Архангельск (8182)63-90-72
Астана (7172)727-132
Астрахань (8512)99-46-04
Барнаул (3852)73-04-60
Белгород (4722)40-23-64
Брянск (4832)59-03-52
Владивосток (423)249-28-31
Волгоград (844)278-03-48
Вологда (8172)26-41-59
Воронеж (473)204-51-73
Екатеринбург (343)384-55-89
Иваново (4932)77-34-06
Ижевск (3412)26-03-58
Казань (843)206-01-48
Калининград (4012)72-03-81
Калуга (4842)92-23-67
Кемерово (3842)65-04-62
Киров (8332)68-02-04
Краснодар (861)203-40-90
Красноярск (391)204-63-61
Курск (4712)77-13-04
Липецк (4742)52-20-81
Магнитогорск (3519)55-03-13
Москва (495)268-04-70
Мурманск (8152)59-64-93
Набережные Челны (8552)20-53-41
Нижний Новгород (831)429-08-12
Новокузнецк (3843)20-46-81
Новосибирск (383)227-86-73
Омск (3812)21-46-40
Орел (4862)44-53-42
Оренбург (3532)37-68-04
Пенза (8412)22-31-16
Пермь (342)205-81-47
Ростов-на-Дону (863)308-18-15
Рязань (4912)46-61-64
Самара (846)206-03-16
Санкт-Петербург (812)309-46-40
Саратов (845)249-38-78
Севастополь (8692)22-31-93
Симферополь (3652)67-13-56
Смоленск (4812)29-41-54
Сочи (862)225-72-31
Ставрополь (8652)20-65-13
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Тверь (4822)63-31-35
Томск (3822)98-41-53
Тула (4872)74-02-29
Тюмень (3452)66-21-18
Ульяновск (8422)24-23-59
Уфа (347)229-48-12
Хабаровск (4212)92-98-04
Челябинск (351)202-03-61
Череповец (8202)49-02-64
Ярославль (4852)69-52-93

http://cannon.nt-rt.ru || cnn@nt-rt.ru

Колонны дистилляции CANNON

Техническое описание

PRO-PAK®
Protruded Metal Distillation Packing

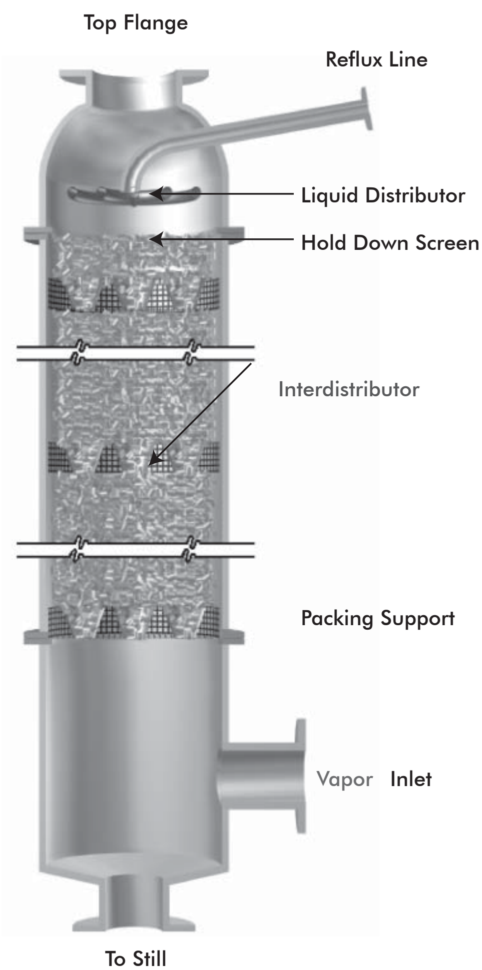


Figure 1
Schematic Column Drawing

Distillation Facts

Wettability: Pro-Pak is formed from metal ribbon through which more than 1,000 tiny holes per square inch have been protruded. As the points of the die push through the metal, jagged burrs are formed on the back side of the ribbon. Pro-Pak's unique wetting properties derive from a rectangular network of capillaries on the surface of the metal, produced by the combined effect of the holes in the ribbon and the roughness of the burrs. To observe the wetting action, one has only to dip a strip of protruded ribbon into a beaker of liquid hydrocarbon. Almost instantly the liquid crawls above the submerged portion of the ribbon, wetting both sides. A colored blotter held against the ribbon one-half inch above the liquid level can be seen to deepen in color at once. This self-wetting property ensures that Pro-Pak stays wet in service in the distillation column and retains its high efficiency. Because the surface area of the packing remains effective under low liquid loadings, high column efficiency is maintained at vapor velocities very much lower than the flooding velocity.

Surface Area: The large surface area made effective by the wettability of Pro-Pak allows for efficient mass transfer between the liquid and vapor phases. The surface area is approximately 576 square feet per cubic foot for the 0.16-inch size and 372 square feet per cubic foot for the 0.24-inch size. The packing factor is 693 for the 0.16-inch size and 420 for the 0.24-inch size.

Free Space: High free space is especially important in vacuum distillation (for reduction of pressure drop) and in extractive distillation and absorption (where high liquid or vapor loading is common). Pro-Pak has high free space (94% for the 0.16-inch size and 96% for the 24-inch size).

