



PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

Practical, simple and cost-effective alternatives for process industries to purge gases from chambers, exhaust, evacuate or prime using liquid, steam or air operating media



FEATURES

- Simple design with no moving parts to wear out.
- No lubrication required.
- Virtually maintenance-free.
- Easy to install without special structures or foundations.
- Self-priming.
- Cast, fabricated or non-metallic constructions.
- Variety of materials to suit specific characteristics of the process gases.
- Critical flow paths machined smoothly with no abrupt turns or steps, producing the most efficient flow during the motive function.

GENERAL APPLICATION

Applications include creating vacuums, exhausting vapors from process systems, evacuating tanks and vessels, scrubbing a gas to remove contaminants, priming, fume removal, fluid concentration, humidifying and condensing, drying, distilling and deaerating gas.

TECHNICAL DATA

Materials: Bronze, iron, carbon steel, 316 SS, PVC, PP, PVDF
Sizes: 1/2" to 12"
Pressure range: 20 to 200 psig (1.38 to 13.8 barg)
Temperature (max): to 200°F (93°C)

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS OVERVIEW; OPERATION

PRODUCT OVERVIEW

There are eight models of Penberthy jet pumps available for pumping gases:

Models LM and ELL are used for exhausting, evacuating and priming operations where a liquid operating medium is available. They are available with suction and discharge fittings ranging from 1/2" to 12", depending on the type of construction.

Model FL 'fume movers' also use a liquid operating medium and are available with suction and discharge fittings ranging from 1/2" to 4".

GL and GH models are used for exhausting, evacuating and priming applications using operating steam or air in sizes from 1/2" to 12".

Models U and L are single-stage ejectors which use steam as the operating medium. They are available in 16 capacities and suction sizes from 1" to 4".

The 2NC is a two-stage steam operated ejector with the same range of capacities and sizes as the U and L.

TABLE 1 - MODEL SPECIFICATIONS

Model	LM	ELL	FL	GL	GH
Motive medium	Liquid	Liquid	Liquid	Steam, gas	Steam, gas
Motive medium pressure range	20-200 psig (140-1380 kPag)	20-200 psig (140-1380 kPag)	20-100 psig (140-690 kPag)	60-120 psig (415-830 kPag)	20-80 psig (140-550 kPag)
Application range, inches Hg Abs(kg/cm ² Abs)	1-27 (.03-.93)	1-27 (.03-.93)	27-30 (.93-1.04)	6-30 (.18-1.04)	6.5-30 (.2-1.04)
Functions	Evac/Exh/Prime	Evac/Exh/Prime	Exh	Evac/Exh/Prime	Evac/Exh/Prime

TABLE 2 - MODEL SPECIFICATIONS

Model	U	L	2NC
Motive medium	Steam	Steam	Steam
Motive medium pressure range	80-200 psig (550-1380 kPag)	80-200 psig (550-1380 kPag)	100-200 psig (690-1380 kPag)
Application range, inches Hg Abs(kg/cm ² Abs)	6-12 (.18-.36)	3-6 (.09-.18)	0.5-3 (.002-.09)
Functions	Evac/Exh	Evac/Exh	Evac/Exh

OPERATION

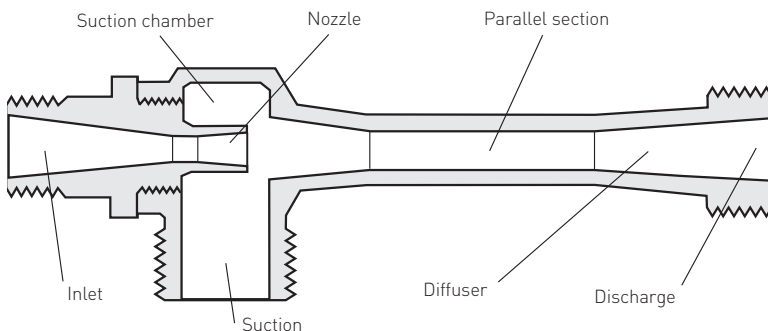
All jet pumps operate on the principle of a fluid entraining a second fluid. Although design and construction may vary, this applies to all jet pumps.

All jet pumps have three common features: inlet, suction and discharge. They function as follows:

Inlet - The operating medium (liquid, steam or air) under pressure enters the inlet and travels through the nozzle into the suction chamber. The nozzle converts the pressure of the operating medium into a high velocity stream, which passes from the discharge side of the inlet nozzle.

Suction - Pumping action begins when vapor, gases or liquid in the suction chamber are entrained by the high velocity stream emerging from the inlet nozzle, lowering the pressure in the suction chamber. The resulting action causes the liquid, gas or vapor in the suction chamber to flow toward the discharge.

Discharge - The entrained material from the suction system mixes with the operating medium and acquires part of its energy in the parallel section. In the diffuser section, part of the velocity of the mixture is converted to a pressure greater than the suction pressure, but lower than the operating medium pressure.



PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LM, ELL AND FL

PUMPING GASES USING LIQUID OPERATING MEDIUM

The LM and ELL jet pumps are used for exhausting, evacuating and priming operations where a liquid operating medium is available in a 20 to 200 psig pressure range. The maximum vacuum with closed suction is one inch Hg abs. These models are available with suction and discharge fittings ranging from 1/2" to 12", depending on the type of construction.

Model FL 'fume movers' operate in facilities where the liquid operating medium is available in the 20 to 100 PSIG range. They are identical in principle to the LM and ELL units but differ in their 'water consumption to capacity' ratio. Where the ELL Model requires more than 2 gpm of operating fluid for each scfm of air pumped, the FL with 2 gpm can pump approximately 14 scfm of air.

The other distinguishing factor is the capacity of the FL models to move large volumes of air at a suction pressure just slightly below atmospheric.

The ELL is better suited for moving air at a suction pressure of 1/2 to 1/10 atmospheric pressure - about 13 times the vacuum of the FL fume mover.

FL models are available with suction and discharge fittings ranging from 1/2" to 4" and nozzle size ranging from 1/2 to 3, depending on the type of unit selected.

TABLE 3 - MODEL CONSTRUCTION DATA

Model	LM, ELL	Standard materials	FL	Standard materials
Sizes available	1/2 A-4"	Cast: Low lead bronze, iron, C. steel, 316 STS	1"A - 4"B	Cast: iron, carbon steel, 316 STS
	4" and up	Fabricated: Carbon steel, 316 STS		
	1/2 A-3"	Non-Metallic: PVC, PP, PVDF (Kynar®)		

NOTE

Kynar® is a registered trademark of Arkema Inc.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LL, LM, LH

PUMPING GASES USING LIQUID OPERATING MEDIUM

Evacuating and priming* (Models LM, ELL)

- | | |
|---|--------------------|
| First determine: | Example |
| • Volume of space to be evacuated - ft ³ : | 30 ft ³ |
| • Required evacuation time - minutes: | 3 min. |
| • Operating liquid pressure - psig (h _m): | 80 psig |
| • Discharge pressure required - psig (h _d): | atmospheric |
- (Refer to LM, ELL evacuation time chart)

Step 1 - Determine evacuation time in minutes per 10 ft³ or 100 ft³ depending on volume of space to be evacuated (in this case, 30 ft³ - otherwise expressed as .3 hundred ft³). 32.5
(gpm operating × $\frac{1.82}{(C.F.)}$ = 59.2 actual
water used) water consumption

$$\frac{\text{Required time to evacuate (3 mins)}}{\text{Evacuation time/100 ft}^3 (.3)} = 10 \text{ min/100 ft}^3$$

* Priming: The procedure for selecting jet pumps for priming applications is the same as that for evacuation except: it takes twice the time to prime the same volume that can be evacuated with a given jet.

- Step 2 - Locate operating water pressure (in this case 80 psig) and suction pressure (in this case 5" hg abs) on the left side of the chart.
- Step 3 - Following along the appropriate line into the '100 ft³ evacuated' section, find the evacuation time that's 'equal to or lower than' the evacuation time requirement expressed in minutes/100 ft³ (in this case 10 minutes for ELL 2).
- Step 4 - Continuing to the right on the same line, you'll find the operating water used for the selected model (in this case 32.5 gpm for the ELL 1½")
Then multiply this figure times the ELL 2 capacity factor (C.F.) to determine the actual water consumption of the selected unit.

TABLE 4 - LM, ELL EVACUATION TIME

Operating water pressure (h _m) psig	Suction pressure Hg. Abs (h _s)	Time in minutes per																Operating water used, gpm (Q _m) 1½"					
		10 cubic feet evacuated				100 cubic feet evacuated																	
		½ A		½ B		½"		¾"		1"		1¼"		1½"		2"		2½"		3"			
LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL		
20	25"	24	13	15	8.3	59	32	34	19	21	11	12.00	6.4	7.10	3.9	3.90	2.10	2.20	1.20	0.66	17.5	17.2	
	20"	87	50	55	32	215	123	125	72	76	43	43.00	24.0	26.00	15.0	14.00	8.20	8.20	4.70	4.40	2.50	18.4	18.1
	15"	180	107	114	68	448	264	260	154	157	93	88.00	52.0	54.00	32.0	30.00	18.00	17.00	10.00	9.10	5.40	19.2	18.8
	10"	-	-	-	-	826	-	481	-	291	-	-	-	100.00	-	55.00	-	31.00	-	17.00	-	20.0	-
40	25"	8.3	6	5.3	3.8	21	15	12	8.7	7.3	5.2	4.10	2.9	2.50	1.8	1.40	0.99	0.79	0.57	0.42	0.30	24.2	23.0
	20"	33	22	21	14	83	55	48	32	29	19	16.00	11.0	10.00	6.7	5.60	3.70	3.20	2.10	1.70	1.10	24.8	23.6
	15"	83	50	53	32	208	124	121	72	73	43	41.00	24.0	25.00	15.0	14.00	8.20	7.90	4.70	4.20	2.50	25.4	24.2
	10"	157	90	100	57	392	223	228	130	138	78	77.00	44.0	47.00	27.0	26.00	15.00	15.00	8.50	8.00	4.50	26.0	24.7
60	5"	320	163	204	104	793	405	461	236	279	143	-	80.0	96.00	49.0	53.00	27.00	30.00	15.00	16.00	8.30	26.6	25.3
	25"	3.7	4.7	2.3	3	91	12	5.3	6.7	3.2	4.1	1.80	2.3	1.10	1.4	0.60	0.77	0.35	0.44	0.18	0.24	29.4	27.3
	20"	17	14	11	9.1	41	36	24	21	14	12	8.10	7.0	5.00	4.3	2.70	2.40	1.60	1.30	0.84	0.72	30.0	27.8
	15"	43	30	28	19	110	74	64	43	39	26	22.00	15.0	13.00	8.9	7.30	4.90	4.20	2.80	2.20	1.50	30.5	28.3
80	10"	97	50	62	32	240	124	139	72	84	44	47.00	24.0	29.00	15.0	16.00	8.20	9.10	4.70	4.90	2.50	30.9	28.7
	5"	207	87	132	55	512	215	298	125	180	76	-	43.0	62.00	26.0	34.00	14.00	19.00	8.20	10.00	4.40	31.4	29.2
	25"	2.3	3.7	1.5	2.3	5.8	9.1	3.4	5.3	2	3.2	1.10	1.8	0.70	1.1	0.38	0.60	0.22	0.35	0.11	0.18	33.8	30.9
	20"	11	11	7	7	27	27	15.9	16	9.6	9.5	5.40	5.3	3.30	3.3	1.80	1.80	1.00	1.00	0.55	0.55	34.2	31.3
100	15"	26	22	17	14	64	54	37.5	31	23	19	13.00	11.0	7.80	6.5	4.30	3.60	2.40	2.00	1.30	1.10	34.7	31.7
	10"	60	37	38	23	153	91	89	53	54	31	30.00	17.0	18.00	11.0	10.00	5.90	5.80	3.40	3.10	1.80	35.1	32.1
	5"	143	60	91	38	355	149	207	87	125	54	70.00	30.0	43.00	18.0	24.00	10.00	13.00	5.80	7.20	3.10	35.6	32.5
	25"	2.2	3.3	1.4	2.1	5.4	8.3	3.1	4.8	1.9	2.9	1.10	1.6	0.65	1.0	0.36	0.55	0.20	0.31	0.11	0.17	37.7	34.0
140	20"	7.7	9	4.9	5.7	19	22	11	13	6.7	7.9	3.70	4.4	2.30	2.7	1.30	1.50	0.72	0.86	0.39	0.46	38.1	34.4
	15"	19	18	12	11	48	44	28	25	17	15	9.50	8.7	5.80	5.3	3.20	2.90	1.80	1.70	0.98	0.90	38.5	34.7
	10"	40	29	25	19	99	73	58	42	35	25	20.00	14.0	12.00	8.8	6.60	4.80	3.80	2.80	2.00	1.50	38.9	35.1
	5"	100	50	64	32	249	124	145	72	88	44	49.00	25.0	30.00	15.0	17.00	8.30	9.50	4.70	5.10	2.50	39.3	35.4
140	25"	2	2.7	1.3	1.7	4.9	6.6	2.9	3.8	1.7	2.3	0.98	1.3	0.60	0.8	0.33	0.44	0.19	0.25	0.10	0.13	44.5	39.4
	20"	4.7	7	3	4.5	12	17	6.7	10	4.1	6.2	2.30	3.5	1.40	2.1	0.77	1.20	0.44	0.68	0.24	0.36	44.8	39.6
	15"	11	13	7.2	8.5	28	33	16	19	9.6	12	5.50	6.6	3.40	4.0	1.90	2.20	1.10	1.30	0.57	0.68	45.2	40.0
	10"	24	23	15	14	59	56	35	33	21	20	12.00	11.0	7.20	6.8	4.00	3.70	2.30	2.10	1.20	1.10	45.5	40.2
140	5"	47	40	30	26	118	99	69	58	41	34	23.00	19.0	14.00	12.0	7.90	6.40	4.50	3.70	2.40	2.00	45.9	40.6

