4).

Item	Description	Item	Description
1	Shaft coupling	16	Impeller, MF
2	Impeller shaft	17	Impeller, HH
3	Oil tube	18	Key, impeller
4	Tube bearing adapter	19	Split ring
5	Tube bearing	20	Lock ring
6	Upper tube bearing	21	Gib pin
7	Lower tube bearing	22	Screw, gib pin
8	Diffusor cone	23	Cover plate
9	Stud, diffusor cone	24	Bowl liner (optional)
10	Bolt, column to bowl unit	25	Bowl liner (wear ring) optional
11	Top bowl, PL	26	Suction bell
12	Top bowl, MF	27	Sleeve bearing, suction bell
13	Top bowl, HH	28	Plug, suction bell
14	Sleeve bearing, bowl	29	Bolt
15	Impeller (propeller) PL	30	Cap screw or stud & nut
		31	Grease line (optional)

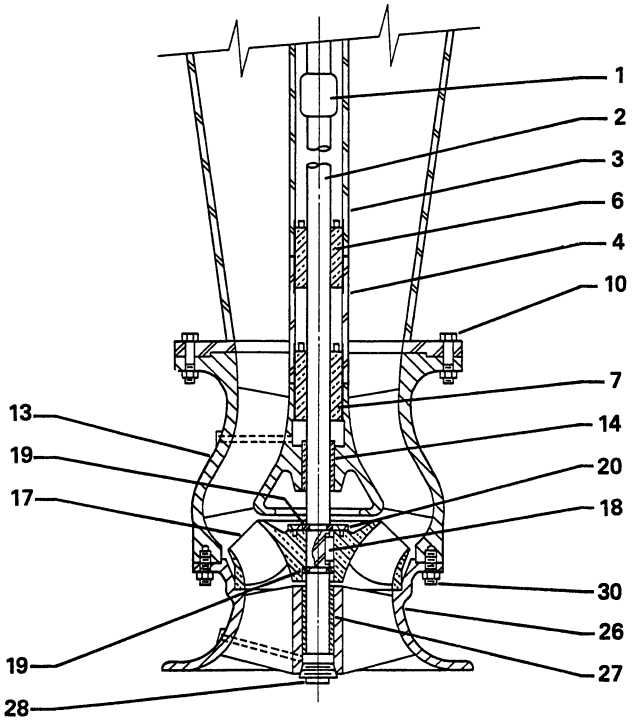


Type PL

Type MF



Type HH



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MOUNTING ARRANGEMENTS FOR BELOW BASE ELBOWS

Elbow Style	Description
BB-1	Style BB-1, with driver mounted directly on base plate, is discontinued. Use BB-2 or BB-3.
BB-2	See illustration below. Driver mounts on integral yoke. Tube nut plate is integral with base plate.
BB-3	See illustration below. Driver mounting and tube nut plate are integral with separate internally gusseted yoke.

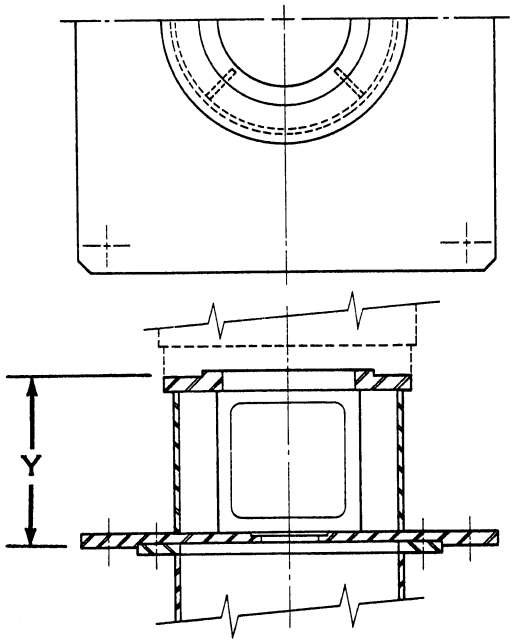
Notes:

1. Yoke height "Y" accommodates a 2-piece top shaft with threaded coupling (but not a flanged or spacer coupling).
2. On 48" and larger BB elbows, external gusseting may be added at factory option.