Flood Rate: Because of its high free space, Pro-Pak has a high flood rate. Flood rates at any pressure can be predicted by the following equation, applicable to both sizes of Pro-Pak:

$$G = 270\,(\rho_1)^{0.58}\,(\rho g)^{0.42}$$

where G = Mass vapor velocity in lbs. per hour per square foot.

ρ_1 = Density of liquid phase in lbs. per cubic foot.

ρg = Density of gas phase in lbs. per cubic foot.

Vacuum Efficiency: As operating pressure is reduced, the efficiency of Pro-Pak increases. For example, when a 2-inch diameter column filled with 0.16-inch Pro-Pak is operated at its maximum rate, the number of theoretical plates more than doubles after the pressure is reduced from 735 to 10 mm Hg. See Table IV.

Holdup: Holdup depends not only on the packing, but also on the vapor velocity, vapor density, liquid density, etc. (see Figure 2). Note that the holdup at flooding velocity for n-heptane is considerably more than forthe heavier ethylene dichloride. Note also that the flooding velocity for ethylene dichloride is about 45% greater than n-heptane.

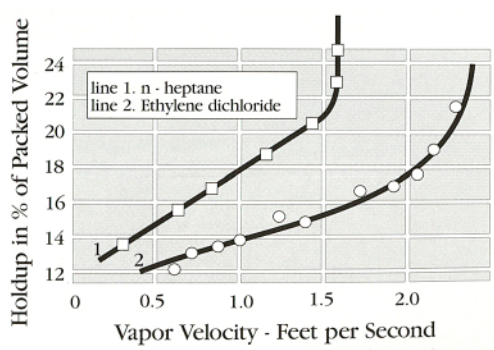


Figure 2

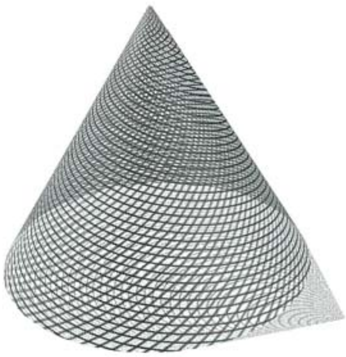


Figure 3

Figure 4

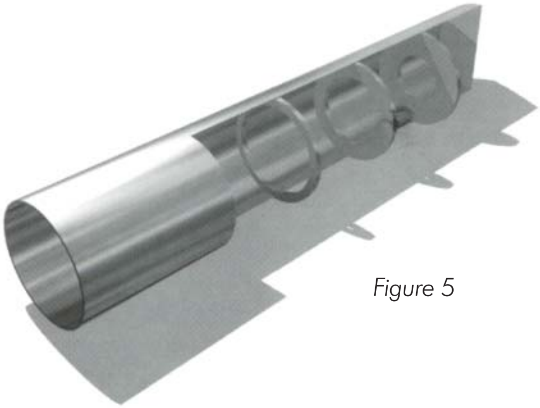


Figure 5

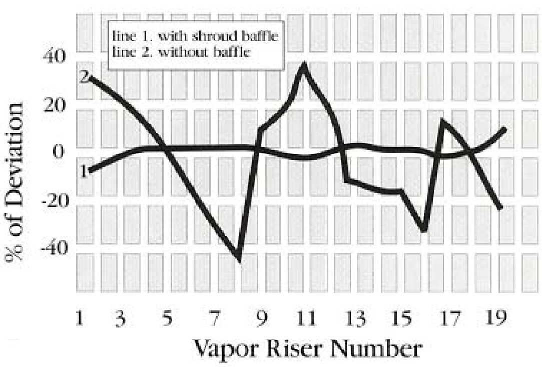


Figure 6

Filling Pro-Pak Columns

Pour the packing into the column through a funnel. The discharge end of the funnel should be 0.6 inches or less in diameter for the 0.16-inch packing and 1.25 inches or less in diameter for the 0.24-inch packing. Make sure the packing falls three feet or more. When the packing in the column reaches a level approximately three feet from the top of the column, the remainder of the packing should be poured through a tube or pipe three feet long. This ensures uniform packed density.

Internal liquid and Vapor Distribution

For optimum operation, the liquid and vapor must be distributed evenly across the cross-sectional area of the column at all packed heights. A good packing support will ensure even distribution of the vapor into the base of the packing bed. Similarly a good liquid distributor at the top of the bed will ensure that the returning liquid will be well distributed (see page 5 of this bulletin).

Within the packing bed the velocity pressure of the ascending vapor tends to push the descending liquid toward the walls. When the packed height is not great, the migration of liquid to the walls does not significantly affect column operation. In taller columns, however, interdistributor screens (see Figure 4) have been developed which control phase distribution within the packing bed. Cannon Instrument Company manufactures screens to custom-fit columns. A general description of their construction is offered here.

1. From a flat screen, cut two circular disks slightly smaller in diameter than the inside diameter of the column to be used.
2. Place a number of truncated cones (open at both the base and apex), made of thin gauge sheet metal or screen, in a precise pattern between the two flat screens. Spot weld them to the screen. The number of cones will depend on the column diameter.
3. Spot weld a peripheral band of screen (with a width equal to the height of the cones) to the edges of the two flat screens to form a cylinder with the top and bottom screens as ends.
4. Finally, snip out the screen which covers the base of the cones. When installed in the column the screen with the holes cut out of it will be facing upward and the apex of the cones will be pointed downward. This allows the cones to fill with Pro-Pak when the packing is poured into the column.

