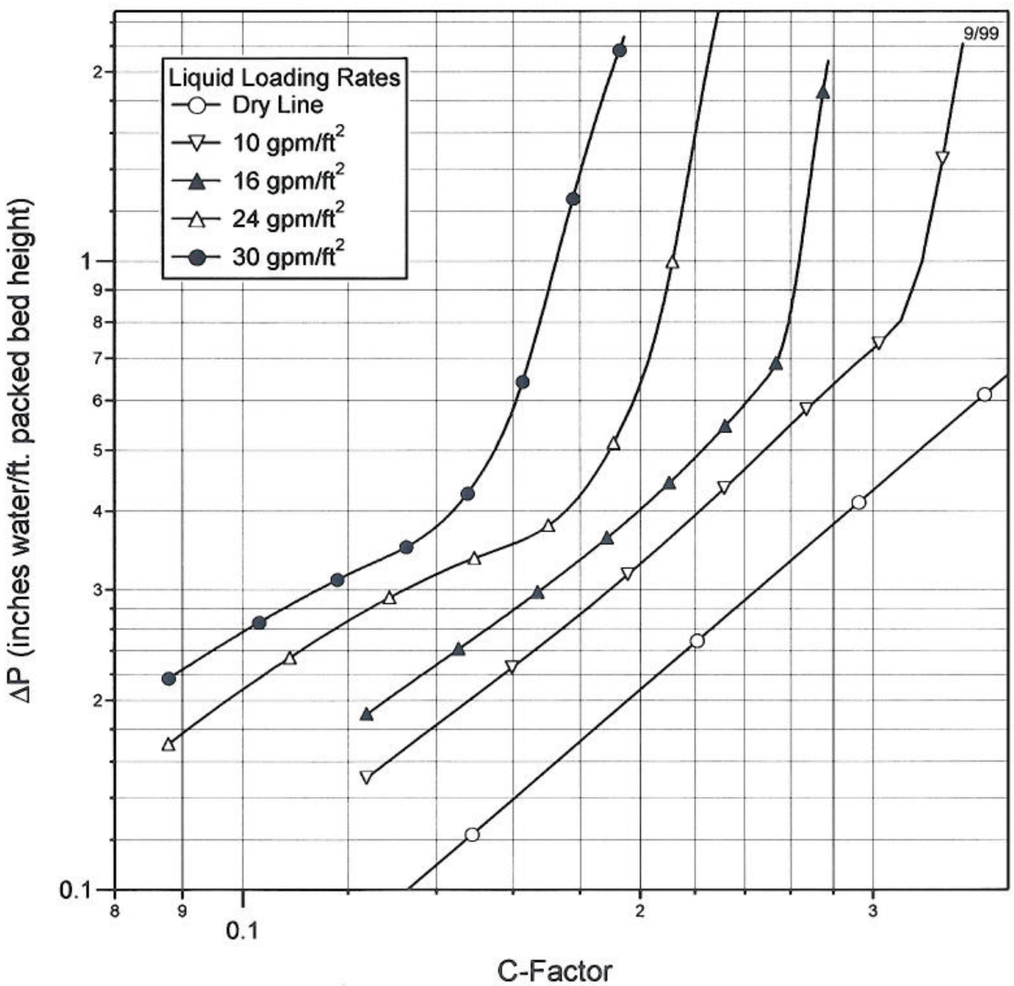
Pressure Drop vs. C-Factor

1.25" Plastic Jaeger Tri-Packs®

Ambient Air-Water Systems for Various Liquid Loadings



C-Factor = $V_s[(\rho_V)/(\rho_L - \rho_V)]^{1/2}$ where
V_s = Superficial Vapor Velocity in ft/sec
ρ_L and ρ_V = Density of Liquid and Vapor in lb/ft^3

For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = $lb/hr\text{-}ft^2$; gpm/ft^2 x 499.7 = $lb/hr\text{-}ft^2$