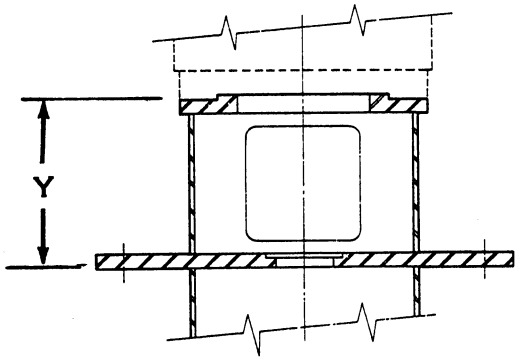
YOKE HEIGHT

Styles BB-2 and BB-3 only

ELBOW SIZE	DIMENSION Y
10	1' 3/4"
12	1' 3/4"
14	1' 1"
16	1' 1"
18	1' 1"
20	1' 3"
24	1' 3 1/8"
30	1' 9 1/8"
36	1' 9 1/4"
42	1' 11 1/4"
48	1' 11 1/2"
54	2' 0"
66	2' 0"



STYLE BB-3
Separate Yoke

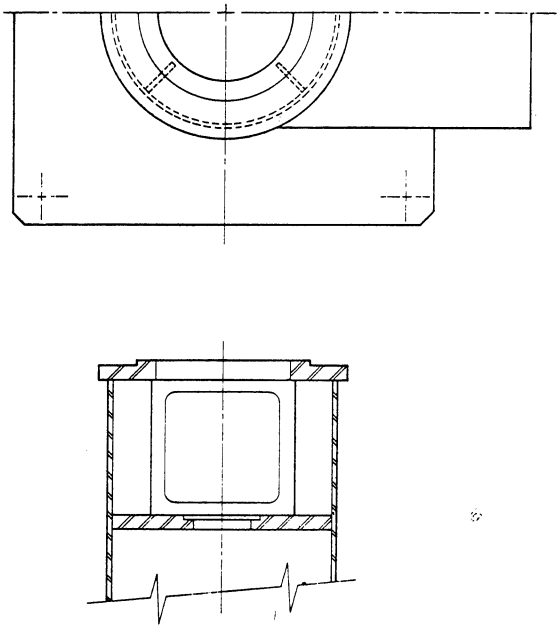


STYLE BB-2
Integral Yoke

MOUNTING ARRANGEMENTS FOR ABOVE BASE ELBOWS

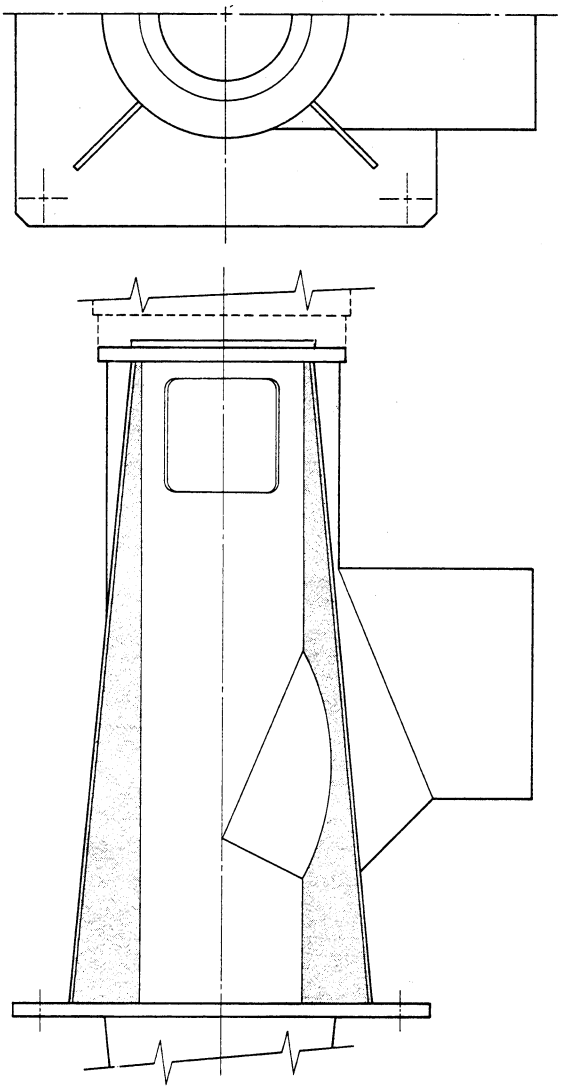
Elbow Style	Description
AB-1	See Section 310, page 5. Elbow and driver mount are without gusseting.
AB-2	See illustration below. External gusseting from driver mount to base plate.
AB-3	See illustration below. Driver mount to tube nut plate is internally gusseted.

Gusseting requirements for above base elbows will be determined by the factory.