An interdistributor screen constructed as described is supported easily by the Pro-Pak. No flange or ring is required to support the interdistributor screen unless it is used at the bottom of the column as the packing support.

Interdistributor screens are very effective in producing good phase I distribution because the velocity pressure equalizes throughout the cross-sectional area and the liquid is not forced to the column walls. At the same time, there is "incipient" flooding of the liquid above the flat screen, and as the liquid spills into the cones, uniform redistribution of the liquid occurs. Channeling is also broken up by use of the screens. Channeling in short packed columns is of comparatively little importance, but in tall packed columns it can seriously degrade performance. When well designed interdistributor screens are used, the throughput of the packing doesn't decrease.

It is recommended that interdistributor screens be installed in the bed of the packing approximately 36 inches apart. The uppermost screen should be about six inches below the ton of the packed bed.

Interdistributor screens as packing supports

The packing support at the bottom of the column serves a dual function: 1) It must support the packing in the column, and 2) It must distribute the vapor uniformly into the packing without causing local flooding.

In order to develop packing supports which would meet these criteria, various designs were tested in columns of varying diameter. The results of our tests are as follows:

1. Efficiency and capacity were so greatly reduced when a flat screen was used that it can be emphatically stated: NEVER use a flat screen for a packing support in any size column.
2. In columns two inches in diameter and under, a conical screen with apex pointing upward (see Figure 3) is recommended. Cones with included angles at the apex between 90 and 120 degrees give best results. Mesh size—6 x 6 x 0.035" or 10 x 10 x 0.025". The cone should rest on a ¼-inch flange.
3. In columns larger than two inches in diameter, an interdistributor screen (see Figure 7) resting on a ¼-inch flange has been found to be very satisfactory as a packing support. No additional support is necessary in columns up to eight inches in diameter. When the column diameter exceeds eight inches, a grid to support the interdistributor screen is adequate.

Even with properly designed packing supports, the vapor must enter at a fairly uniform velocity immediately below the support. Poor distribution of the vapor into the packing can occur under the following conditions:

1) Vapor enters from the side of the column through a port located less than one column diameter below the packing support; 2) The diameter of the port is one-third or less of the column diameter

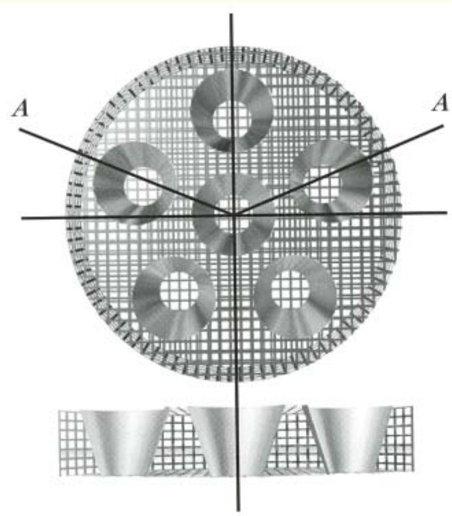
Under these conditions, some areas of the packing will have less than 50 percent of the desired vapor flow, while other areas will have too much flow. Poor vapor distribution causes poor liquid distribution.

If a column exhibits poor vapor distribution for the reasons given above, a shroud baffle (see Figure 5) can be used to even out the vapor flow and to return the column to satisfactory operating condition. Figure 6 shows how a shroud baffle can improve column distribution. Fabrication of a shroud baffle is described briefly as follows: use a sheet metal or thin wall sleeve tube of the proper diameter to slip into the vapor inlet port. Beyond the support, cut the tubing longitudinally into a half cylinder. The half cylinder should extend into the column as far as possible depending upon fabrication method. At the ¼, ½ and ¾ distances across the column, fit and fasten thin gauge "doughnut" shaped baffles. The center area of the open disks should be 75%, 50% and 25% of the area of the vapor inlet tube respectively, so as to cause the high velocity vapor to lose its kinetic energy and be directed upward and around the half cylindrical covering of the shroud and thus evenly into the packing. It should be noted, however, that it is better to design columns with a large vapor inlet port located more than one column diameter below the packing support. A shroud baffle should be used only as a corrective expedient. CANNON Instrument Company does not manufacture shroud baffles.

Installation of the screens is relatively easy:

1. After the packing support has been inserted into the bootom of the column, pour about 36 inches of Pro-Pak into the column. When pouring the packing, follow the installation instructions for Pro-Pak (see page 3). Level the top of the packing carefully with a long probe.
2. Install the first interdistributor screen by dropping it into the column so that it comes to rest horizontally on top of the packing. Make sure that the apex of the cones is pointing downward. This allows the packing to flow into the open base of the cones on the next pour.
3. Repeat the operation, pouring in increments of approximately 36 inches of packing each time until the desired height has been attained. Be sure to allow six inches between the top interdistributor screen and the holddown screen. The space between these screens is filled with packing.

The schematic column drawing in Figure 1 shows the proper placement of the screens.



Section A-A

Figure 7

Figure 8

Liquid Distribution at the Top of the Bed of Packing

Good liquid distribution at the top of the bed of packing is highly important. Optimum conditions result when the liquid is evenly distributed over the entire cross-sectional area of the column or when the liquid distribution at the center of the column is slightly more dense than at the walls, since there is a tendency for the vapor pressure to push the liquid toward the walls.