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LM, ELL AND FL

Exhausting

First determine: Example
 Suction load - scfm air (Q_g): 1.3 scfm
 Suction pressure - inches Hg abs (h_g): 15"
 Operating liquid pressure, psig (h_m): 60 psig
 Discharge pressure, psig (h_d): 5 psig
 (Refer to FL exhauster and 1½ LM and ELL exhauster comparative performance chart.)

Step 1 - Locate appropriate suction pressure (in this case 15") on left side of chart and the line that applies to existing water pressure (in this case 60 psig).

Step 2 - Read across the 60 psig line to the 5 psig discharge pressure column noting
 LM suction capacity: 1.4 scfm
 ELL suction capacity: 3.1 scfm

Step 3 - Following along the same line you'll note
 Operating water used: 28.3 gpm

Step 4 - Since the ELL 1½ was the unit with the greater suction capacity in comparison to our requirement, we'll use it in computing the ideal capacity factor (C.F.)

$$\frac{\text{Desired capacity (1.3 scfm)}}{\text{Suction capacity - ELL 1½ (3.1 scfm)}} = .419 \text{ (ideal C.F.)}$$

Then using the capacity factor chart, find the size unit that provides a capacity factor that's equal to or greater than .419 (ideal C.F.)

The actual capacity of the selected unit is then determined by multiplying:

$$\begin{matrix} 3.1 \\ \text{(ELL 1½ scfm} \\ \text{per chart)} \end{matrix} \times \begin{matrix} .613 \\ \text{(ELL 1¼} \\ \text{capacity factor)} \end{matrix} = 1.90 \text{ scfm}$$

Step 5 - To determine water consumption of the selected unit, multiply:

$$\begin{matrix} 28.3 \\ \text{(gpm operating} \\ \text{water used)} \end{matrix} \times \begin{matrix} .613 \\ \text{(Selected} \\ \text{unit C.F.)} \end{matrix} = 17.3 \text{ gpm}$$

Step 6 - In checking the capacity and consumption of the other unit considered, we find that the LM 1½, with a capacity of 1.4 scfm, has a water consumption rate of 28.3 gpm. It then becomes obvious that the ELL 1¼ is the best unit for this application as it delivers the greatest capacity with the least volume of water consumed.

Step 7 - (FL models only) - The connecting discharge line must be sized to handle both the operating liquid and entrained air without producing more than a few inches of water discharge pressure. If this cannot be done, a box, tank or separator should be provided at the discharge end to separate non-condensable washed gases from the liquid and to vent washed gases to the atmosphere.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LM, ELL AND FL - PERFORMANCE

TABLE 5 - LM, ELL capacity factor

Size	Factor
1/2 A	0.030
1/2 B	0.047
1/2	0.121
3/4	0.208
1	0.344
1 1/4	0.613
1 1/2	1.000
2	1.820
2 1/2	3.170
3	5.920
4	11.800
6	24.000
8	49.000
10	71.000
12	123.000

TABLE 6 - 1 1/2 LM AND ELL EXHAUSTERS COMPARATIVE PERFORMANCE

Suction pressure Hg. Abs. (h _g)	Operating water pressure (h _m)	Suction capacity in scfm at discharge pressure below (Q _s)										Operating water gpm (Q _m)	
		0 psig		5 psig		10 psig		15 psig		20 psig			
		LM	ELL	LM	ELL	LM	ELL	LM	ELL	LM	ELL		
30" *	20	8.0	7.0	-	-	-	-	-	-	-	-	-	16.4
	40	10.0	9.0	2.5	5.0	-	-	-	-	-	-	-	22.5
	60	13.0	12.0	3.8	8.0	3.0	6.0	-	-	-	-	-	26.9
	80	14.0	13.0	5.5	10.0	3.9	8.5	3.2	7.2	2.9	-	-	30.6
	100	18.0	14.0	10.0	13.0	5.8	11.0	4.4	9.5	3.6	8.6	-	33.8
	140	19.0	18.0	13.0	16.0	8.5	15.0	6.2	14.0	5.6	13.0	-	39.2
	200	21.0	19.0	19.0	18.0	16.0	18.0	11.0	18.0	8.6	17.0	-	45.0
25"	20	1.6	3.0	-	-	-	-	-	-	-	-	-	17.2
	40	3.6	5.6	1.7	3.5	-	-	-	-	-	-	-	23.0
	60	5.8	8.0	2.8	5.9	2.2	4.6	-	-	-	-	-	27.3
	80	8.4	10.2	3.9	8.0	3.0	6.7	2.5	5.8	2.2	-	-	30.9
	100	9.9	11.4	6.1	10.0	4.1	9.0	3.4	7.9	3.0	7.3	-	34.0
	140	12.6	14.5	8.4	13.7	6.1	13.0	5.0	11.9	4.5	11.2	-	39.4
	200	16.7	17.4	14.3	17.0	10.7	16.8	8.7	16.1	6.9	15.7	-	45.1
20"	20	0.9	1.6	-	-	-	-	-	-	-	-	-	18.1
	40	1.9	3.6	1.2	2.4	-	-	-	-	-	-	-	23.6
	60	3.3	5.7	2.1	4.4	1.6	3.5	-	-	-	-	-	27.8
	80	4.9	7.8	2.8	6.3	2.3	5.2	1.9	4.6	1.6	-	-	31.3
	100	6.2	8.8	4.0	7.7	3.1	7.2	2.6	6.4	2.3	6.0	-	34.4
	140	8.9	11.3	5.6	10.8	4.4	10.2	3.8	9.6	3.4	9.1	-	39.6
	200	13.0	14.0	10.3	13.7	7.4	13.4	6.4	13.0	5.2	12.7	-	45.4
15"	20	0.5	0.8	-	-	-	-	-	-	-	-	-	18.8
	40	1.1	2.4	0.8	1.5	-	-	-	-	-	-	-	24.2
	60	1.8	3.9	1.4	3.1	1.1	2.6	-	-	-	-	-	28.3
	80	2.5	5.3	1.9	4.9	1.6	3.8	1.4	3.5	1.1	-	-	31.7
	100	3.7	6.3	2.5	5.9	2.2	5.4	1.9	5.0	1.6	4.6	-	34.7
	140	5.3	8.4	3.4	8.0	3.0	7.6	2.6	7.3	2.4	7.1	-	40.0
	200	8.8	10.5	6.5	10.3	4.8	10.1	4.3	9.9	3.6	9.7	-	45.7
10"	40	0.6	1.3	0.5	-	-	-	-	-	-	-	-	24.7
	60	0.9	2.6	0.8	2.0	0.7	1.5	-	-	-	-	-	28.7
	80	1.3	3.5	1.2	3.0	1.0	2.7	0.9	2.4	0.7	-	-	32.1
	100	2.0	3.9	1.4	3.8	1.3	3.7	1.2	3.5	1.1	3.3	-	35.1
	140	2.6	5.9	2.0	5.6	1.8	5.4	1.6	5.3	1.4	5.3	-	40.2
	200	5.1	7.0	3.7	6.9	2.8	6.8	2.4	6.7	2.2	6.6	-	45.9
5"	40	0.3	0.6	0.3	-	-	-	-	-	-	-	-	25.3
	60	0.4	1.6	0.3	1.2	0.3	-	-	-	-	-	-	29.2
	80	0.7	2.0	0.5	1.7	0.5	1.5	0.4	1.0	0.2	-	-	32.5
	100	0.8	2.2	0.6	2.1	0.6	2.1	0.6	2.0	0.6	1.9	-	35.4
	140	1.2	3.1	1.0	3.0	0.8	2.9	0.8	2.9	0.8	2.9	-	40.6
	200	2.0	3.5	1.5	3.5	1.2	3.5	0.9	3.5	0.9	3.5	-	46.2

* atmospheric

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MODELS LM, ELL AND FL - PERFORMANCE

TABLE 7 - FL 51 capacity factor

Size	Factor
1 A	0.30
1 B	0.48
1½	1.00
2	1.60
2½	2.70
3	4.90
4	9.20

TABLE 8 - FL 101 capacity factor

Size	Factor
1½ A	0.69
1½ B	1.00
2	1.60
3	3.20
4A	5.00
4B	9.00

TABLE 9 - FL FUME MOVER COMPARATIVE PERFORMANCE

Suction pressure inches water vacuum (h _s)	Operating water pressure (h _m)	Capacity in scfm at atmospheric discharge (Q _s)		Operating water consumption, gpm (Q _m)	
		FL 51 1½"	FL 101 1½"B	FL 51 1½"	FL 101 1½"B
0" *	20	24.6	21.9	10.5	3.5
	40	36.5	29.3	14.0	4.8
	60	43.8	37.0	16.7	5.7
	80	51.1	41.3	18.9	6.4
	100	58.6	46.9	20.8	7.0
5"	20	14.6	-	10.5	-
	40	29.6	10.0	14.0	4.8
	60	38.1	21.1	16.7	5.7
	80	46.1	29.9	18.9	6.4
	100	54.2	37.1	20.8	7.0
10"	20	6.7	-	10.5	-
	40	23.0	-	14.0	-
	60	32.6	6.8	16.7	5.7
	80	41.2	18.5	18.9	6.4
	100	50.0	27.5	20.8	7.0
15"	40	16.9	-	14.0	-
	60	27.2	-	16.7	-
	80	36.6	7.0	18.9	6.4
	100	45.9	17.0	20.8	7.0
20"	40	11.5	-	14.0	-
	60	22.2	-	16.7	-
	80	32.2	-	18.9	-
	100	41.8	7.8	20.8	7.0
25"	40	7.0	-	14.0	-
	60	17.7	-	16.7	-
	80	28.0	-	18.9	-
	100	38.7	-	20.8	-
30"	40	3.3	-	14.0	-
	60	13.7	-	16.7	-
	80	24.3	-	18.9	-
	100	34.2	-	20.8	-
35"	40	0.4	-	14.0	-
	60	10.5	-	16.7	-
	80	20.9	-	18.9	-
	100	30.6	-	20.8	-
45"	40	-	-	-	-
	60	4.8	-	16.7	-
	80	14.8	-	18.9	-
	100	24.4	-	20.8	-