Style AB-3

Internally Gusseted



Style AB-2

Externally Gusseted

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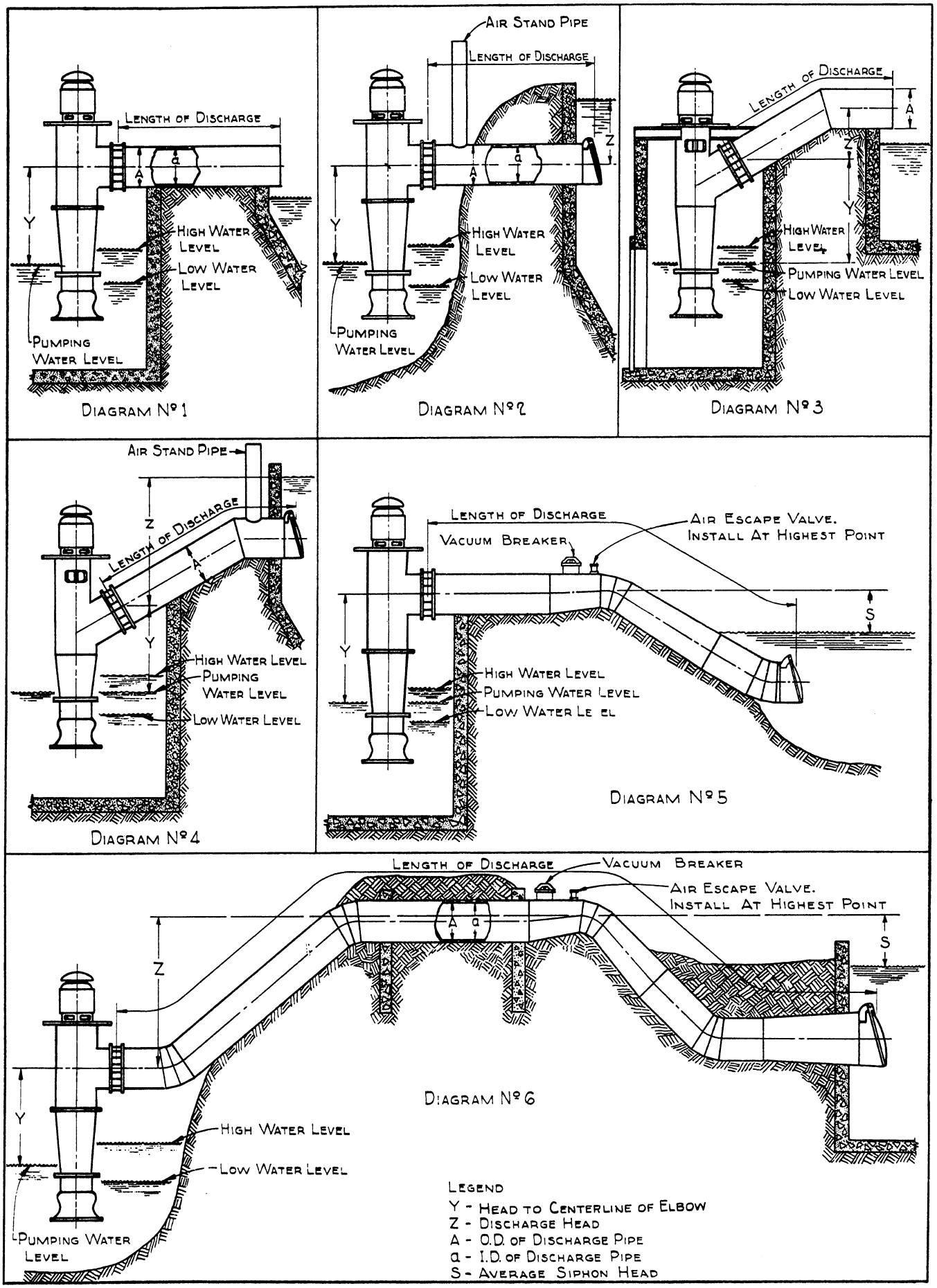
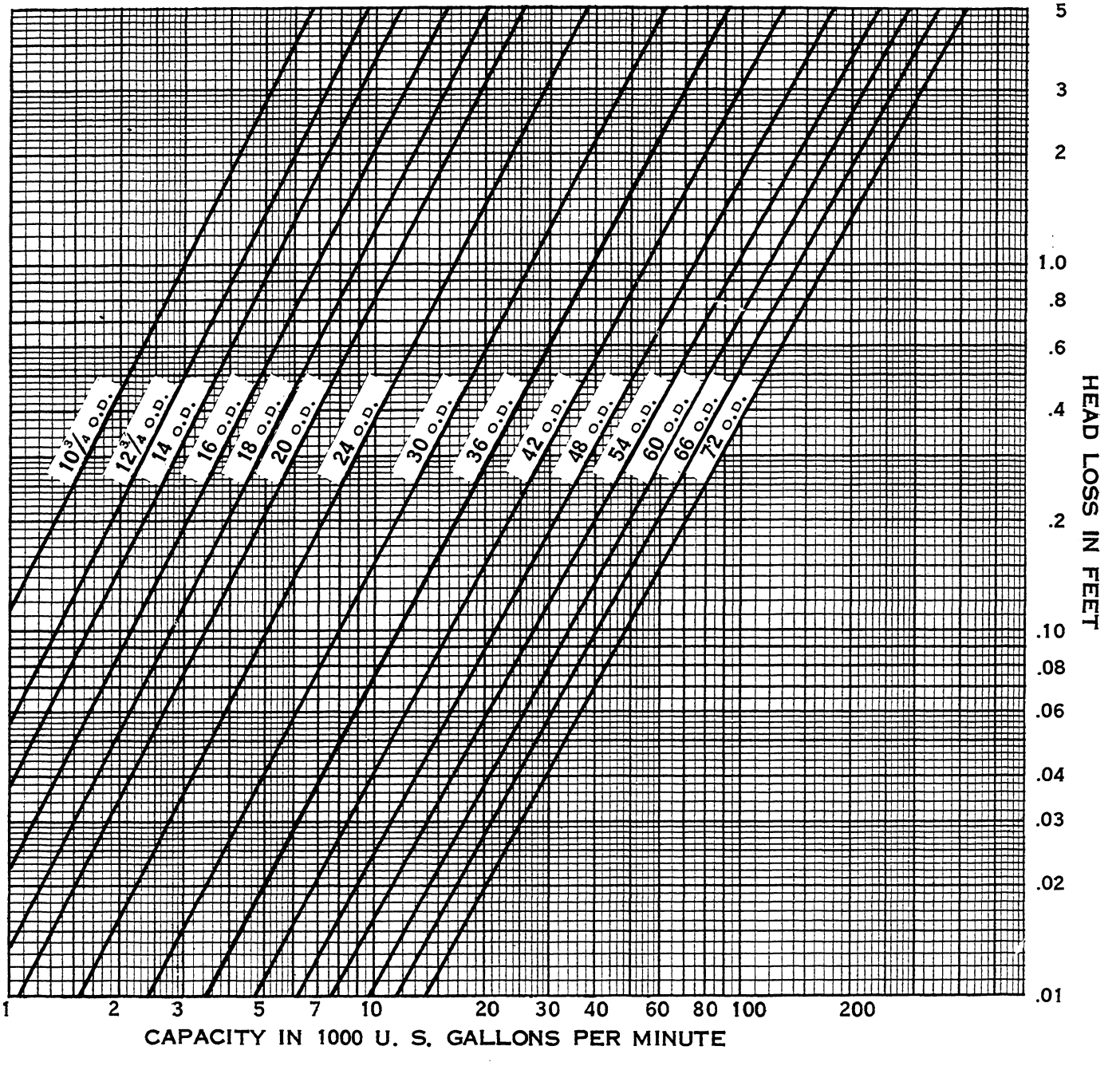
TYPICAL HYDRO-FOIL INSTALLATIONS