The following reconunendations can be made:

1. In columns one and two inches in diameter, the liquid reflux should be returned to the center of the column.
2. In columns three and four inches in diameter, all the liquid reflux may be returned at the center with little loss of efficiency. It is recommended, however, that an interdistributor screen be placed about six inches down from the top of the bed to equalize the downward flow of the liquid.
3. In columns five inches and larger in diameter, a good liquid distributor at the top of the bed of packing is essential. The design of the distributor depends upon the particular installation. Several general types have been designed and have worked successfully. It is important that the reflux be returned evenly over the cross-sectional area at the top of the packing to prevent significant quantities of reflux from entering at the wall, and it is important to provide sufficient cross-sectional area for the vapor to pass through into the condenser. This is an especially important consideration for high vacuum distillations.
4. For columns 10 inches in diameter and larger, one effective method of distribution is by the use of a circular manifold of concentric tubes (see Figure 8) with holes drilled and tapped on the bottom side on approximately 2” centers. Into the tapped holes “orifice screws” are inserted. These screws regulate the amount of liquid reflux which flows from each hole and thus ensures that there will be flow from all holes rather than from a scattered indefinite few. At the same time the screws serve as drip points.

Other distributor designs were designed and tested. These were fabricated from plates with vapor risers and liquid return tubes also with orifice screws. Variations using Weir tubes were also tried. It is important that the free area for vapor risers be at least 35%.

Packing Holddown Screen

In order to prevent the bed of packing from being disturbed when “bumping” occurs in the reboiler, or when the column is operated under flooding conditions, it is necessary to use a packing “holddown” screen. This is merely a circular flat screen (6 x 6 x 0.035” or 10 x 10 x 0.025” mesh) which is placed in the column directly under the top flange as shown in the schematic column drawing (see Figure 1). The inside diameter of the top flange should be slightly less than the column diameter to form a retainer collar. Any other similar retention device will suffice.

Column Test Data 0.24 Inch Size

Atmospheric Operation

Test data obtained with n-heptane – methylcyclohexane test mixture at total reflux.

Table 1

Column Diameter Inches	Packed Height Feet	Reflux Liters per Hour	Vapor Velocity feet/ Second	Total Theoretical Plates	HETP Inches	Pressure Drop Inches of Water	
						per Foot of Packing	per Plate
2	8.4	3.7	0.35	57.2	1.77	0.12	0.02
		6.1	0.51	51.2	1.97	0.28	0.05
		11.3	1.06	49.5	2.04	0.86	0.15
		15.6	1.46	48.00	2.10	1.70	0.30
4	10.0	16.6	0.39	71.0	1.70	0.10	0.01
		28.2	0.66	66.0	1.83	0.22	0.03
		40.6	0.94	57.0	2.10	0.60	0.11
		48.0	1.11	53.0	2.26	0.91	0.17
		65.1	1.51	47.0	2.54	1.90	0.40
6	6.0*	37	0.40	44.1	1.66	0.18	0.03
		53	0.58	40.0	1.83	0.32	0.05
		82	0.90	37.2	1.96	0.82	0.13
		102	1.11	35.6	2.05	1.31	0.22
		130	1.41	31.6	2.31	2.36	0.45
		144	1.57	28.6	2.56	3.52	0.75
	12.2*	30	0.33	78.4	1.87	0.10	0.02
		66	0.71	75.3	1.94	0.43	0.07
		111	1.21	67.7	2.15	1.48	0.27
		148	1.61	56.5	2.58	3.20	0.69
	17.2*	28	0.31	128.00	1.58	0.08	0.01
		55	0.60	105.5	1.95	0.29	0.05
		98	1.07	94.0	2.22	1.15	0.21
		114	1.25	89.4	2.32	1.83	0.35
		146	1.60	80.0	2.57	2.86	0.61
12	3.0	254	0.65	18.3	1.97	0.24	0.04
		340	0.88	166.0	2.25	0.38	0.07
		405	1.04	15.9	2.27	0.53	0.10
		503	1.30	14.9	2.41	1.00	0.20
		560	1.44	15.1	2.39	1.10	0.22
		607	1.56	14.4	2.50	1.39	0.28
	5.4	282	0.73	32.1	2.01	0.29	0.05
		383	0.99	29.4	2.20	0.50	0.09
		444	1.14	25.1	2.57	0.68	0.15
		503	1.30	22.0	2.93	0.87	0.21
		585	1.51	20.6	3.13	1.18	0.31
		630	1.62	18.9	3.41	1.34	0.38

*Interdistributor used every three feet within a packed bed.