* atmospheric

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LM, ELL AND FL - DIMENSIONS

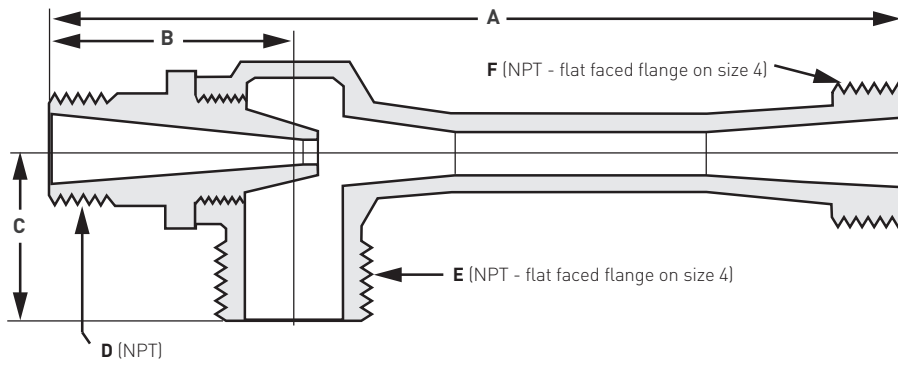


TABLE 10 - CAST LM, ELL

Size	Model	A	B	C	D	E	F
1/2 A	LM	4 3/8	1 1/2	1 1/4	1/4	1/2	1/2
1/2 B	LM, ELL	4 3/8	1 1/2	1 1/4	1/4	1/2	1/2
1/2	LM, ELL	4 1/2	1 5/8	1 1/4	3/8	1/2	1/2
3/4	LM, ELL	5 7/8	2	1 1/2	1/2	3/4	3/4
1	LM, ELL	7 1/8	2 1/4	1 3/4	3/4	1	1
1 1/4	LM, ELL	9	2 1/2	2 1/4	1	1 1/4	1 1/4
1 1/2	LM, ELL	11	2 3/4	2 1/2	1	1 1/2	1 1/2
2	LM, ELL	14 3/8	3 1/8	3	1 1/4	2	2
2 1/2	LM, ELL	18 1/8	3 1/2	4 1/8	1 1/2	2 1/2	2 1/2
3	LM, ELL	23 7/8	4	5	2	3	3
4	LM, ELL	32 7/8	5	6	3	4 ❖	4 ❖

❖ Flange. Bolting corresponds to ASA 150 lbs.

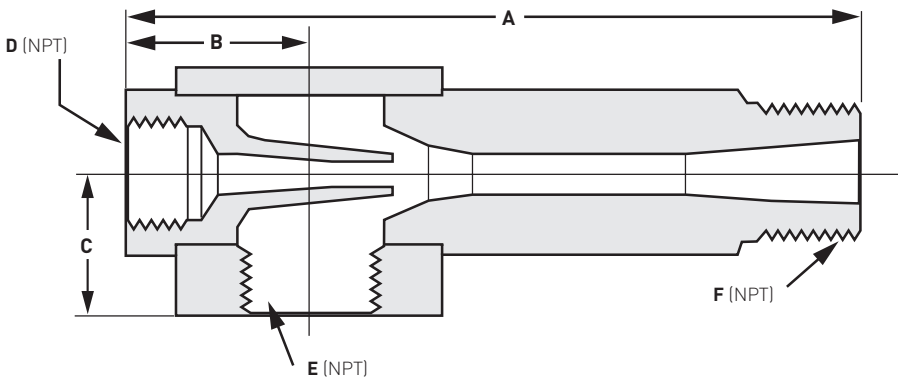


TABLE 11 - PVC LM, ELL

Size	Model	A	B	C	D	E	F
1/2 A	LM	3 3/4	1 11/16	1 5/16	1/4	1/2	1/2
1/2 B	LM	3 3/4	1 11/16	1 5/16	1/4	1/2	1/2
1/2	LM	4 5/8	1 11/16	1 5/16	1/4	1/2	1/2
3/4	LM	5 3/4	1 7/8	1	1/2	3/4	3/4
1	LM, ELL	6 7/8	2 1/8	1 5/16	3/4	1	1
1 1/4	LM, ELL	9 1/16	2 3/4	1 1/2	1	1 1/4	1 1/4
1 1/2	LM, ELL	10 15/16	3	1 3/4	1	1 1/2	1 1/2
2	LM, ELL	14 3/16	3 1/2	1 15/16	1 1/4	2	2
2 1/2	LM, ELL	18 1/2	4	2 1/2	1 1/2	2 1/2	2 1/2
3	LM, ELL	24 3/16	4 1/2	3	2	3	3

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES
 MODELS LM, ELL AND FL - DIMENSIONS

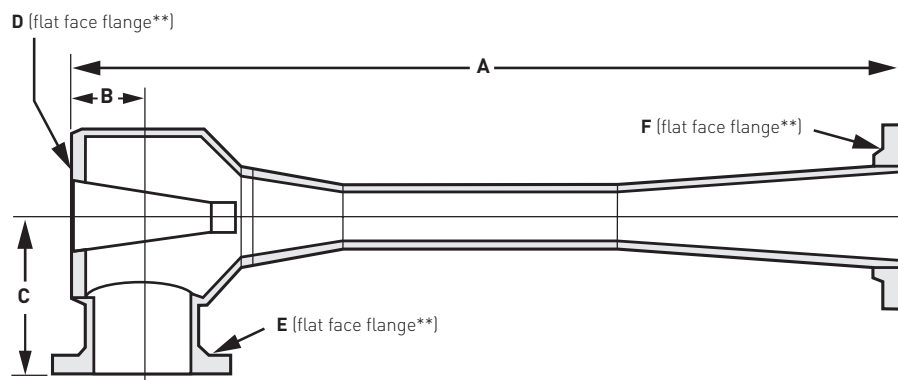


TABLE 12 - FABRICATED LM, ELL

Size	A	B	C	D**	E**	F**
4	38 ¹ / ₄	5 ¹ / ₄	8	3	4	4
6	52 ⁷ / ₈	5 ⁷ / ₈	9 ¹ / ₂	4	6	6
8	74 ⁷ / ₁₆	8 ⁷ / ₁₆	13	6	8	8
10	87 ³ / ₈	10 ³ / ₈	14	8	10	10
12	110 ³ / ₄	11 ³ / ₄	18	10	12	12

** Bolting corresponds to ASA 150 lbs. Bolt holes in D flange of all sizes are blind tapped

PENBERTHY JET PUMPS FOR PUMPING GASES

MODELS LM, ELL AND FL - DIMENSIONS

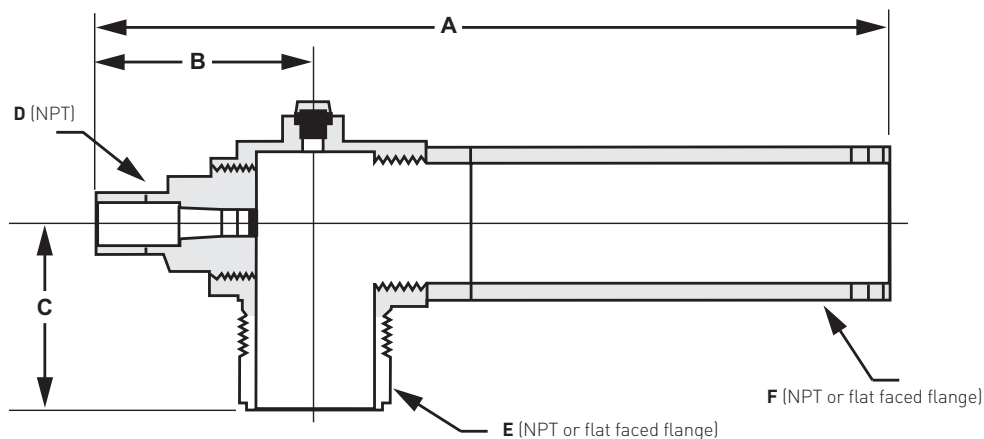


TABLE 13 - CAST FL51

Size	Nozzle sizes	A	B	C	D	E	F
1A	3/4	11 7/8	2 1/2	1 3/4	1/2	1	1
1B	1	11 7/8	2 1/2	1 3/4	3/4	1	1
1 1/2	1 1/4	16 7/16	3	2 1/2	1	1 1/2	1 1/2
2	1 1/2	20 11/16	3 1/4	3	1	2	2
2 1/2	2	25 7/8	3 3/4	4 1/8	1 1/4	2 1/2	2 1/2
3	2 1/2	33 15/16	4 1/4	5	1 1/2	3	3
4	3	45	5	6	2	4	4

TABLE 14 - CAST FL101

Size	Nozzle sizes	A	B	C	D	E	F
1 1/2 A	1/2	10 5/16	2 13/16	2 1/2	3/8	1 1/2	1 1/2
1 1/2 B	3/4	10 5/16	2 13/16	2 1/2	1/2	1 1/2	1 1/2
2	1	12 3/4	3 1/4	3	3/4	2	2
3	1 1/4	17 7/16	4	5	1	3	3
4A	1 1/2	26 1/8	5	6	1	4	4
4B	2	26 1/8	5	6	1 1/4	4	4

NOTE

Always specify material, model and unit size.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH

PUMPING GASES USING STEAM OR AIR OPERATING MEDIUM

Series G jet pumps include the GL and GH models. They are used for exhausting, evacuating and priming applications.

Model GL uses operating steam or air from 60 to 120 psig. The maximum vacuum with closed suction is 6" Hg abs.

Model GH uses operating steam or air from 20 to 80 psig. The maximum vacuum with closed suction is 6½" Hg abs.

Each model is available in 15 sizes from ½" to 12" suction and discharge. Units are cast construction in sizes ½ through 6. Sizes 4 through 12 are available with fabricated construction. Certain sizes of units are also available in PVC or other polymer constructions.

NOTE

Always specify material, model and unit size when ordering.

TABLE 15 - MODEL CONSTRUCTION DATA

Model	GL, GH	Standard materials
Sizes Available	½A-4"	Cast: Low lead bronze, iron, C. steel, 316 STS
	4" and up	Fabricated: Carbon steel, 316 STS
	½A-3"	Non-Metallic: PVC, PP, PVDF (Kynar™)

The capacities of both models are slightly higher when using air as the operating medium instead of steam. The following information is required for selection of both the GL and GH models for exhausting, evacuating and priming:

Exhausting

- Suction load, standard cubic feet per minute (scfm) air (Q_s)*
 - Suction pressure, inches Hg. abs. (h_s)
 - Operating steam or air pressure, psig (h_m)
 - Discharge pressure required, psig (h_d)
- * For suction loads other than air, refer to dry air equivalent section on page 22.

Evacuating

- Suction load, in cubic feet of space to be evacuated
- Required time to evacuate, in minutes
- Operating steam or air pressure, psig (h_m)
- Final suction pressure, inches Hg abs. (h_s)
- Discharge pressure required, psig (h_d)

Priming

The selection procedure for ejectors in priming applications is the same as that for evacuation, except: The evacuation time must be doubled for priming applications because the priming capacity of any given ejector is half that of the evacuating capacity.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH

G SERIES UNIT SELECTION USING PERFORMANCE CHARTS

The following procedures and examples are included for selecting Series G jet pumps. Refer to the performance curves and tables when determining individual unit sizes.

For air operating medium, use the same performance data as for steam.

To estimate the air consumption in standard cubic ft/minute, divide the listed values by 3.

For example: The GH-1½ steam consumption is 497 lbs/hr at 60 psig. The air consumption at the same pressure would be $497 \div 3 = 166$ scfm.

Exhausting - selection procedure

Step 1 - From the family of performance curves, select the one matching the available operating pressure, psig (h_m) and required discharge pressure, psig (h_d).

Step 2 - At the point where this curve intersects the suction pressure (h_s), read down the line to determine suction capacity (Q_s) of 1½" unit.

Step 3 - Compute ideal capacity factor (C.F.) by dividing:

$$\frac{Q_s - \text{required}}{Q_s - \text{from curve}}$$

Step 4 - Select (from C.F. chart) the unit having C.F. equal to or greater than that determined in Step 3.

Step 5 - To figure steam consumption, refer to steam consumption table. Find the consumption listed for available operating pressure (h_m) and multiply this by the C.F. for the selected unit.

Exhausting - example

To exhaust 200 scfm:

Suction pressure, inches Hg abs. (h_s): 20

Operating steam pressure, psig (h_m): 80

Maximum discharge pressure, psig (h_d): 5

Both GL and GH Models are considered in this example to illustrate selection on the basis of operating economy.

Step 1 - Go to the 80 psig curves (h_m) and note discharge pressure of each.