HEAD LOSS CHART -- INSERT ELBOWS

Loss in Feet within the 90° turn only.



HYDRO-FOIL PUMPS

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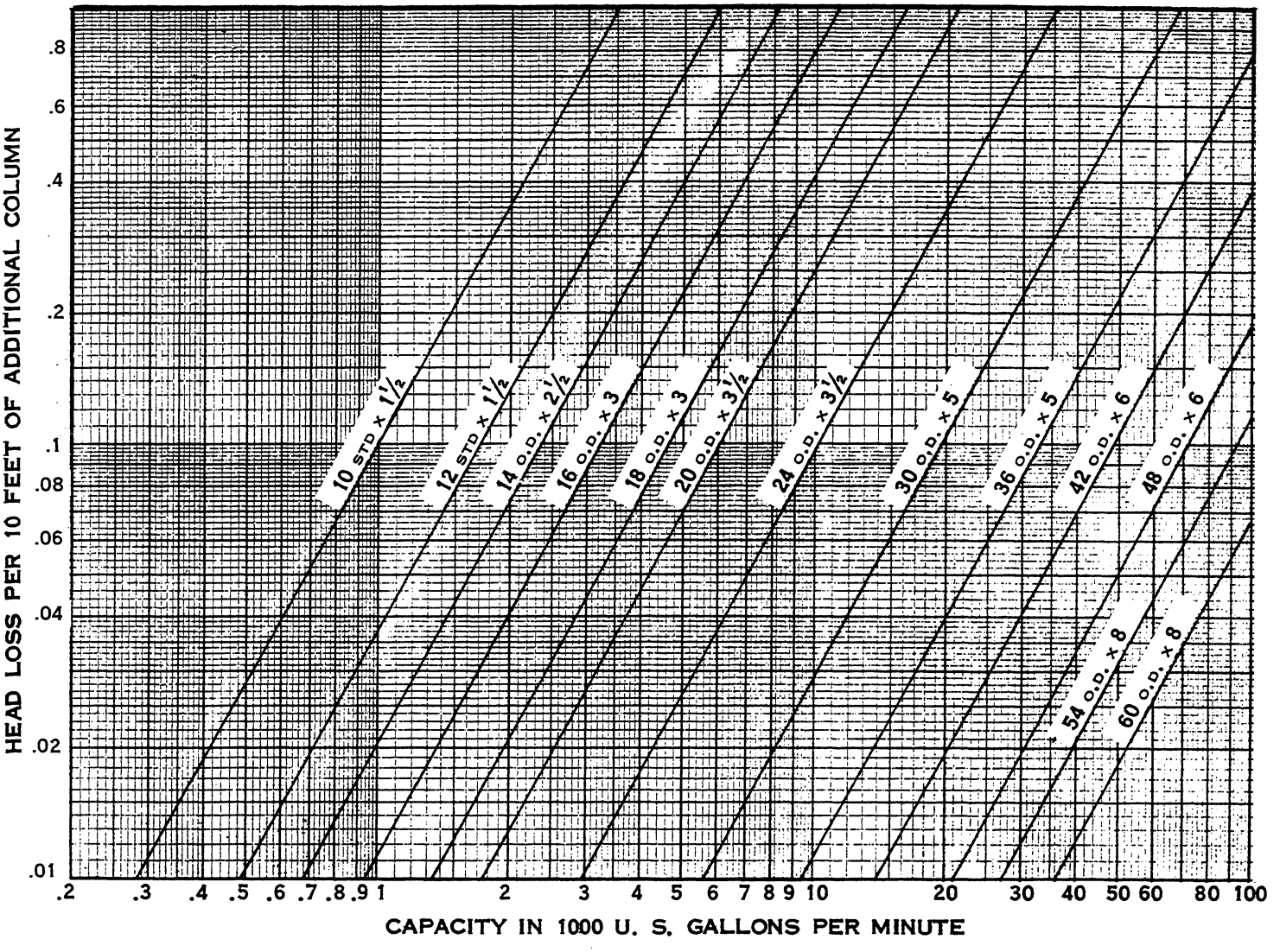
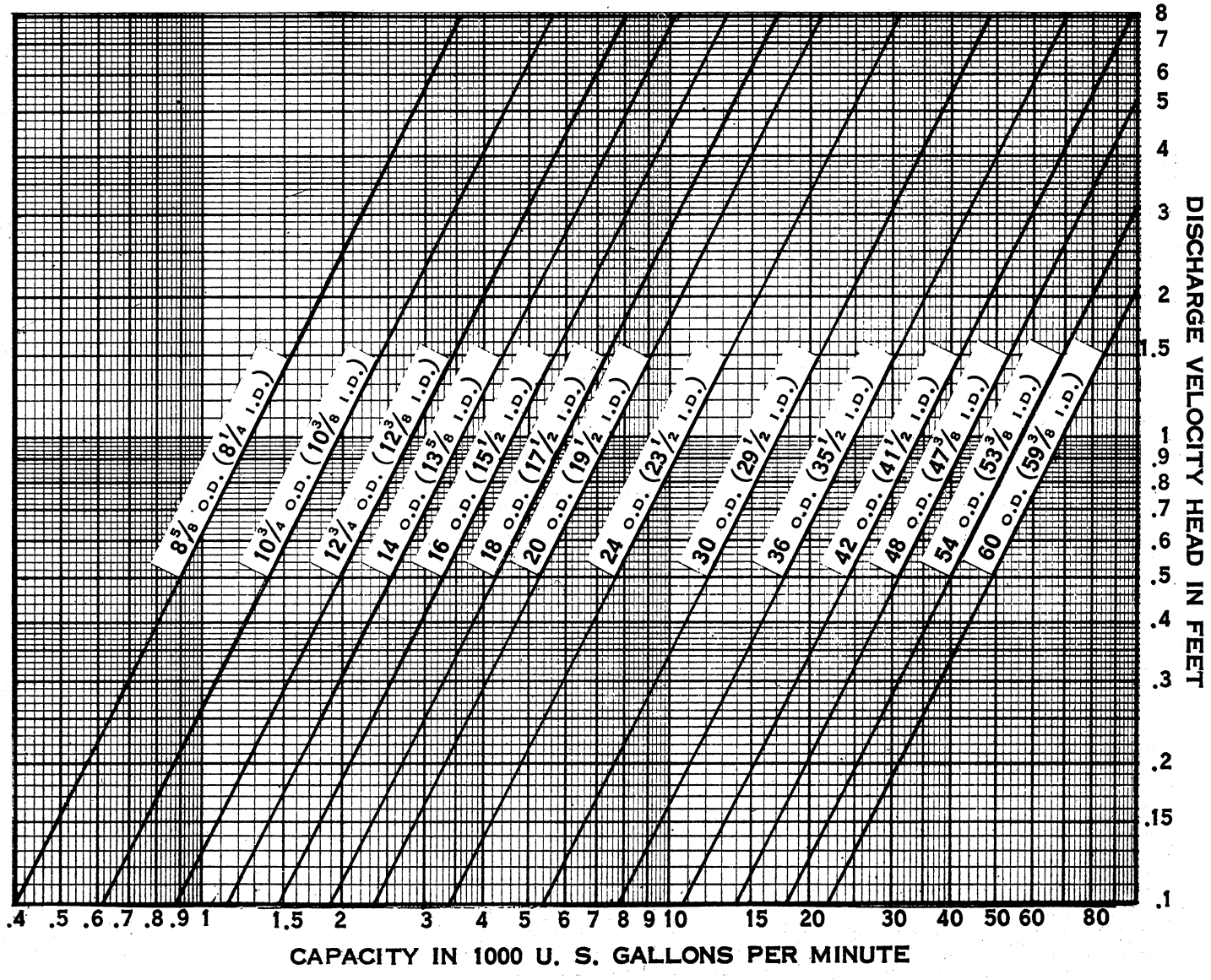
HEAD LOSS PER 10 FT OF STRAIGHT COLUMN