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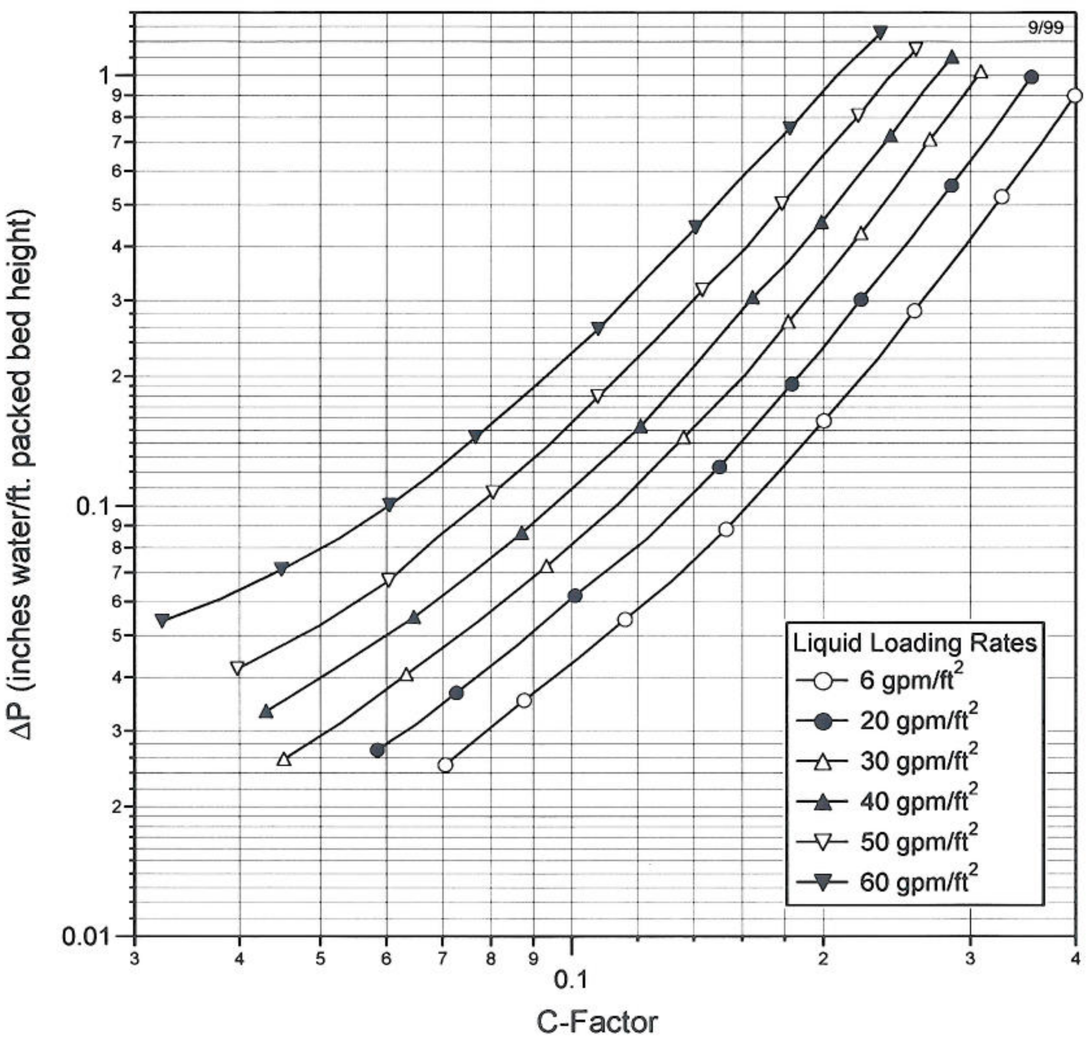
Pressure Drop vs. C-Factor