Step 2 - These curves intersect suction pressures (h_s) at:

35.5 scfm on the GL - 1½ curve

17.0 scfm on the GH - 1½ curve

Step 3 - Ideal capacity factor (CF)

$$\frac{Q_s - \text{required}}{Q_s - \text{from curve}}$$

$$\text{GL} - 1\frac{1}{2} = \frac{200}{35.5} = 5.63$$

$$\text{GH} - 1\frac{1}{2} = \frac{200}{17.0} = 11.76$$

Step 4 - From the CF chart

GL - 3 = 5.92

GH - 4 = 11.8

Step 5 - To determine the most economical model of those considered, check steam consumption chart and determine the steam consumption of both under available operating pressure 80 psig:

GL-3 uses 277 lbs/hr x CF 5.92 = 1640 lbs/hr.

Maximum discharge pressure (from curve) = 6 psig

GH-4 uses 623 lbs/hr x CF 11.8 = 7351 lbs/hr

Maximum discharge pressure (from curve) = 21 psig

Therefore: the GL-3, having the lower steam consumption, in the desired range of operation, is the correct unit.

NOTE

GL and GH PVC units are for air operation only.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH

Evacuating - selection procedure

- Step 1 - Compute time in minutes per hundred cubic feet to complete the required evacuation.
- Step 2 - Refer to the GL, GH evacuation time chart. Find the operating pressure (h_m) and suction pressure (h_s).
- Step 3 - Read across to the right and find the unit that will complete the evacuation within the desired time.
- Step 4 - To figure steam consumption, multiply the steam used (shown in the right-hand column of the same chart) by the appropriate capacity factor (C.F.).

Evacuating - example

To evacuate 200 cubic feet in 30 minutes:

Final suction pressure, inches Hg abs. (h_s):	10
Operating steam pressure, psig (h_m):	40
Discharge pressure (h_d):	atmospheric

Step 1 - Determine time in minutes per 100 cubic feet to complete evacuation:

$$\frac{30 \text{ minutes total}}{2 \text{ (hundred ft}^3\text{)}} = 15 \text{ minutes per 100 cubic feet}$$

Step 2 - Locate operating steam pressure, 40 psig (h_m) and suction pressure, 10 inches Hg. abs. (h_s) on evacuation time chart.

Step 3 - Read across to the right and locate unit that will complete evacuation in desired time. The GH-1 will complete the evacuation in 14 minutes.

Step 4 - Find steam used in right-hand column - 366 lbs/hr

Multiply this by the C.F. for the GH-1:

$$.344 \times 366 \text{ lbs/hr} = 126 \text{ lbs/hr}$$

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES
MODELS GL, GH - PERFORMANCE

TABLE 16 - GL, GH EVACUATION TIME

Operating water pressure (h _m) psig	Suction pressure, in. Hg abs (h _s)	Time in minutes per												Operating steam used, lbs/hr (Q _m)									
		10 cubic feet evacuated				100 cubic feet evacuated																	
		1/2" A		1/2" B		1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		1 1/2"	
30	25"	-	2.4	-	1.5	-	6.0	-	3.5	-	2.1	-	1.20	-	0.73	-	0.40	-	0.23	-	0.12	-	301
	20"	-	4.7	-	3.0	-	12.0	-	6.7	-	4.1	-	2.30	-	1.40	-	0.77	-	0.44	-	0.24	-	301
	15"	-	8.7	-	5.5	-	21.0	-	12.0	-	7.5	-	4.20	-	2.60	-	1.40	-	0.82	-	0.44	-	301
	10"	-	15.0	-	9.6	-	37.0	-	22.0	-	13.0	-	7.30	-	4.50	-	2.50	-	1.40	-	0.76	-	301
40	25"	-	1.7	-	1.1	-	4.1	-	2.4	-	1.4	-	0.81	-	0.50	-	0.27	-	0.16	-	0.08	-	366
	20"	-	4.0	-	2.5	-	9.9	-	5.8	-	3.5	-	2.00	-	1.20	-	0.66	-	0.38	-	0.20	-	366
	15"	-	8.3	-	5.3	-	21.0	-	12.0	-	7.3	-	4.10	-	2.50	-	1.40	-	0.79	-	0.42	-	366
	10"	-	15.7	-	10.0	-	39.0	-	23.0	-	14.0	-	7.70	-	4.70	-	2.60	-	1.50	-	0.79	-	366
60	25"	1.0	1.7	0.64	1.1	2.5	4.1	1.4	2.4	0.87	1.4	0.49	0.81	0.3	0.50	0.16	0.27	0.09	0.16	0.05	0.08	221	497
	20"	2.3	4.7	1.50	3.0	5.8	12.0	3.4	6.7	2.00	4.1	1.10	2.30	0.7	1.40	0.38	0.77	0.22	0.44	0.12	0.24	221	497
	15"	4.0	9.3	2.50	6.0	9.9	23.0	5.8	13.0	3.50	8.1	1.90	4.60	1.2	2.80	0.66	1.50	0.38	0.88	0.20	0.47	221	497
	10"	7.7	19.0	4.90	12.0	19.0	47.0	11.0	27.0	6.70	17.0	3.70	9.30	2.3	5.70	1.30	3.10	0.72	1.80	0.39	0.96	221	497
80	25"	1.0	2.0	0.64	1.3	2.5	5.0	1.4	2.9	0.87	1.7	0.49	0.98	0.3	0.60	0.16	0.33	0.09	0.19	0.05	0.10	277	623
	20"	2.0	5.0	1.30	3.2	5.0	12.0	2.9	7.2	1.70	4.4	0.98	2.40	0.6	1.50	0.33	0.82	0.19	0.47	0.10	0.25	277	623
	15"	4.0	9.7	2.50	6.2	9.9	24.0	5.8	14.0	3.50	8.4	2.00	4.70	1.2	2.90	0.66	1.60	0.38	0.91	0.20	0.49	277	623
	10"	8.0	20.0	5.10	13.0	20.0	50.0	11.0	29.0	7.00	17.0	3.90	9.80	2.4	6.00	1.30	3.30	0.76	1.90	0.40	1.00	277	623
100	25"	1.0	2.0	0.64	1.3	2.5	5.0	1.4	2.9	0.87	1.7	0.49	0.98	0.3	0.60	0.16	0.33	0.09	0.19	0.05	0.10	333	750
	20"	2.3	5.3	1.50	3.4	5.8	13.0	3.4	7.7	2.00	4.6	1.10	2.60	0.7	1.60	0.38	0.88	0.22	0.50	0.12	0.27	333	750
	15"	4.7	12.0	3.00	7.4	12.0	29.0	6.7	17.0	4.10	10.0	2.30	5.70	1.4	3.50	0.77	1.90	0.44	1.10	0.24	0.59	333	750
	10"	8.7	40.0	5.50	26.0	21.0	99.0	12.0	58.0	7.60	35.0	4.30	-	2.6	-	1.40	6.60	0.82	3.80	0.44	2.00	333	750
120	25"	1.0	-	0.64	-	2.5	-	1.4	-	0.87	-	0.49	-	0.3	-	0.16	-	0.09	-	0.05	-	390	-
	20"	2.7	-	1.70	-	6.6	-	3.8	-	2.30	-	1.30	-	0.8	-	0.44	-	0.25	-	0.13	-	390	-
	15"	5.3	-	3.40	-	13.0	-	7.7	-	4.60	-	2.60	-	1.6	-	0.88	-	0.50	-	0.27	-	390	-
	10"	9.0	-	5.70	-	22.0	-	13.0	-	7.80	-	4.40	-	2.7	-	1.50	-	0.85	-	0.46	-	390	-

TABLE 17 - 1 1/2 GL, GH STEAM CONSUMPTION (lbs/hr Q_m)

Steam pres. (hm)	20	40	60	80	100	120	150
GL			221	277	333	390	474
GH	236	366	497	623	750	878	1067

TABLE 18 - GL, GH capacity factor

Size	Factor
1/2 A	0.030
1/2 B	0.047
1/2	0.121
3/4	0.208
1	0.344
1 1/4	0.613
1 1/2	1.000
2	1.820
2 1/2	3.170
3	5.920
4	11.800
6	24.000
8	49.000
10	71.000
12	123.000

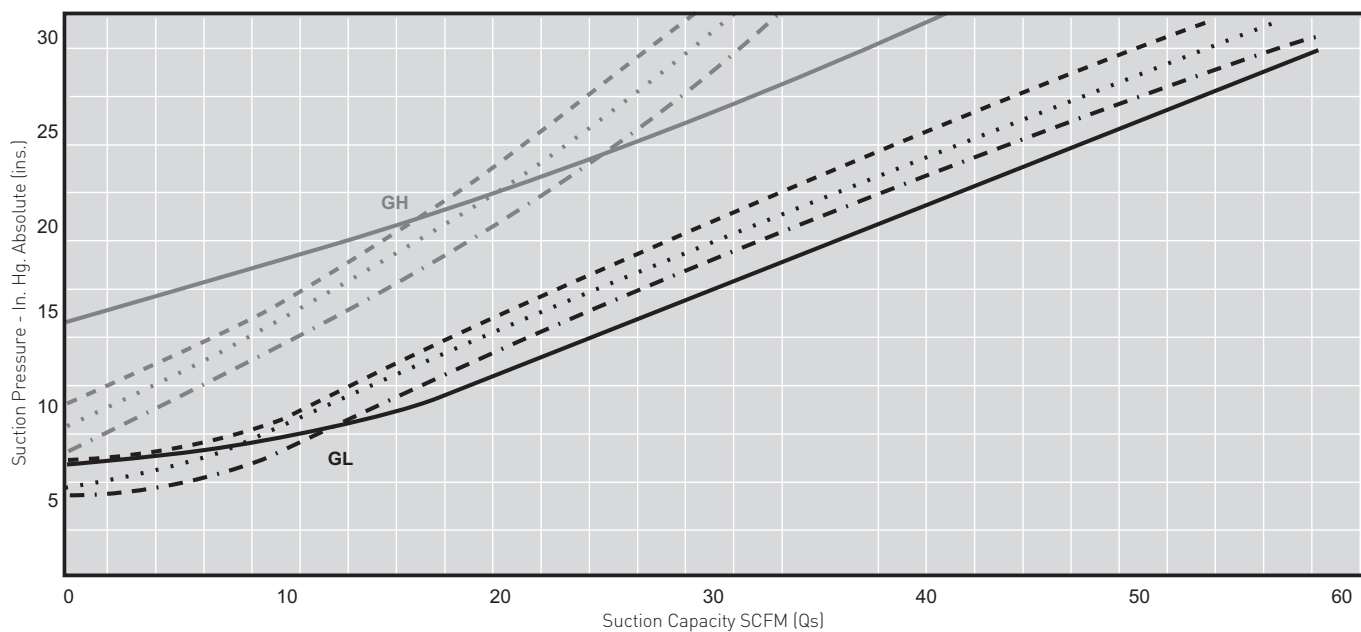
TABLE 19 - 1 1/2 GL, GH AIR CONSUMPTION (scfm)

Air pres. (hm)	20	40	60	80	100	120	150
GL			74	92	111	130	158
GH	78	122	166	208	250	293	356

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH - PERFORMANCE

1½ GL, GH SUCTION AIR LOAD SCFM (Qs) PERFORMANCE CURVES (EXHAUSTING)



GH

- - - 80 psig O.P. with up to 21 psig D.P.
- 60 psig O.P. with up to 14 psig D.P.
- . - 40 psig O.P. with up to 6 psig D.P.
- 20 psig Operating Pressure (hm) with 0 psig Discharge Pressure (hd)

GL

- - - 120 psig Operating Pressure (hm) with up to 12 psig Discharge Pressure
- 100 psig O.P. with up to 9 psig D.P.
- . - 80 psig O.P. with up to 6 psig D.P.
- 60 psig O.P. with up to 1 psig D.P.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH - DIMENSIONS

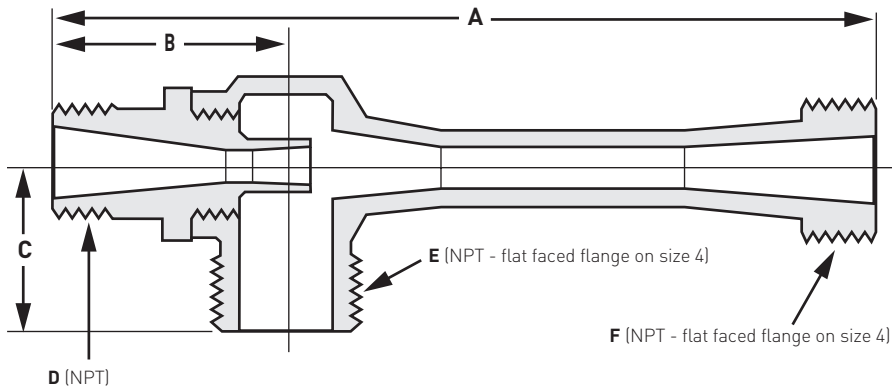


TABLE 20 - Cast GL, GH dimensions (in inches)

Size	A	B	C	D*	E*	F*
1/2 A	4 3/8	1 1/2	1 1/4	1/4	1/2	1/2
1/2 B	4 3/8	1 1/2	1 1/4	1/4	1/2	1/2
1/2	4 1/2	1 5/8	1 1/4	3/8	1/2	1/2
3/4	5 7/8	2	1 1/2	1/2	3/4	3/4
1	7 1/8	2 1/4	1 3/4	3/4	1	1
1 1/4	9	2 1/2	2 1/4	1	1 1/4	1 1/4
1 1/2	11	2 3/4	2 1/2	1	1 1/2	1 1/2
2	14 3/8	3 3/8	3	1 1/4	2	2
2 1/2	18 1/8	3 1/2	4 1/8	1 1/2	2 1/2	2 1/2
3	23 3/8	4	5	2	3	3
4	32 7/8	5	6	3	4 ❖*	4 ❖*

❖ Flange.