Atmospheric Operation 0.24 Inch Size

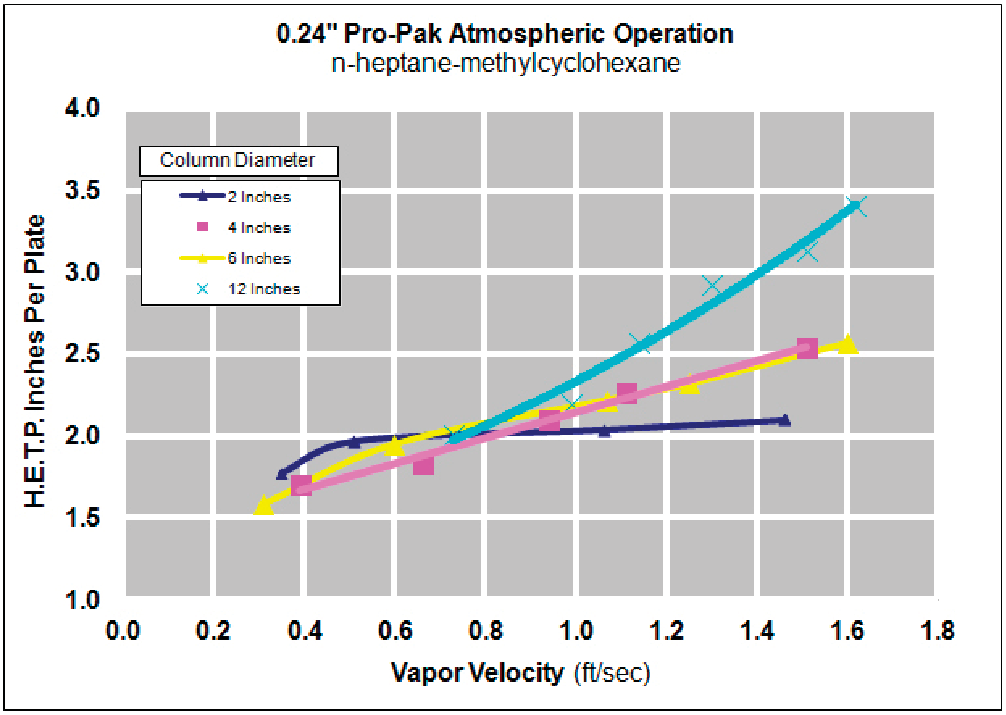


Figure 9

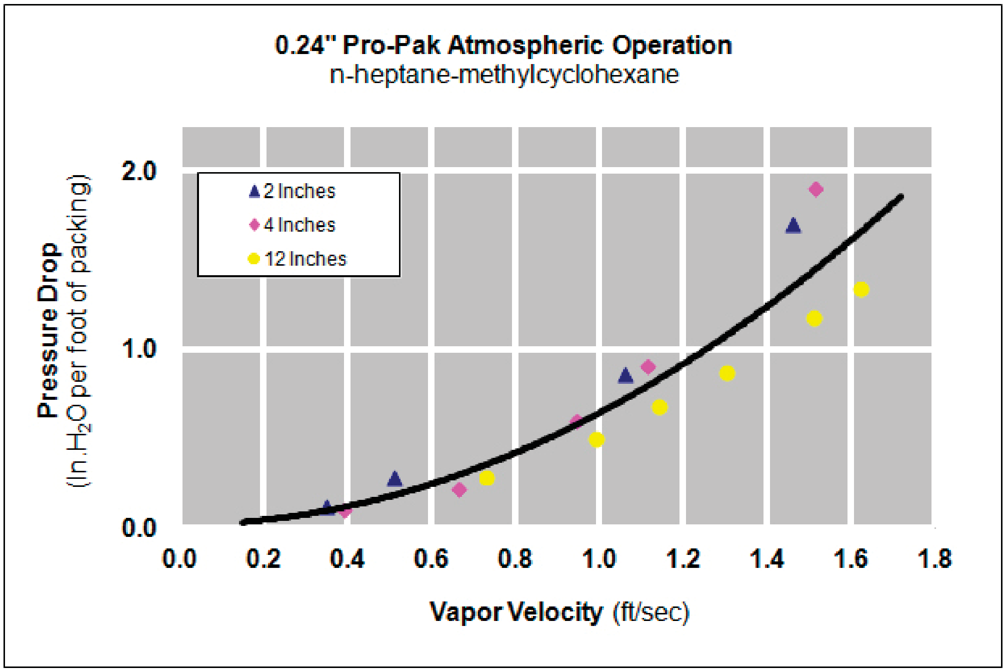


Figure 10

Column Test Data 0.24 Inch Size

Vacuum Operation

Test data obtained with n-decane – trans-decalin test mixture.

Table 2

Column Diameter Inches	Condenser Pressure mm Hg	Reflux Liters per Hour	Vapor Velocity feet/ Second	Total Theoretical Plates	HETP Inches	Pressure Drop Inches of Water	
						per Foot of Packing	per Plate
2	10	1.22	5.42	35.5	0.68	0.92	0.052
		1.95	7.76	33.4	0.72	2.03	0.122
		2.81	10.5	31.4	0.76	2.91	0.185
		3.24	11.2	30.6	0.78	4.07	0.266
	50	1.92	2.03	33.2	0.72	0.46	0.028
		2.80	2.94	31.6	0.76	0.97	0.059
		4.60	4.70	26.0	0.92	2.54	0.196
		6.65	6.41	21.6	1.11	6.01	0.557
	100	1.06	0.59	33.8	0.71	0.18	0.011
		2.16	1.20	32.1	0.75	0.46	0.029
		5.38	2.95	25.7	0.93	1.94	0.151
		8.17	4.42	22.1	1.08	4.50	0.405
	200	1.05	0.31	30.4	0.79	0.23	0.015
		3.50	1.03	27.3	0.88	0.65	0.047
		7.80	2.27	22.0	1.09	1.76	0.160
		11.15	3.20	18.1	1.33	5.23	0.580
	350	2.08	0.37	25.2	0.95	0.23	0.018
		5.35	0.95	23.7	1.01	0.60	0.051
		7.80	1.38	21.6	1.11	1.43	0.133
		11.80	2.05	19.1	1.25	3.92	0.410
12	30	62	3.14	33.9	0.91	0.97	0.028
		88	4.26	26.8	1.15	1.78	0.066
		141	6.25	18.0	1.71	3.89	0.216
		200	7.98	9.5	3.25	6.64	0.699
	76	39	0.88	39.6	1.04	0.49	0.017
		80	1.80	39.4	1.05	0.81	0.028
		147	3.18	24.3	1.27	1.95	0.080
		240	4.90	17.0	1.81	3.73	0.219