2" Plastic Jaeger Tri-Packs®

Ambient Air-Water Systems for Various Liquid Loadings



C-Factor = $V_s[(\rho_V)/(\rho_L - \rho_V)]^{1/2}$ where
V_s = Superficial Vapor Velocity in ft/sec
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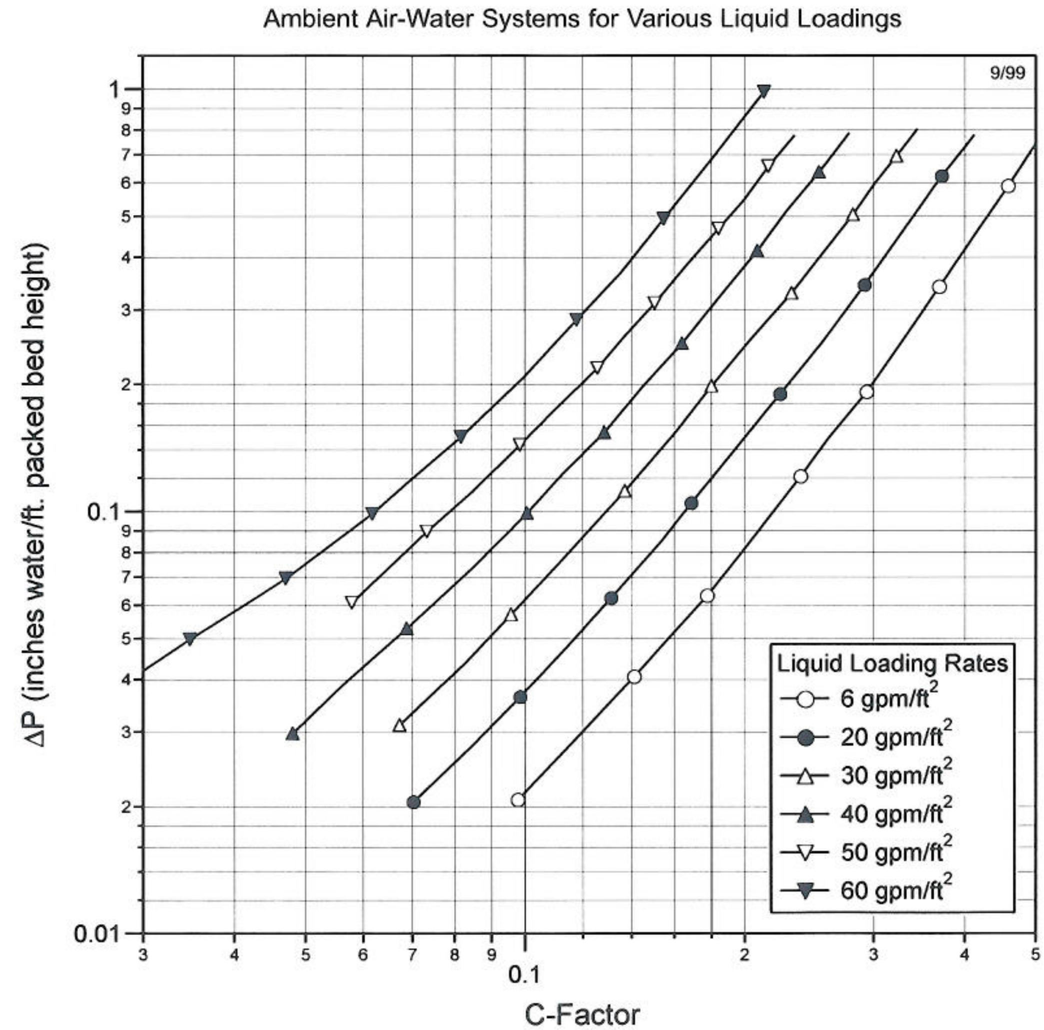
For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = lb/hr-ft^2; gpm/ft^2 x 499.7 = lb/hr-ft^2

Pressure Drop vs. C-Factor

3.5" Plastic Jaeger Tri-Packs®



C-Factor = $V_s[(\rho_V)/(\rho_L - \rho_V)]^{1/2}$ where
V_s = Superficial Vapor Velocity in ft/sec
ρ_L and ρ_V = Density of Liquid and Vapor in lb/ft^3

For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = lb/hr-ft^2; gpm/ft^2 x 499.7 = lb/hr-ft^2