* Bolting corresponds to ASA 150 lbs.

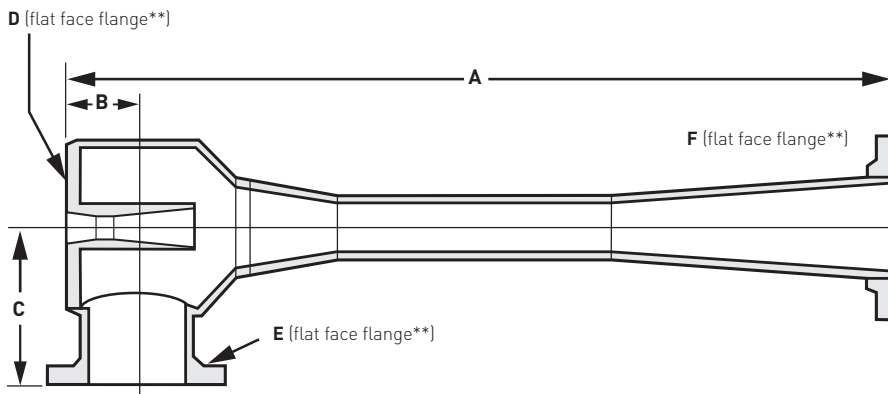


TABLE 21 - Fabricated GL, GH dimensions (in inches)

Size	A	B	C	D**	E**	F**
4	38 1/4	5 1/4	8	3	4	4
6	52 7/8	5 7/8	9 1/2	4	6	6
8	74 7/16	8 7/16	13	6	8	8
10	87 3/8	10 3/8	14	8	10	10
12	110 3/4	11 3/4	18	10	12	12

** Bolting corresponds to ASA 150 lbs. Bolt holes in D flange of all sizes are blind tapped.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES
 MODELS GL, GH - DIMENSIONS

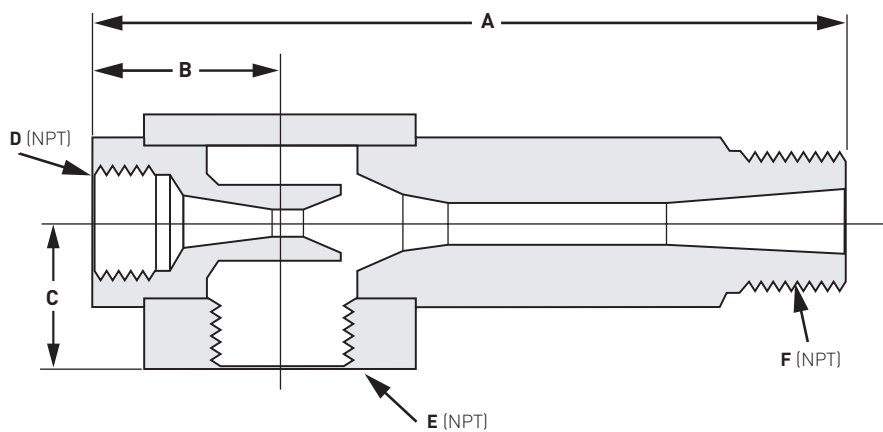


TABLE 22 - PVC GL, GH - for air operation only dimensions (in inches)

Size	A	B	C	D	E	F
1/2 A	3 3/4	1 11/16	15/16	1/4	1/2	1/2
1/2 B	3 3/4	1 11/16	15/16	1/4	1/2	1/2
1/2	4 5/8	1 11/16	15/16	1/4	1/2	1/2
3/4	5 3/4	1 7/8	1	1/2	3/4	3/4
1	6 7/8	2 1/8	15/16	3/4	1	1
1 1/4	9 1/16	2 3/4	1 1/2	1	1 1/4	1 1/4
1 1/2	10 15/16	3	1 3/4	1	1 1/2	1 1/2
2	14 3/16	3 1/2	1 15/16	1 1/4	2	2
2 1/2	18 1/2	4	2 1/2	1 1/2	2 1/2	2 1/2
3	24 3/16	4 1/2	3	2	3	3

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS LM, ELL, GL, GH - SELECTION

SELECTION GUIDE - MODELS ELL, LM, GL, GH

Example	LM	- 04	CS	C	NT	NT	NT	- 01
Model								
ELL Model ELL								
LM Model LM								
GL Model GL								
GH Model GH								
Jet size								
4A ½A 20 2½"								
4B ½B 24 3"								
04 ½" 32 4"								
06 ¾" 48 6"								
08 1" 64 8"								
10 1¼" 80 10"								
12 1½" 96 12"								
16 2"								
Material of construction								
BZ Bronze								
CS Carbon steel								
IR Cast iron								
SS 316 SST								
HC Hastelloy C								
MO Monel								
20 A20								
PP Polypropylene								
PV PVC								
CP CPVC								
KY Kynar®								
Style of construction								
C Cast metal 2-PC (standard for sizes ½A - 3")								
F Metal fabricated (4" - 12") (flanged only)								
B Plastic barstock or metal barstock								
W Metal weld construction								
Inlet (motive) connection style								
NT NPT (standard for sizes ½A - 3")								
RS Raised face slip on #150 flange (20,CS,IR,SS,HC and MO material only)								
RT Raised face threaded #150 flange (20,CS,IR,SS,HC and MO material only)								
FS Flat face slip on #150 flange (BZ,PP,PV and KY material)								
FT Flat face threaded #150 flange (BZ,PP,PV and KY material)								
FF Flat face #150 on fabricated 4" - 12" jet								
RF Raised face #150 on fabricated 4" - 12" jet								
Suction connection style								
NT NPT (standard for sizes ½A - 3")								
RS Raised face slip on #150 flange (20,CS,IR,SS,HC and MO material only)								
RT Raised face threaded #150 flange (20,CS,IR,SS,HC and MO material only)								
FS Flat face slip on #150 flange (BZ,PP,PV and KY material)								
FT Flat face threaded #150 flange (BZ,PP,PV and KY material)								
FF Flat face #150 on fabricated 4" - 12" jet								
RF Raised face #150 on fabricated 4" - 12" jet								
Discharge connection style								
NT NPT (standard for sizes ½A - 3")								
RS Raised face slip on #150 flange (20,CS,IR,SS,HC and MO material only)								
RT Raised face threaded #150 flange (20,CS,IR,SS,HC and MO material only)								
FS Flat face slip on #150 flange (BZ,PP,PV and KY material)								
FT Flat face threaded #150 flange (BZ,PP,PV and KY material)								
FF Flat face #150 on fabricated 4" - 12" jet								
RF Raised face #150 on fabricated 4" - 12" jet								
Variation								
01 Catalog Standard								

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODEL FL - SELECTION

SELECTION GUIDE - MODELS FL51, FL101

Example	FL5	16	IR	S	NT	NT	NT	- 01
Model								
FL5 Model FL51								
FL1 Model FL101								
Jet size (refer to page 10 for applicable sizes)								
FL51								
1A 1" (1/2" NPT nozzle)								
1B 1" (3/4" NPT nozzle)								
12 1 1/2"								
16 2"								
20 2 1/2"								
24 3"								
32 4"								
FL101								
A2 1 1/2" (3/8" NPT nozzle)								
B2 1 1/2" (1/2" NPT nozzle)								
16 2"								
24 3"								
4A 4" (FL101 w/ 1 1/2" nozzle)								
4B 4" (FL101 w/ 2" nozzle)								
Material of construction								
IR Iron body w/ carbon steel nozzle and carbon steel diffuser (FL51)								
IR Iron body and nozzle & carbon steel diffuser (FL101)								
SS 316 SST								
Style of construction								
S Standard								
Inlet (motive) connection style								
NT NPT								
Suction connection style								
NT NPT								
RS Raised face slip on #150 flange								
RT Raised face threaded #150 flange								
FS Flat face slip on #150 flange								
FT Flat face threaded #150 flange								
Discharge connection style								
NT NPT								
RS Raised face slip on #150 flange								
RT Raised face threaded #150 flange								
FS Flat face slip on #150 flange								
FT Flat face threaded #150 flange								
Variation								
01 Catalog standard								

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC

PUMPING GASES USING STEAM OPERATING MEDIUM

Model U and L single stage ejectors are available in 16 capacities and suction sizes from 1" to 4". Model U operates efficiently in a vacuum range of 6" to 12" Hg abs.; model L in the range of 3" to 6" Hg. abs. These ejectors are used for exhausting and evacuating applications where steam is the operating medium in the range of 80 to 200 psig.

The 2NC two stage non-condensing ejector is also available in 16 capacity ranges for similar applications in a vacuum range of 1/2" to 3" Hg abs. It uses steam as the operating medium in the range of 100 to 200 psig.

Nozzles supplied with U, L and 2NC ejectors are selected to match the operating steam pressure specified when units are ordered. Nozzles are available for operating steam pressures of 80 (for U and L only), 100, 120, 140, 160, 180 or 200 psig.

Steam consumption data given in charts in this section are valid for any one of these pressures. When the operating steam pressure specified falls between two of these standard pressures, the lower pressure nozzle will be supplied. Steam consumption will be slightly higher for such units unless the operating steam pressure is regulated to match that of the nozzle.

The following information is required for selection of these three steam operated models in exhausting and evacuating applications:

Exhausting

- Suction load (Q_s) lbs./hr. of dry air at 70°F, or dry air equivalent (DAE)
(For suction loads other than air, refer to dry air equivalent section on page 28).
Air - pounds per hour
Water vapor - pounds per hour
Molecular weights and quantities of other suction gases - pounds per hour
- Suction pressure, inches Hg abs. (h_s)
- Operating steam pressure, psig (h_m)
- Discharge pressure, psig (h_d) (if greater than 1 psig, contact factory)

Evacuating

- Suction load, in cubic feet of air to be evacuated
Required time to evacuate, in minutes
 - Operating steam pressure, psig (h_m)
 - Final suction pressure, inches Hg abs (h_s)
 - Discharge pressure required, psig (h_d)
- For evacuating applications using Model L or Model 2NC, contact the factory

Sizes available

Each model is available in 16 sizes from 1 inch to 4 inches suction and discharge. Sizes 1 through 3 are NPT. Size 4 is drilled in accordance with ASA 125 lbs. bolt pattern.

NOTE

When ordering, always specify operating steam pressure, for correct nozzle sizing. Also specify material, model and unit size. For available materials, see below.