DISCHARGE VELOCITY HEAD LOSS



HYDRO-FOIL PUMPS

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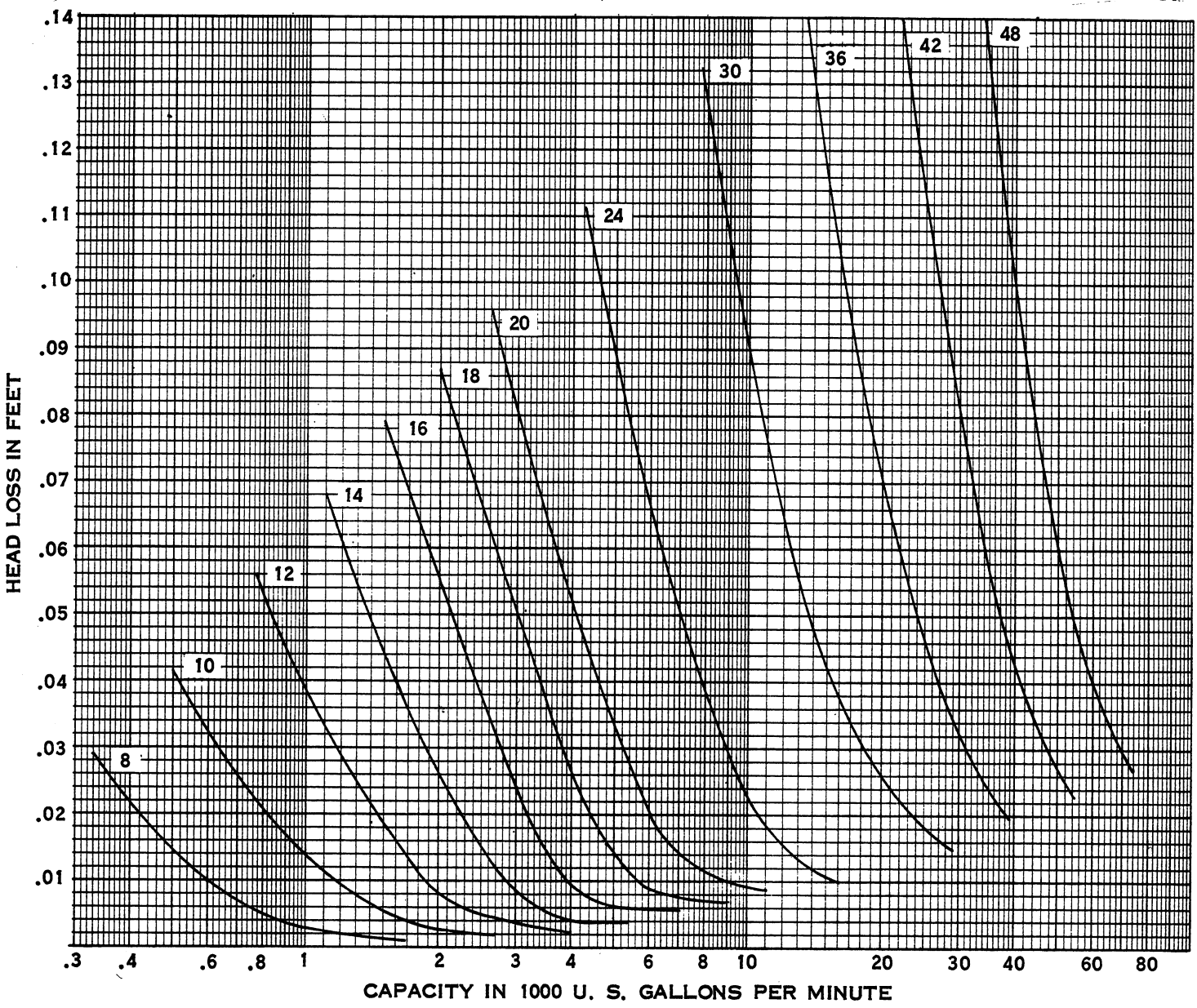
HEAD LOSS CHART FOR LIGHT FLAP VALVES