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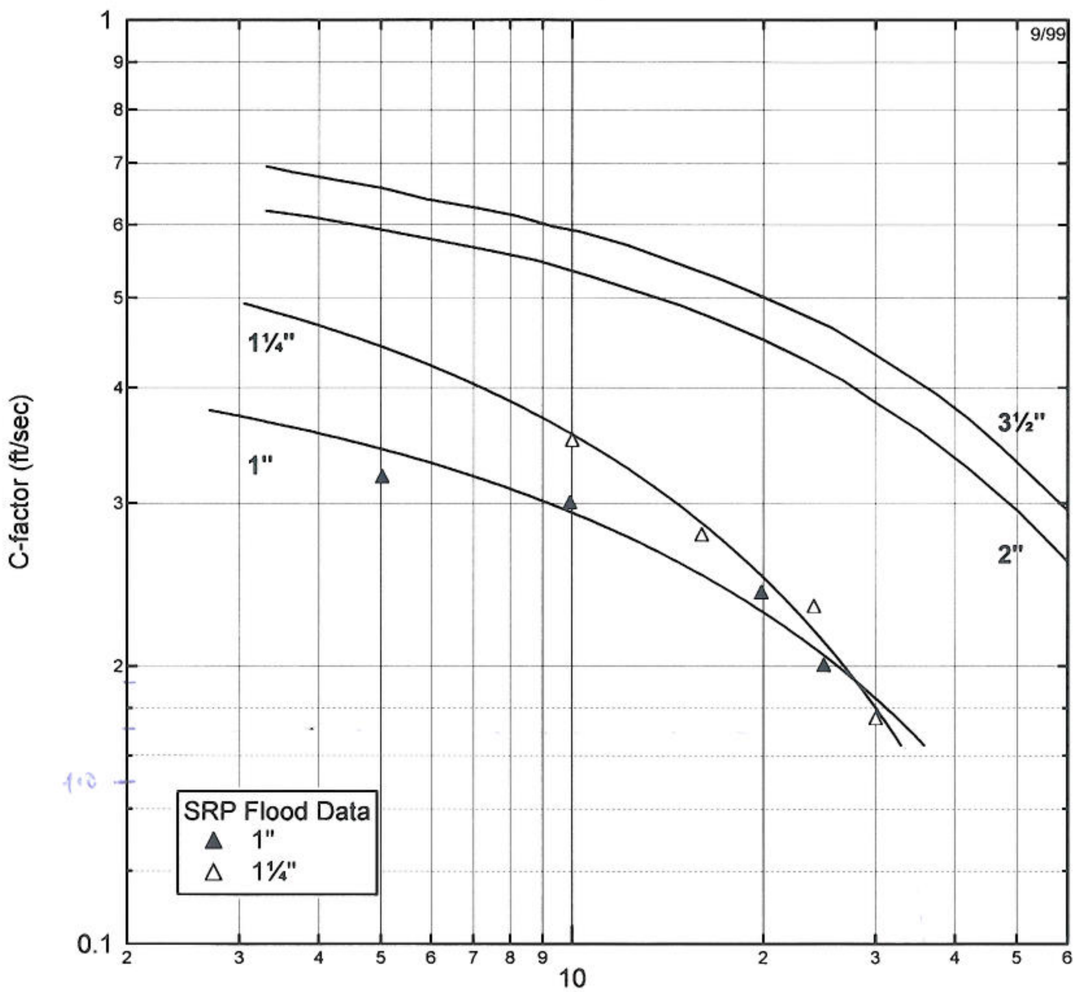
Generalized Flooding Curves

Plastic Jaeger Tri-Packs®

Ambient Air-Water Systems at 1 atm, 70°F



C-Factor = $V_s[(\rho_V)/(\rho_L - \rho_V)]^{1/2}$ where
V_s = Superficial Vapor Velocity in ft/sec
ρ_L and ρ_V = Density of Liquid and Vapor in lb/ft³

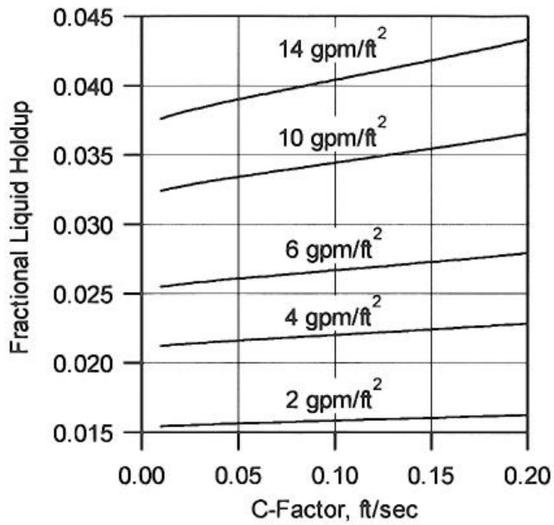
For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = lb/hr-ft²; gpm/ft² x 499.7 = lb/hr-ft²

SRP - Separations Research Program, University of Texas at Austin.