TABLE 23 - MODEL CONSTRUCTION DATA

Model	U, L, 2NC	Standard materials
Sizes available	1H-16H	Cast: Carbon steel, iron body, 316 STS nozzle or all 316 STS

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC

U, L, 2NC UNIT SELECTION USING PERFORMANCE CHARTS

The following procedures and examples are included for selecting U, L and 2NC ejectors. Refer to the performance curves and tables to determine individual unit sizes.

Exhausting - selection procedure

Refer to U, L performance curves on pages 23 and 24.

Step 1 - Determine the unit having a suction pressure within the application range.

Step 2 - Determine the capacity of the selected unit using the following procedure:

- a. Refer to the required suction pressure (hs) in the left-hand column.
- b. Read across to the operating steam pressure curve (hm).

Read down this line and note the suction capacity at the bottom of the chart.

NOTE

Both U and L curves are drawn for U-4 and L-4 units. Capacity factors are used to determine capacities of all other units.

Step 3 - Calculate the ideal capacity factor:

$$\text{Ideal C.F.} = \frac{\text{Desired capacity}}{\text{Capacity from curve}}$$

Step 4 - Choose the unit with the capacity factor equal to or greater than the ideal.

Step 5 - Refer to the capacity factor chart and note the operating steam consumption (Qm) for the selected unit.

The selection procedure for Model 2NC is identical to that for models U and L. Use 2NC performance curves and steam consumption chart.

Exhausting - Example

To exhaust 55 pounds of 70°F dry air per hour:

Suction pressure, inches Hg abs (hs):	6
Operating steam pressure, psig (hm):	160
Discharge pressure, psig (hd):	1

Step 1 - Consider both U-4 and L-4 units based on suction pressure of 6 inches Hg abs.

Step 2 - Starting at 6 (hs) on curve, read across to required operating steam pressure (hm). Read down this vertical line and note suction capacity (Qs) at bottom.

U-4 capacity is 84 lbs. per hour

L-4 capacity is 85 lbs. per hour

Step 3 - Calculate ideal capacity factor:

$$\begin{aligned} \frac{\text{Desired capacity}}{\text{Capacity from curve}} &= \text{for U - 4} && \frac{55\text{lbs / hr}}{84} = .655 \\ &= \text{for L - 4} && \frac{55\text{lbs / hr}}{85} = .647 \end{aligned}$$

Step 4 - Choose the exact unit size having a C.F. equal to or greater than the ideal.

Both models U-3 and L-3 have a C.F. of .694.

U-3 Capacity = .694 x 84 (from Step 2) = 58.2 lbs/hr

L-3 Capacity = .694 x 85 = 58.9 lbs/hr

This particular example illustrates the close performance characteristics of both U and L models at the suction pressure of 6" Hg abs. In this case, the model U is operating in the lower end of its application range and its performance improves at suction pressures above 6. The model L, however, is operating in the upper extreme of the application range and performance improves at suction pressures below 6.

Step 5 - Note operating steam consumption (Qm) on capacity factor chart. Model U-3 and L-3 steam consumption = 195 lbs/hr.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC

U, L, 2NC UNIT SELECTION USING PERFORMANCE CHARTS

Evacuating - selection procedure

Refer to U evacuation time chart.

Step 1 - Figure evacuation time in minutes per hundred cubic feet.

Step 2 - Go to the left-hand column in table, final suction pressure (h_s). Read across to find evacuation time equal to or less than that determined in Step 1. Read to the top of the table and note unit number.

Step 3 - Read steam consumption of unit selected off capacity factor chart.

Evacuating - example

To evacuate 3000 cubic foot vessel full of air at atmospheric pressure:

Operating steam pressure, psig (h_m):	100
Final suction pressure, inches Hg abs. (h_s):	5
Time to evacuate, hrs:	2.5
Discharge pressure (h_d):	atmosphere

Step 1 - Determine evacuation time in minutes per hundred cubic feet.

$$\frac{2.5 \text{ hours} \times 60}{30 \text{ (hundred) ft}^3} = 5 \text{ minutes/100 cubic feet}$$

Step 2 - Go to the final pressure on left of evacuation time chart (5 in. Hg. h_s). Read across and find evacuation time equal to or less than 5 minutes.

The U-2 will evacuate the tank in 5.33 minutes per hundred cubic feet and the U-3 will complete the evacuation in 3.42 minutes per cubic hundred feet.

Step 3 - Read steam consumption of selected unit off capacity factor chart. The unit to select would be the U-3 in this case and its steam consumption is 195 lbs/hr.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC - PERFORMANCE

TABLE 24 - U MODEL EVACUATION TIME (in minutes per 100 cu. ft at 100 psig operating steam pressure)

Suction press. In. Hg abs (h _s)	Model number															
	U-1H	U-2H	U-3H	U-4H	U-5H	U-6H	U-7H	U-8H	U-9H	U-10H	U-11H	U-12H	U-13H	U-14H	U-15H	U-16H
12"	4.68	3.08	1.98	1.37	1.01	0.769	0.610	0.494	0.409	0.343	0.293	0.253	0.206	0.171	0.145	0.123
11"	5.06	3.32	2.14	1.48	1.09	0.830	0.657	0.532	0.441	0.370	0.316	0.273	0.222	0.185	0.156	0.133
10"	5.44	3.57	2.30	1.59	1.17	0.894	0.707	0.572	0.474	0.398	0.340	0.293	0.239	0.198	0.168	0.143
9"	5.85	3.84	2.46	1.71	1.26	0.960	0.760	0.615	0.510	0.427	0.365	0.315	0.257	0.213	0.180	0.154
8"	6.29	4.14	2.66	1.84	1.35	1.040	0.818	0.662	0.549	0.460	0.393	0.339	0.276	0.230	0.194	0.165
7"	6.76	4.45	2.86	1.98	1.46	1.120	0.880	0.711	0.590	0.495	0.423	0.365	0.297	0.247	0.209	0.178
6"	7.35	4.84	3.10	2.15	1.58	1.210	0.955	0.774	0.640	0.537	0.460	0.396	0.323	0.268	0.227	0.193
5"	8.10	5.33	3.42	2.37	1.74	1.330	1.060	0.853	0.706	0.592	0.507	0.437	0.356	0.295	0.250	0.213
4"	9.32	6.13	3.94	2.73	2.01	1.540	1.220	0.981	0.813	0.683	0.584	0.504	0.410	0.340	0.288	0.245
3"	11.60	7.60	4.87	3.38	2.48	1.900	1.500	1.220	1.010	0.845	0.721	0.623	0.507	0.422	0.356	0.304

TABLE 25 - U AND L CAPACITY FACTOR AND STEAM CONSUMPTION

	Model number															
	L-1H	L-2H	L-3H	L-4H	L-5H	L-6H	L-7H	L-8H	L-9H	L-10H	L-11H	L-12H	L-13H	L-14H	L-15H	L-16H
	U-1H	U-2H	U-3H	U-4H	U-5H	U-6H	U-7H	U-8H	U-9H	U-10H	U-11H	U-12H	U-13H	U-14H	U-15H	U-16H
*	0.293	0.445	0.694	1	1.36	1.78	2.25	2.78	3.36	4	4.69	5.43	6.66	8.03	9.49	11.12
**	85	125	195	270	370	480	610	755	910	1090	1280	1480	1820	2190	2580	3030

* Capacity factor

** Operating steam consumption lb per hour (Q_m) [Valid at standard nozzle pressure of 80, 100, 120, 140, 160, 180 or 200 psig]

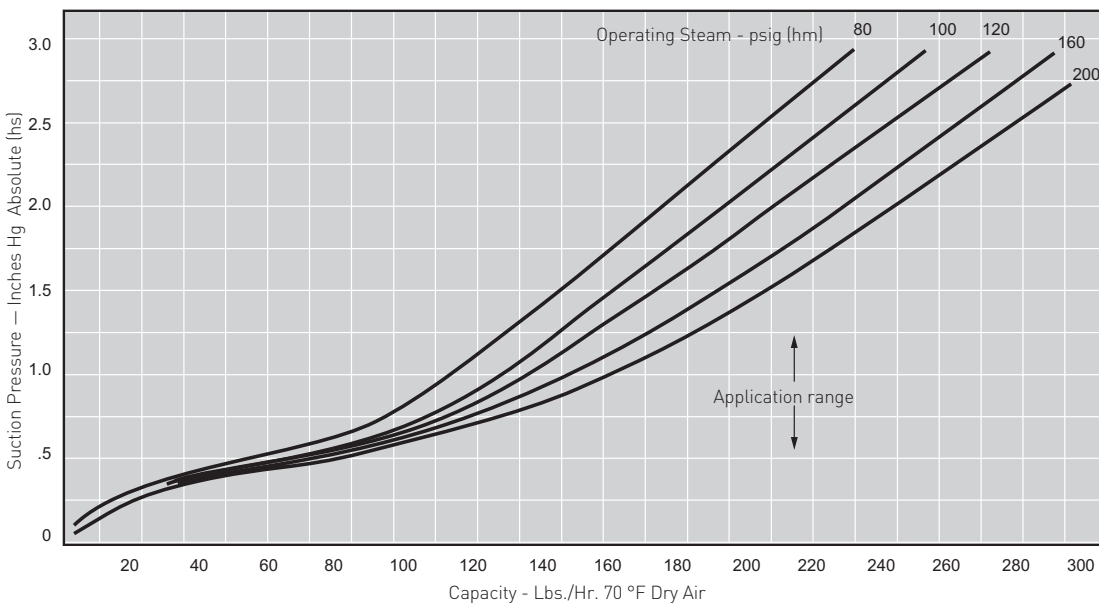
TABLE 26 - 2NC CAPACITY FACTOR AND STEAM CONSUMPTION

	Model number															
	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC	2NC
	1H	2H	3H	4H	5H	6H	7H	8H	9H	10H	11H	12H	13H	14H	15H	16H
*	0.293	0.445	0.694	1	1.36	1.78	2.25	2.78	3.36	4	4.69	5.43	6.66	8.03	9.49	11.12
**	106	160	240	330	450	590	740	920	1110	1320	1525	1800	2200	2660	3140	3660

* Capacity factor

** Operating steam consumption lb per hour (Q_m) [Valid at standard nozzle pressure of 100, 120, 140, 160, 180 or 200 psig]