Vacuum Operation 0.24 Inch Size

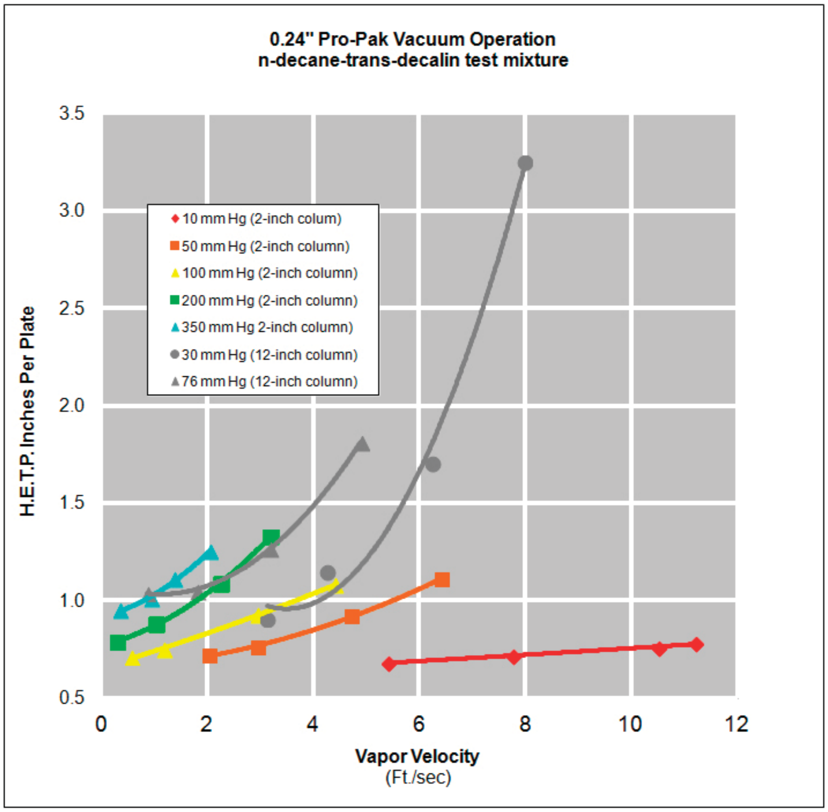


Figure 11

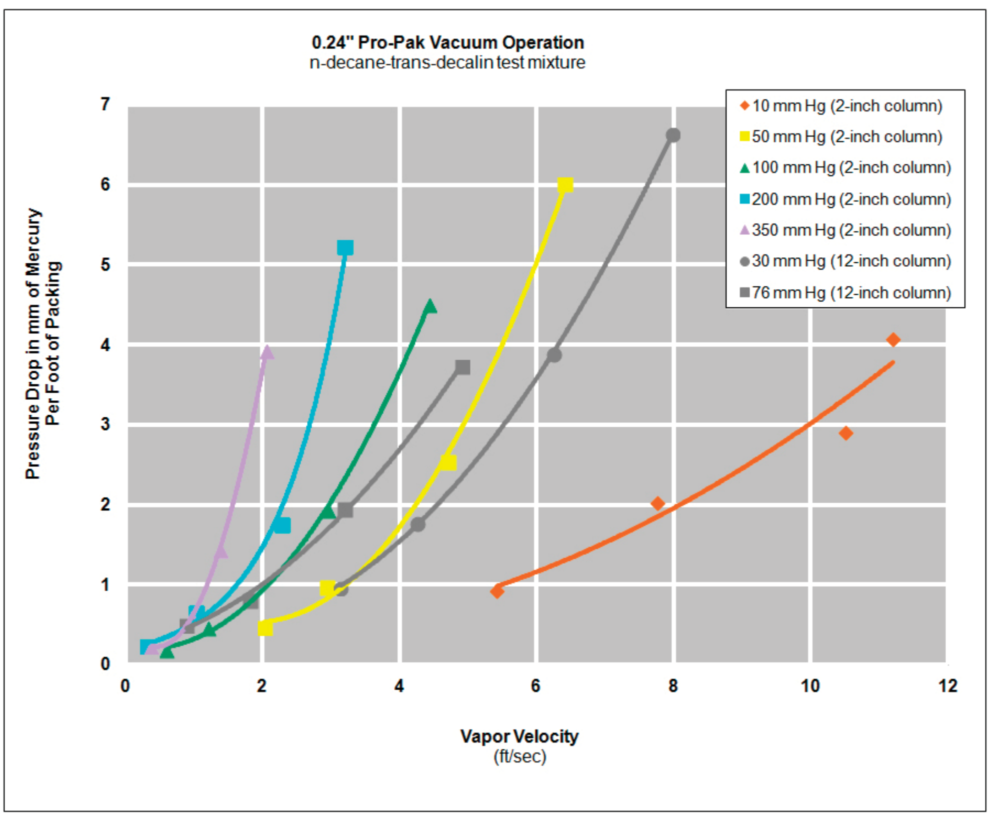


Figure 12

Column Test Data 0.16 Inch Size

Atmospheric Operation

Test data obtained with n-heptane – methylcyclohexane test mixture at total reflux.