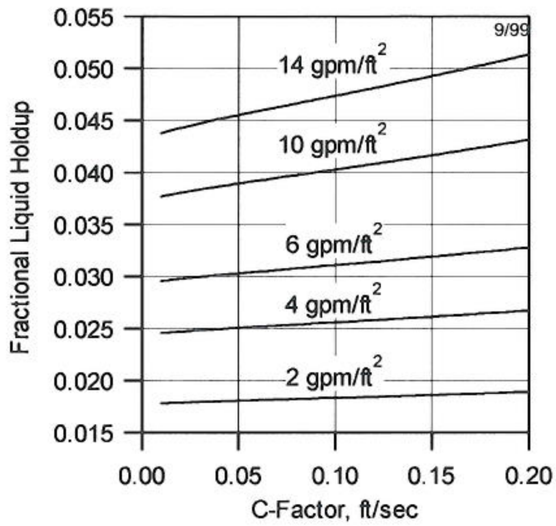
Liquid Holdups

Jaeger Tri-Packs®

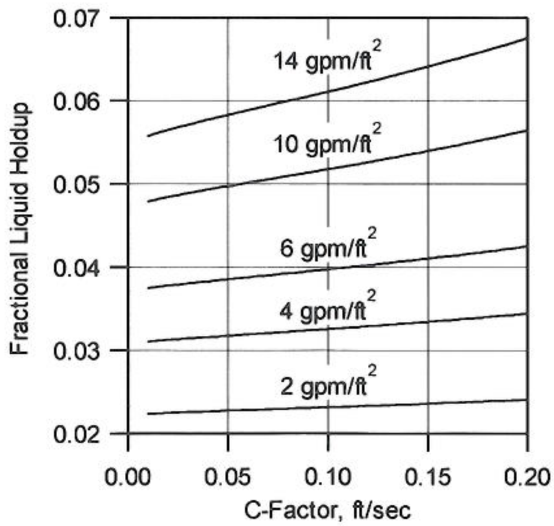
3 1/2"Jaeger Tri-Packs®



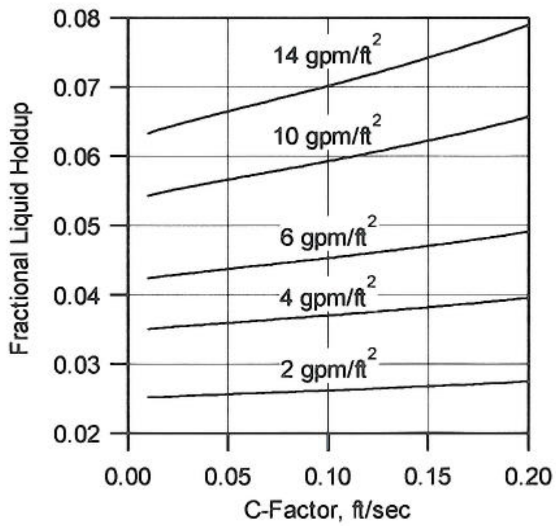
2"Jaeger Tri-Packs®



1 1/4"Jaeger Tri-Packs®



1"Jaeger Tri-Packs®

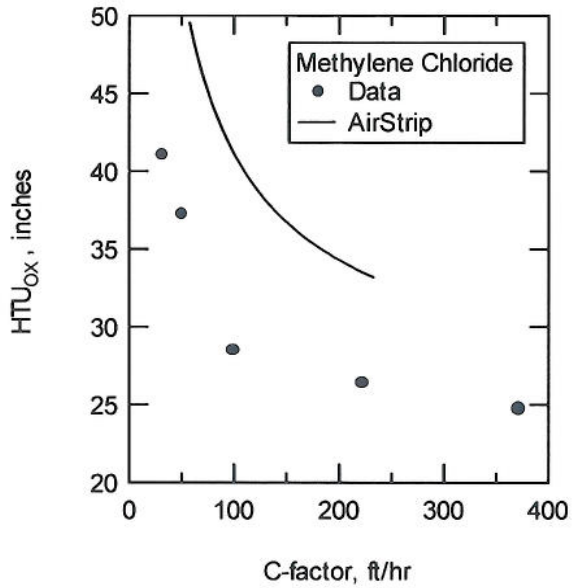


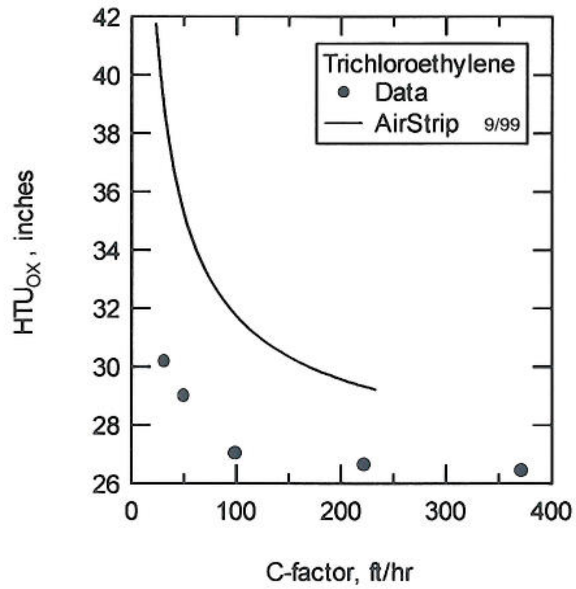