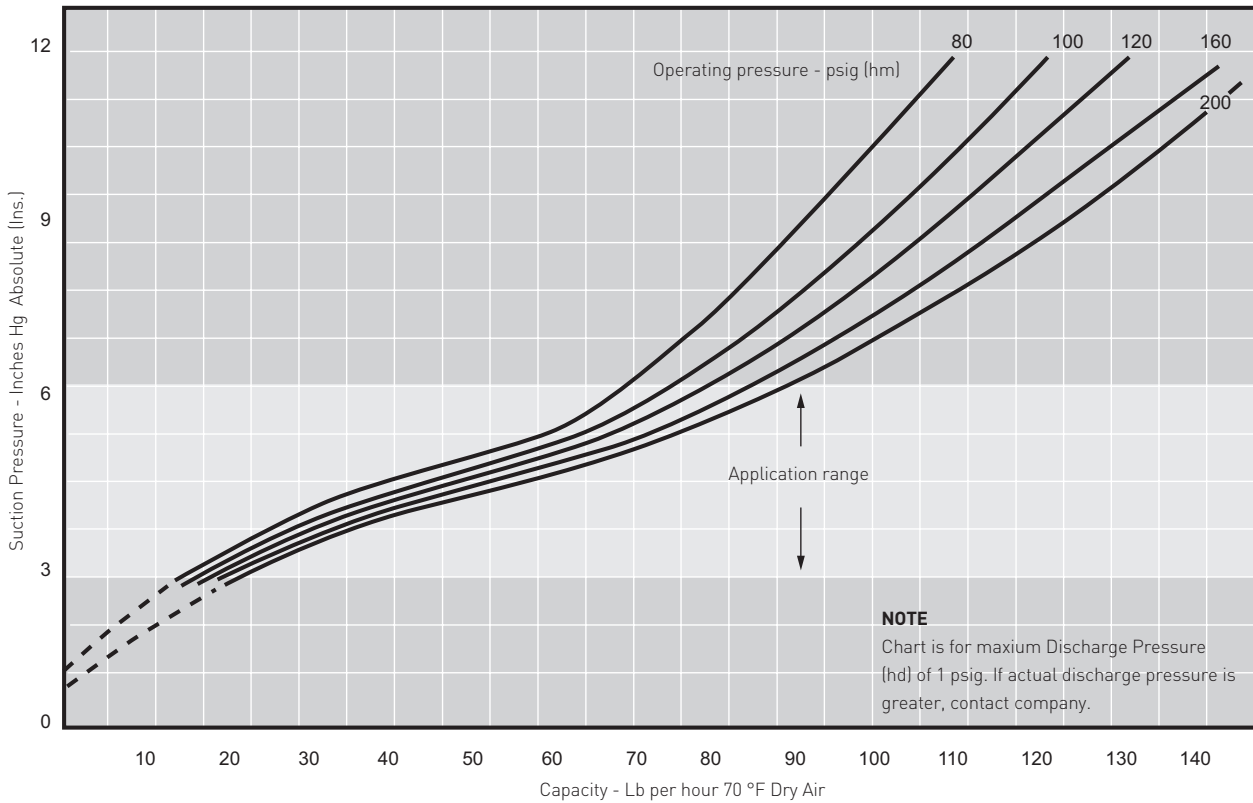
U-4H PERFORMANCE CURVES



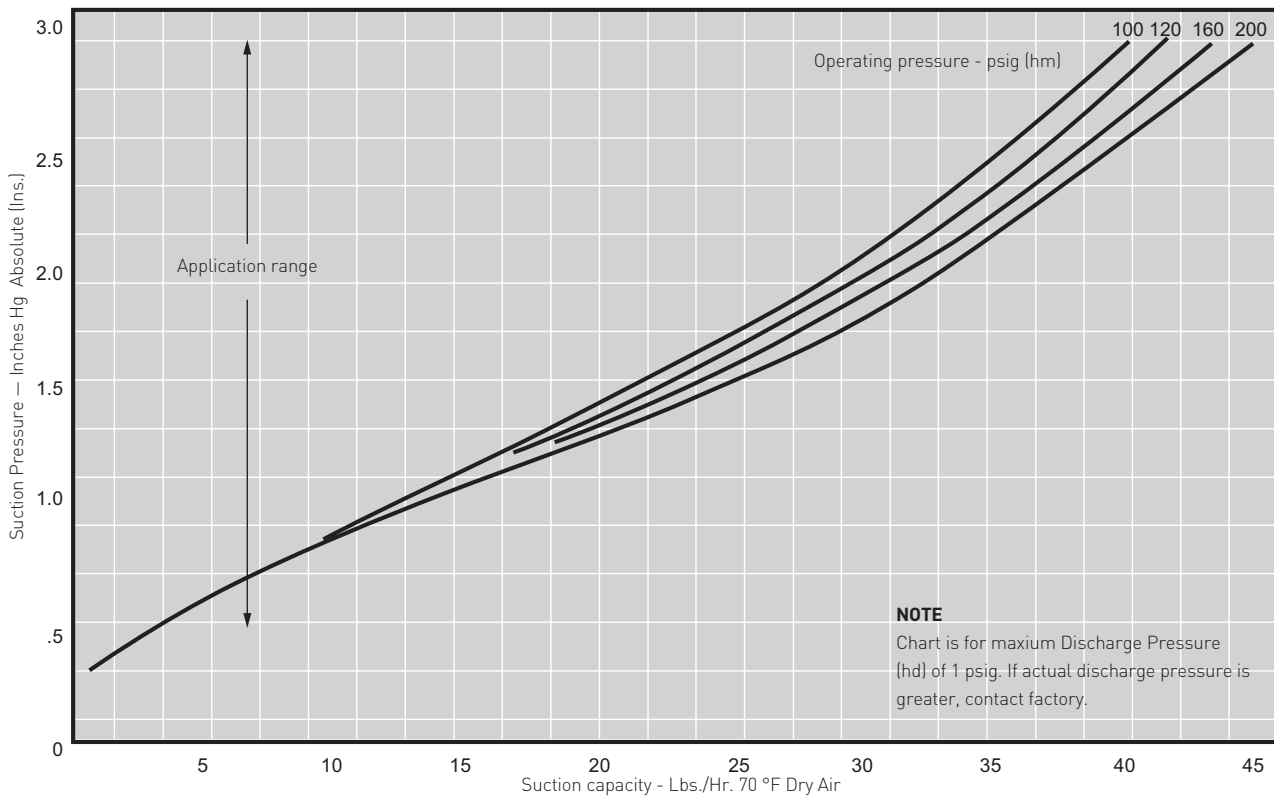
NOTE
 Chart is for maximum Discharge Pressure (hd) of 1 psig. If actual discharge pressure is greater, contact factory.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES
 MODELS U, L, 2NC - PERFORMANCE

L-4H PERFORMANCE CURVES



2NC-4H PERFORMANCE CURVES



PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC - DIMENSIONS

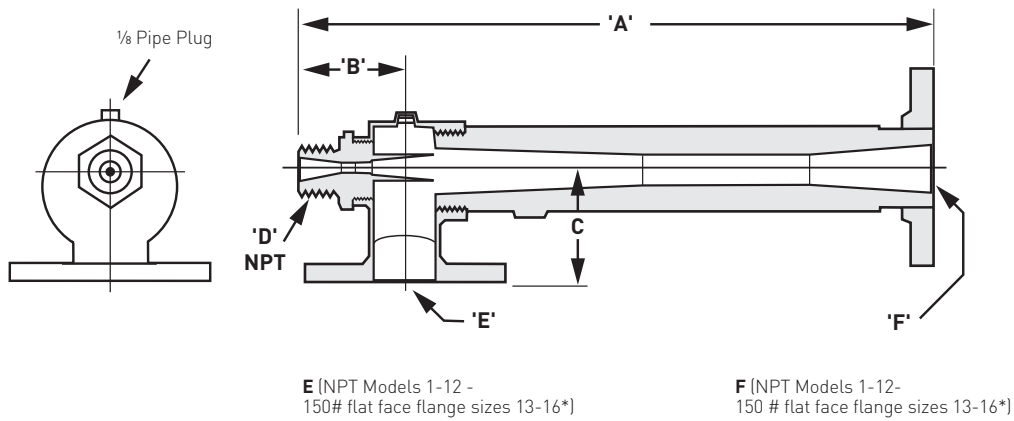


TABLE 27 - CAST U AND L DIMENSIONS

Model	Dimensions in inches					
	'A'	'B'	'C'	'D'	'E'	'F'
L-1H, U-1H	9 $\frac{1}{4}$	2 $\frac{1}{4}$	1 $\frac{3}{4}$	$\frac{1}{2}$	1	1
L-2H, U-2H	10 $\frac{3}{4}$	2 $\frac{1}{4}$	1 $\frac{3}{4}$	$\frac{1}{2}$	1	1
L-3H, U-3H	13 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$
L-4H, U-4H	15 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$
L-5H, U-5H	18 $\frac{1}{8}$	3 $\frac{1}{8}$	3	1 $\frac{1}{4}$	2	2
L-6H, U-6H	20 $\frac{1}{8}$	3 $\frac{1}{8}$	3	1 $\frac{1}{4}$	2	2
L-7H, U-7H	22 $\frac{3}{4}$	3 $\frac{1}{2}$	4 $\frac{1}{8}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$
L-8H, U-8H	24 $\frac{3}{4}$	3 $\frac{1}{2}$	4 $\frac{1}{8}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$
L-9H, U-9H	27 $\frac{1}{2}$	4	5	2	3	3
L-10H, U-10H	29 $\frac{1}{2}$	4	5	2	3	3
L-11H, U-11H	31 $\frac{1}{2}$	4	5	2	3	3
L-12H, U-12H	33 $\frac{1}{2}$	4	5	2	3	3
L-13H, U-13H	38 $\frac{1}{8}$	5	6	3	4	4
L-14H, U-14H	41 $\frac{1}{8}$	5	6	3	4	4
L-15H, U-15H	45	5 $\frac{7}{8}$	6	3	4	4
L-16H, U-16H	47 $\frac{1}{2}$	5 $\frac{7}{8}$	6	3	4	4

* Bolting corresponds to ASA 125 lbs.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC - DIMENSIONS

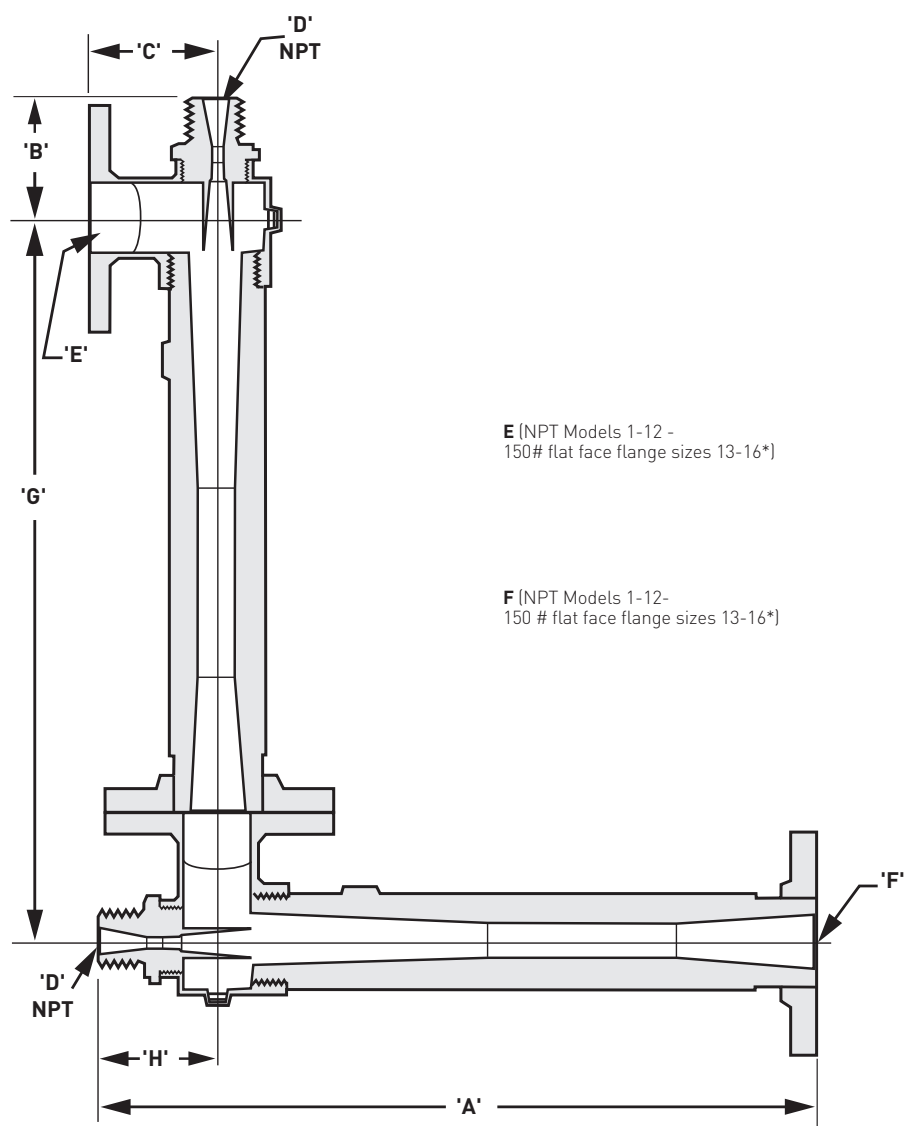


TABLE 28 - CAST 2NC DIMENSIONS

Model	Dimensions in inches							
	'A'	'B'	'C'	'D'	'E'	'F'	'G'	'H'
2NC1H	9 $\frac{1}{4}$	2 $\frac{1}{4}$	1 $\frac{3}{4}$	$\frac{1}{2}$	1	1	10 $\frac{1}{8}$	2 $\frac{1}{4}$
2NC2H	10 $\frac{3}{4}$	2 $\frac{1}{4}$	1 $\frac{3}{4}$	$\frac{1}{2}$	1	1	11 $\frac{1}{8}$	2 $\frac{1}{4}$
2NC3H	13 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	15 $\frac{1}{4}$	2 $\frac{3}{4}$
2NC4H	15 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	17 $\frac{1}{4}$	2 $\frac{3}{4}$
2NC5H	18 $\frac{1}{8}$	3 $\frac{1}{8}$	3	1 $\frac{1}{4}$	2	2	19 $\frac{7}{8}$	3 $\frac{1}{8}$
2NC6H	20 $\frac{1}{8}$	3 $\frac{1}{8}$	3	1 $\frac{1}{4}$	2	2	21 $\frac{7}{8}$	3 $\frac{1}{8}$
2NC7H	22 $\frac{3}{4}$	3 $\frac{1}{2}$	4 $\frac{1}{8}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	25 $\frac{1}{4}$	3 $\frac{1}{2}$
2NC8H	24 $\frac{3}{4}$	3 $\frac{1}{2}$	4 $\frac{1}{8}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	27 $\frac{1}{4}$	3 $\frac{1}{2}$
2NC9H	27 $\frac{1}{2}$	4	5	2	3	3	30 $\frac{3}{4}$	4
2NC10H	29 $\frac{1}{2}$	4	5	2	3	3	32 $\frac{3}{4}$	4
2NC11H	31 $\frac{1}{2}$	4	5	2	3	3	34 $\frac{3}{4}$	4
2NC12H	33 $\frac{1}{2}$	4	5	2	3	3	36 $\frac{3}{4}$	4
2NC13H	38 $\frac{1}{8}$	5	6	3	4	4	39 $\frac{1}{8}$	5
2NC14H	41 $\frac{1}{8}$	5	6	3	4	4	44 $\frac{1}{8}$	5
2NC15H	45	5	6	3	4	4	45 $\frac{1}{8}$	5 $\frac{7}{8}$
2NC16H	47 $\frac{1}{2}$	5	6	3	4	4	47 $\frac{7}{8}$	5 $\frac{7}{8}$