Table 3

Column Diameter Inches	Packed Height Feet	Reflux Liters per Hour	Vapor Velocity feet/ Second	Total Theoretical Plates	HETP Inches	Pressure Drop Inches of Water: per Foot of Packing	Pressure Drop Inches of Water: per Plate
1	3.4	3.46	1.24	29.2	1.40	1.28	0.148
		2.81	1.01	31.0	1.32	0.983	0.018
		2.40	0.86	32.2	1.27	0.716	0.0759
		1.90	0.68	34.0	1.20	0.463	0.0465
		1.33	0.48	36.8	1.11	0.268	0.0248
		0.72	0.26	39.3	1.03	0.138	0.0119
2	9.8	16.6	1.51	85.6	1.38	2.16	0.247
		13.5	1.22	87.2	1.35	1.56	0.135
		10.0	0.93	90.0	1.31	0.547	0.0596
		9.60	0.89	85.9	1.37	0.463	0.0530
		6.42	0.60	10.5	1.10	0.168	0.0154
4	9.6	69.0	1.57	42.7	2.70	3.30	0.741
		61.3	1.34	42.2	2.72	3.32	0.749
		42.0	0.96	63.3	1.82	3.25	0.493
		29.0	0.67	59.0	1.95	1.25	0.203
		16.6	0.38	82.8	1.39	0.156	0.0181
6	6.1	113.0	1.23	27.0	2.70	0.91	0.204
		80.5	0.87	30.0	2.44	0.51	0.104
		69.5	0.76	31.2	2.34	0.39	0.074
		35.0	0.38	41.7	1.75	0.16	0.023

**Interdistributor used every three feet within a packed bed.*

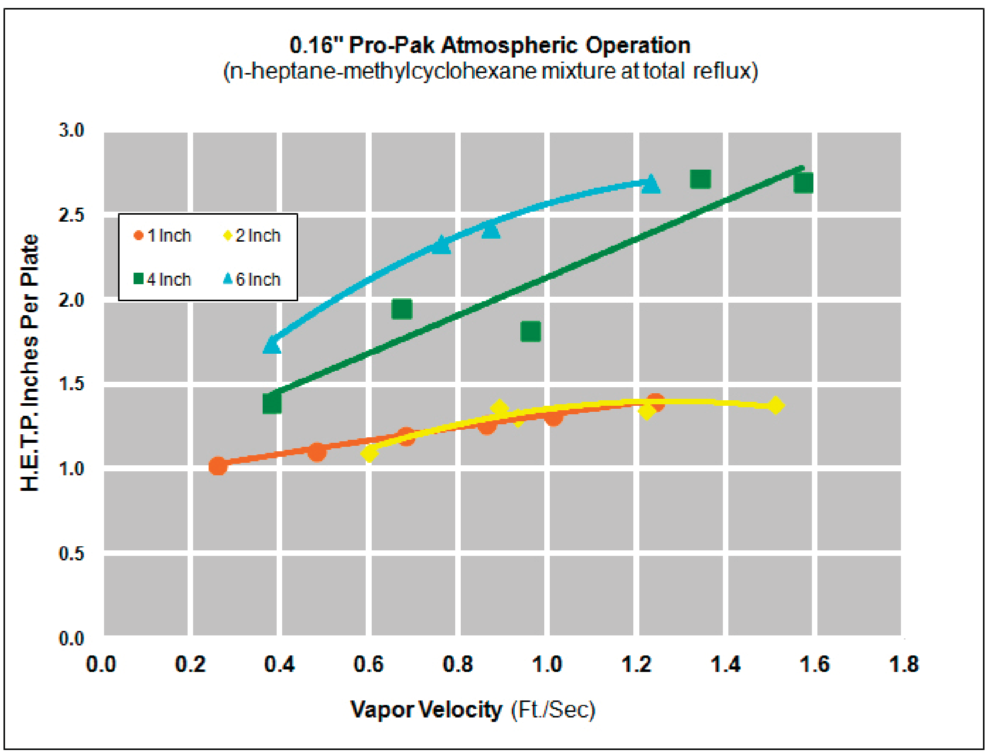


Figure 13

Vacuum Operation

Test data obtained with n-decane – trans-decalin test mixture.