Fractional holdups estimated from formula presented in I&EC Research, 5(33), 1222 (1994).

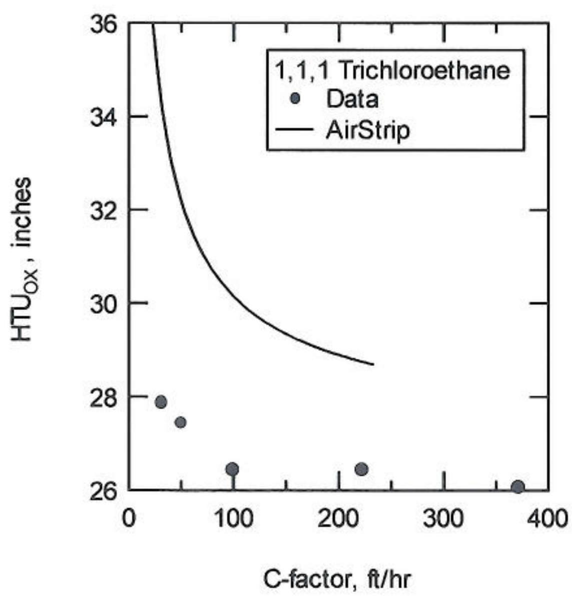
For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = lb/hr-ft^2; gpm/ft^2 x 499.7 = lb/hr-ft^2

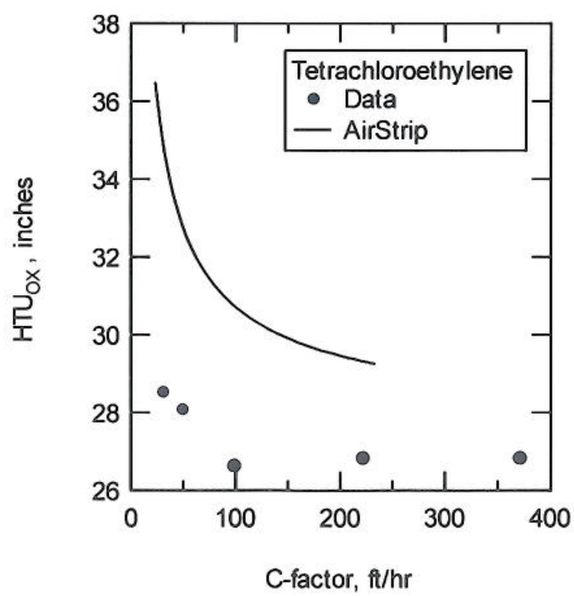
Independent Tests Prove...