ELBOW DATA

Wall Thicknesses

Elbows are fabricated in three wall thicknesses, which are designated as standard, heavy and light wall. The numerical thicknesses for these designations vary according to the elbow size. These values are given in the following table:

Elbow Size	Wall Thickness, inches		
	Standard	Heavy	Light
10" - 30"	0.250	0.375	0.1875
36" - 48"	0.375	0.500	0.3125
54" - 60"	0.500	——	0.375

Max Length

The max length of any single elbow part is 18 ft. This limitation is necessary due to handling facilities at both the fabrication and factory facilities.

Max Working Pressure

The max working pressure of the various elbows is dependent upon both the column and bowl flange thickness. MWP values for the fabricated elbows are:

Types MF and PL: 25 psi (58 ft)

Type HH: 86.5 psi (200 ft)

These limitations apply to all elbows in this section. If higher working pressures are required, refer to the Los Angeles factory.

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MAXIMUM DIAMETERS OF COLUMN FLANGES

Various factors effect the outside diameters of column flanges

For most applications, the nominal values listed below will not be exceeded. If outside diameters of flanges are critical, contact the factory to determine the applicable values.

When sizing a floor hole opening diameter, also check the diameter of the bowl and the strainer (Section 330, pages 9 and 22).

Nominal Pipe size	Nominal maximun column flange outside diameter
10"	15-1/4"
12	17-3/4
14	18-7/8
16	21-1/2
18	23-3/8
20	25-1/2
24	29-3/4
30	36
36	42
42	48-3/4
48	54-3/4
54	62-1/8
60	68-1/4
66	72

HYDRO-FOIL THREADED LINE SHAFT SELECTION CHART

Based on Turned, Ground and Polished Carbon Steel Shaft (AISI C-1045)

The upper figures are the nominal horsepower ratings, and the lower figures (in parentheses) are mechanical friction losses expressed in horsepower per 100 feet of shaft.

RPM of Pump	Diameter of Shaft in Inches												
	1	1-3/16	1-1/2	1-11/16	1-15/16	2-3/16	2-7/16	2-11/16	2-15/16	3-3/16	3-7/16	3-11/16	3-15/16
390	13 (.12)	19 (.17)	42 (.26)	62 (.31)	97 (.42)	123 (.52)	169 (.64)	232 (.75)	304 (.91)	397 (1.07)	505 (1.23)	630 (1.39)	770 (1.6)
430	14 (.13)	21 (.18)	46 (.28)	69 (.34)	107 (.46)	136 (.57)	186 (.71)	256 (.82)	335 (1.00)	437 (1.18)	560 (1.36)	695 (1.53)	850 (1.71)
490	16 (.15)	24 (.21)	53 (.32)	78 (.39)	123 (.52)	155 (.65)	212 (.81)	292 (.94)	382 (1.14)	500 (1.34)	650 (1.54)	793 (1.74)	970 (2.01)
575	19 (.17)	28 (.24)	62 (.38)	92 (.46)	144 (.61)	184 (.77)	250 (.95)	342 (1.10)	450 (1.34)	585 (1.58)	745 (1.81)	930 (2.04)	1135 (2.36)
690	23 (.21)	34 (.29)	75 (.45)	111 (.55)	173 (.74)	218 (.92)	300 (1.13)	410 (1.32)	540 (1.61)	705 (1.89)	895 (2.18)	1108 (2.46)	1370 (2.84)
870	28.2 (.26)	43 (.36)	94 (.56)	139 (.69)	215 (.92)	272 (1.2)	378 (1.4)	515 (1.7)	680 (2.1)	890 (2.35)	1130 (2.7)	1400 (3.1)	1720 (3.5)
1160	39 (.35)	58 (.48)	126 (.75)	186 (.94)	290 (1.2)	368 (1.5)	505 (1.9)	690 (2.3)	910 (2.7)	1180 (3.1)	1510 (3.6)	1880 (4.0)	2305 (4.7)
1760	59.2 (.53)	88.4 (.72)	192 (1.25)	282 (1.4)	442 (1.9)	559 (2.3)	765 (2.9)	1050 (3.4)	1378 (4.2)	1800 (4.8)	2287	2850	3500
Shaft Weight per Foot	2.67	3.77	6.01	7.60	10.02	12.78	15.86	19.29	23.04	27.13	31.56	36.31	41.40
Tube Size													
Oil Lube	1½	2	2½	3	3	3½	4	5	5	5	5	6	6
Water Flush	2	2½	3	3	3½	4	5	5	6	6	6	8	8