Column Test Data 0.16 Inch Size

Table 4

Column Diameter Inches	Packed Height Feet	Reflux Liters per Hour	Vapor Velocity feet/ Second	Total Theoretical Plates	HETP Inches	Pressure Drop Inches of Water: per Foot of Packing	Pressure Drop Inches of Water: per Plate
2	10	0.90	3.98	44.3	0.543	0.93	0.042
		2.01	7.87	41.3	0.581	2.40	0.116
		3.67	9.4	33.4	0.626	3.90	0.203
		3.94	11.2	31.6	0.760	7.50	0.475
	50	0.955	1.01	16.6	0.515	0.23	0.010
		3.00	3.12	41.7	0.575	1.35	0.064
		4.50	4.52	38.4	0.626	2.96	0.154
		6.00	5.78	32.4	0.740	5.97	0.369
	100	1.53	0.856	42.4	0.565	0.23	0.011
		3.71	2.05	38.1	0.630	1.35	0.071
		5.40	2.95	35.1	0.634	3.01	0.171
		8.5	4.33	25.3	0.95	10.5	0.83
	200	1.86	0.546	35.0	0.685	0.33	0.019
		2.88	0.852	34.2	0.703	0.51	0.024
		5.05	1.49	32.8	0.732	1.25	0.076
		7.30	2.13	29.0	0.828	2.96	0.204
		9.17	2.61	25.9	0.923	6.85	0.53
			3.05	20.9	1.15	6.50	0.86
	400	1.45	0.227	30.9	0.777	0.33	0.021
		4.95	0.774	28.7	0.877	0.69	0.048
		9.5	1.48	24.0	1.00	1.96	0.166
		12.3	1.90	22.3	1.077	4.73	0.424
	735	1.84	0.165	26.1	0.92	0.42	0.032
		5.75	0.516	20.4	1.175	0.65	0.064
		8.40	0.755	18.5	1.295	0.93	0.100
		14.10	1.26	15.7	1.53	2.41	0.307
		17.10	1.53	14.9	1.61	3.75	0.503

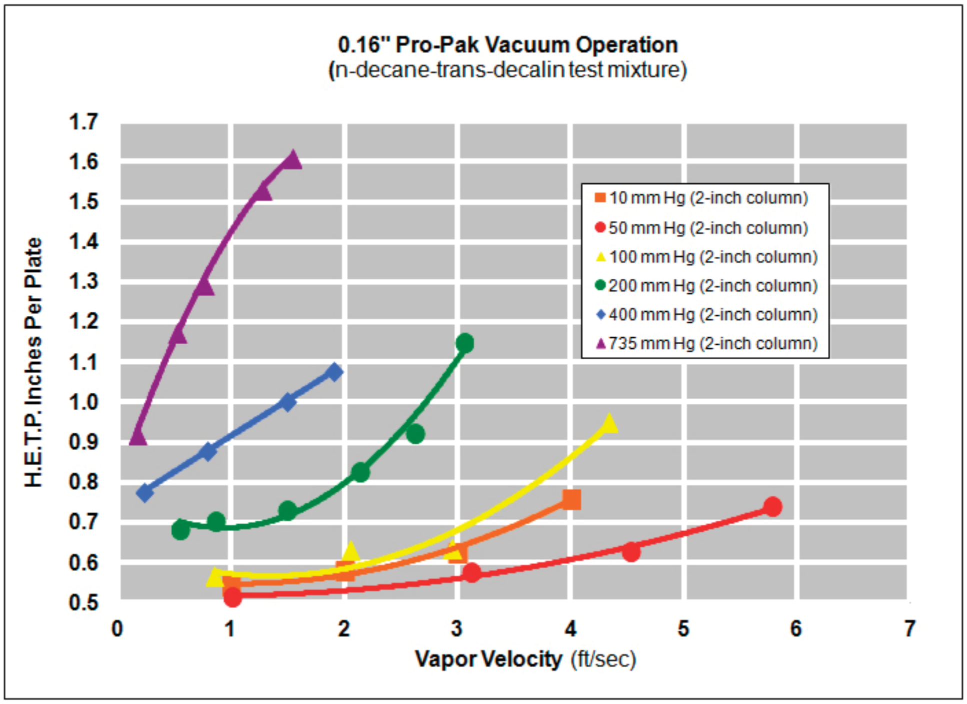


Figure 14

PRO-PAK®
Packing Characteristics

0.24-Inch Protruded Packing

(recommended for columns 2″ in diameter or larger)

- Material: Fabricated from metal ribbon ⅜-inch wide and 0.003-inch thick.
- Shape: Half-cylinder with two corners bent slightly outward.
- Size: 0.24 inch in diameter x 0.24 inch in length.
- Number of holes: 1024 per square inch.
- Size of holes: Approximately 0.40 by 0.37 millimeters.
- Pieces per cubic foot: 290,000.
- Packed density: 21 pounds per cubic foot (for type 316 stainlesss teel).
- Surface area: 372 square feet per cubic foot.
- Per cent free space: 96.
- Packing Factor: 420.

0.16-Inch Protruded Packing

(recommended for columns 2″ in diameter or smaller)

- Material: Fabricated from metal ribbon ¼-inch wide and 0.003-inch thick.
- Shape: Half-cylinder with two corners bent slightly outward.
- Size: 0.16 inch in diameter x 0.16 inch in length.
- Number of holes: 1024 per square inch.
- Size of holes: Approximately 0.40 by 0.37 millimeters.
- Pieces per cubic foot: 800,000.
- Packed density: 2 7.6 pounds per cubic foot (for type 316 stainless steel).
- Surface area: 576 square feet per cubic foot.
- Per cent free space: 94.
- Packing Factor: 693.

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