* Bolting corresponds to ASA 125 lbs.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS U, L, 2NC - SELECTION

SELECTION GUIDE - MODELS U, L, 2NC

Example	U	1H	CS	C	NT	NT	NT	- 01
Model								
U Model U								
L Model L								
2 Model 2NC								
Jet Size (refer to pages 25, 26 for applicable sizes)								
1H 1H								
2H 2H								
3H 3H								
4H 4H								
5H 5H								
6H 6H								
7H 7H								
8H 8H								
9H 9H								
10 10H								
11 11H								
12 12H								
13 13H								
14 14H								
15 15H								
16 16H								
Material of construction								
CS Carbon steel (SST nozzle)								
SS 316 SST								
Nozzle pressure rating								
A 80 psig (model U or L only)								
B 100 psig								
C 120 psig								
D 140 psig								
E 160 psig								
F 180 psig								
G 200 psig								
Inlet (motive) connection style								
NT NPT								
Suction connection style								
NT NPT (1" - 12")								
RF Raised face cast #150 flange (13" - 16")								
Discharge connection style								
NT NPT (1" - 12")								
RT Raised face threaded #150 flange (13" - 16")								
Variation								
01 Catalog standard								

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES

MODELS GL, GH, U, L, 2NC

DRY AIR EQUIVALENT (DAE) CONVERSIONS FOR GL, GH, U, L AND 2NC MODELS

Performance curves for Penberthy steam-air ejectors are plotted in terms of suction pressure and suction gas flow, lb/hr 70°F dry air equivalent (DAE).

Most ejector application data does not include suction gas rate as lb/hr 70°F dry air equivalent, but rather the suction gas rate is presented at some other temperature and for some gas or combination of gases of a composition different from that of air.

Since it is not practical for a manufacturer of steam jet ejectors to maintain facilities for testing ejectors with all the numerous suction gas mixtures and all the many temperatures for which ejectors are used, a method has been devised to permit the design and test of ejectors using air at normal room temperatures or air and steam at any temperature convenient for the manufacturer. The Heat Exchange Institute (HEI) provides a standard that describes the method that is used and accepted by manufacturers and users of ejectors. Material used in this explanation is adapted from the 'Standards for Steam Jet Ejectors' as published by the HEI.

It is important for all persons involved in the application of Penberthy ejectors to be conversant with the method of changing any load gas to its dry air equivalent at 70°F.

To determine average molecular weight

Gas mixtures are presented in terms of lb/hr or can be converted to these terms. Steam or water vapor may be contained in a mixture of gases and vapors, however it is treated as a separate component because temperature correction is different from that of other gases. The following example illustrates the most complex conversion that one might encounter:

Given: 100 lb/hr of a mixture of gases and vapor at 200°F temperature, consisting of 20 lb/hr of carbon dioxide gas, 30 lb/hr of air, 5 lb/hr of hydrogen and 45 lb/hr of water vapor.

Molecular weights are as follows:

$$\text{CO}_2 = 44 \text{ lb/mol}$$

$$\text{Air} = 29 \text{ lb/mol}$$

$$\text{H}_2 = 2 \text{ lb/mol}$$

$$\text{H}_2\text{O} = 18 \text{ lb/mol}$$

Find average molecular weight of the mixture except for water vapor:

$$20 \text{ lb/hr CO}_2 \div 44 \text{ lb/mol} = 0.455 \text{ mol/hr}$$

$$30 \text{ lb/hr air} \div 29 \text{ lb/mol} = 1.035 \text{ mol/hr}$$

$$5 \text{ lb/hr H}_2 \div 2 \text{ lb/mol} = 2.500 \text{ mol/hr}$$

$$\frac{55 \text{ lb/hr}}{\text{mixture}} = \frac{3.990 \text{ mol/hr}}$$

$$\text{Avg. m.w.} = \frac{55 \text{ lb/hr}}{3.99 \text{ mol/hr}} = 13.8 \text{ lb/mol}$$

Molecular weight conversion factors (29 mw = 1.0)

Use same gas as given above and curve no. 1:

$$\text{Cmw correction factor for } 13.8 \text{ mw} = 0.7$$

$$\text{Cmw correction factor for } 18 \text{ (H}_2\text{O)} = 0.81$$

Temperature conversion factors (70°F = 1.0)

Use same gas as above and curve no. 2.

$$\text{Ct temperature correction for } 13.8 \text{ mw gas at } 200^\circ\text{F (use curve for air)} = 0.968$$

$$\text{Ct temperature correction for steam at } 200^\circ\text{F} = 0.957$$

Actual conversion

Use factors from above as follows to find the 70°F dry air equivalent of 100 lb/hr of a mixture of gas and water vapor all at 200°F and consisting of 20 lb/hr of CO₂ plus 30 lb/hr of air plus 5 lb/hr of H₂ plus 45 lb/hr of H₂O.

$$\frac{(20 + 30 + 5)}{0.7 \times 0.968} + \frac{45}{0.81 \times 0.957} = 82 + 58 = 140 \text{ lb/hr}$$

Therefore an ejector that will pump the specified gas load of 100 lb/hr at 200°F must also be able to pump 140 lb/hr of air at 70°F.

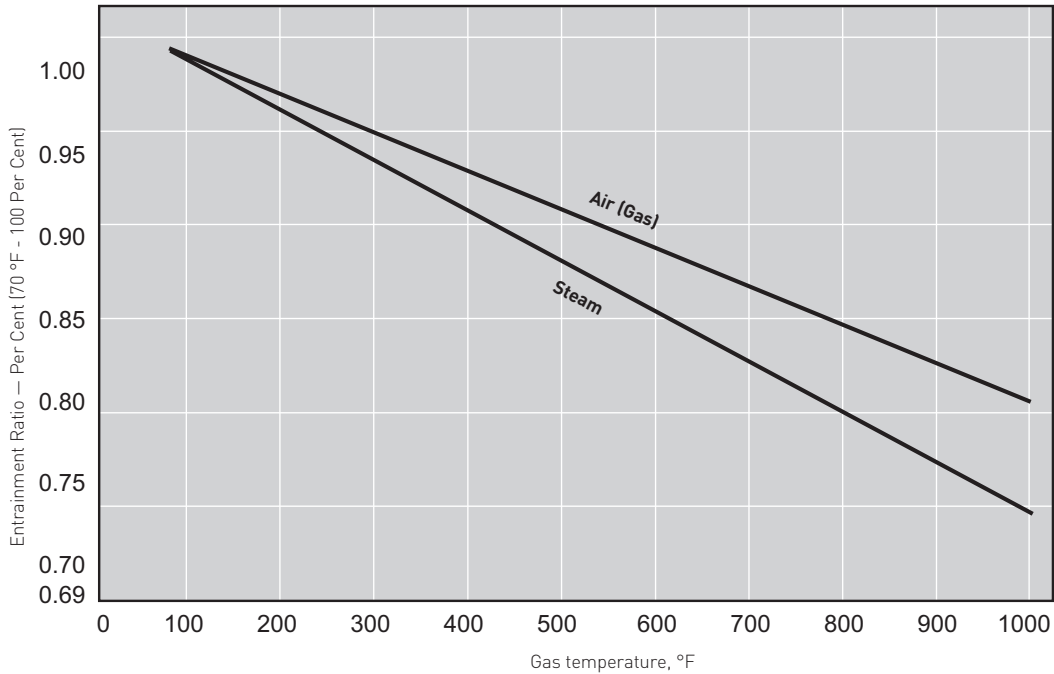
NOTE

Do not confuse DAE with noncondensable gas load.

PENBERTHY SERIES LM, ELL, FL, GL, GH, U, L AND 2NC FOR PUMPING GASES
 MODELS GL, GH, U, L, 2NC

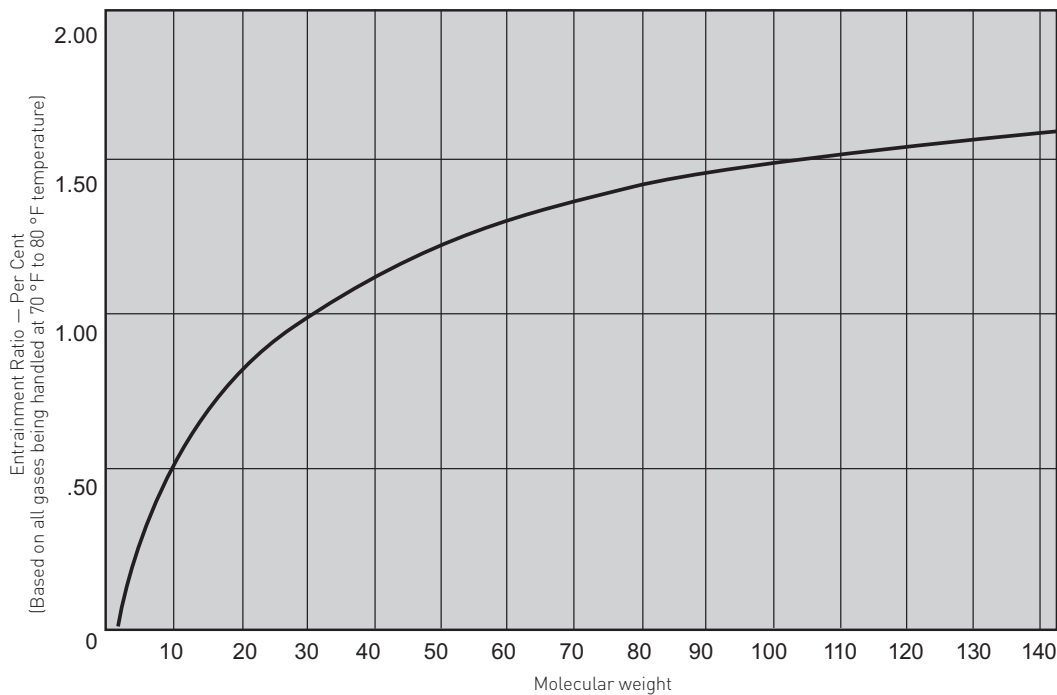
DRY AIR EQUIVALENT (DAE) CONVERSIONS FOR GL, GH, U, L AND 2NC MODELS

TEMPERATURE ENTRAINMENT RATIO CURVE (NO. 2)*



NOTE
 Entrainment ratio is the ratio of the weight of air or steam at 70 °F temperature to the weight of air or steam at a higher temperature that would be handled by the same ejector operation under the exact same conditions

MOLECULAR WEIGHT ENTRAINMENT RATIO CURVE (NO. 1)*



NOTE
 Entrainment ratio is the ratio of the weight of gas handled to the weight of air that would be handled by the same ejector operation under the exact same conditions

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