HYDRO-FOIL PUMPS

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WR^2 (LB. IN^2) MAX SPHERE SIZE

(for lb. ft^2 divide by 144) (inches dia)

Bowl Size	Type PL		Type MF		Type HH		
	WR^2	Sphere Size	WR^2	Sphere Size	Impeller Number	WR^2	Sphere Size
10	83	1-1/4"	75	3/4"	2622864	60.9	1/2"
12	139	1-1/2	126	7/8			
14	484	1-7/8	440	1	2621973	450	11/16
16	897	2-1/8	815	1-1/4	2621593	900	3/4
					2620735	1250	3/4
18	1370	2-3/8	1245	1-1/2	2621974	1900	7/8
					2621975	1900	7/8
20	3380	2-7/8	3070	1-5/8	4600652	2700	1
					4600653	2224	1
24	5680	3-1/8	5160	1-7/8	2621597	5220	1-1/8
					2620986	6750	1-1/8
26					2621599	11100	1-5/16
					2620629	13200	1-11/32
30	12950	3-3/4	11780	2-1/2	2621977	21000	1-5/8
					2621978	30000	1-5/8
36	28250	4-1/2	25670	2-3/4	2621980	45000	1-27/32
					2621981	64000	1-27/32
42	59000	5-1/4	53700	3-1/2			
48	126000	6-1/8	114500	4	2621983	203052	2-1/4
					2621984	289000	2-1/4
54	220000	7	200000	4-1/2			
56					2621987	370000	2-1/2
60	355000	7-3/4					
66			512000	5-1/4			

THRUST CALCULATIONS

Hydraulic downthrust in lb per ft of head for specific gravity 1.0

Weight of rotating element (impeller shaft and impeller).
Weight of lineshaft to be added

Size	Thrust	Wt	Size	Thrust	Wt	Size	Thrust	Wt
10PL	19	9#	18HH	35	151#	36MF	212	361#
10MF	18	13	20PL	98	77	36HH	140	784
12PL	25	16	20MF	87	99	42PL	334	360
12MF	23	18	24PL	116	101	42MF	292	505
14PL	42	32	24MF	107	143	48PL	451	540
14MF	39	33	24HH	57	190	48MF	400	644
16PL	53	40	26HH	69	275	48HH	235	1600
16MF	49	48	30PL	172	175	54PL	570	700
16HH	30	75	30MF	153	210	54MF	503	1040
18PL	65	44	30HH	104	450	60PL	710	1020
18MF	60	66	36PL	243	240	66MF	750	2100

Dimensions of Bowl Assemblies

Drawings are on the following pages.

See Vertical Turbine Section 125 for dimensions of Type HH bowl units.

			TYPE MFAL			TYPE MFAH			TYPES MF & MFH		
	TYPE PL		Single Stage Construction Only								
SIZE	A	D	A	D		A	D		A	D	
				Max. Bell Dia.	Max. Bowl Dia.		Max. Bell Dia.	Max. Bowl Dia.		Max. Bell Dia.	Max. Bowl Dia.
10	10-5/8	11-7/8	———	———	———	———	———	———	10-5/8	11-1/2	11-1/2
12	12-1/4	13-5/8	———	———	———	———	———	———	11-7/8	12-3/4	13-1/8
14	15-1/2	17-3/4	16-5/8	15-1/8	16-1/8	17-1/8	16-1/4	16-1/8	15-1/4	16-1/4	16-1/8
16	17-1/2	20	———	———	———	———	———	———	16-3/4	18-1/8	17-7/8
18	19-3/4	22-1/4	20	20	19-7/8	———	———	———	18-3/4	20	19-7/8
20	23-3/4	27	25-1/8	22-5/16	23-5/8	26-1/4	24	23-5/8	23-1/8	24	23-5/8
24	22-5/8	29	———	———	———	———	———	———	25-1/2	26-1/2	25-5/8
30	28-3/4	36	33-3/16	29-5/16	30	34-3/8	31-1/2	30	30-3/4	31-1/2	30
36	29-3/4	43-1/2	———	———	———	———	———	———	38	37	34-1/2
42	34-5/8	50-1/2	46	40	40-3/4	47-3/4	43	40-3/4	42-3/8	43	40-3/4
48	42	59-1/2	———	———	———	———	———	———	49	50	47-1/4
54	46-5/8	67	———	———	———	———	———	———	58-1/2	57	52-1/4
60	52	74-1/2	———	———	———	———	———	———	———	———	———
66	———	———	———	———	———	———	———	———	71-5/8	70	65-1/2