Jaeger Tri-Packs® Outperform









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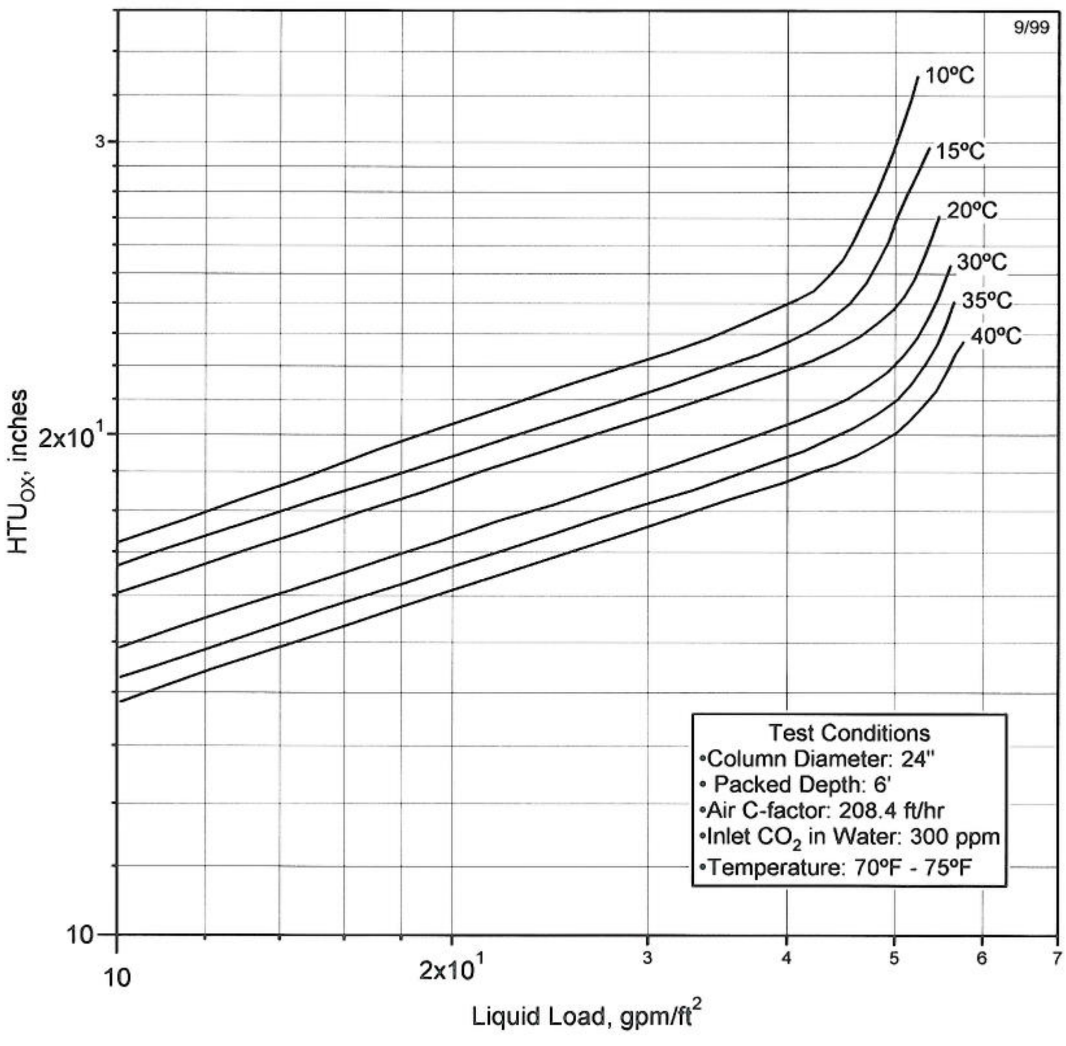
HTU_{ox} for CO_2 Desorption from Water

2" Plastic Jaeger Tri-Packs®



For Air/Water systems at 70°F & 1 atm: C-Factor x 7776.2 = lb/hr-ft²; gpm/ft² x 499.7 = lb/hr-ft²

Absorption/Scrubbing

MASS TRANSFER DATA

Absorption System	G (lb/hr-ft^2)	L (lb/hr-ft^2)	Temp. (°F)	HTU-Inches		
				1	2	32
$HCl-H_2O$	1792	2048	77	7.0	10.6	12.0
HCl-NaOH	1567	2048	68	6.1	8.8	10.0
Cl_2-NaOH	1229	2202	122	9.9	14.5	16.0
$NO_2-Na_2S+NaOH$	717	1127	68	32.0	49.2	54.0
$NH_3-H_2SO_4$	492	1024	68	4.1	6.0	7.0
NH_3-H_2O	512	1024	68	5.6	8.4	10.0
NH_3-H_2O	512	4096	68	3.6	5.4	6.2
SO_2-NaOH	1946	4096	140	8.1	12.0	14.0
$HF-H_2O$	1844	3072	77	4.6	6.9	8.1
H_2S-NaOH	1229	1331	68	13.0	19.4	22.0

Typical Design Parameters

Gas Velocity
100-500 ft/min.
These loadings are based on the cross-sectional area of the scrubber as seen by the gas. In counter-current scrubbers this area corresponds to the cross-section of the tower. In cross-flow scrubbers, it corresponds to the cross-section on a vertical plane of the packed bed.

Liquid Loading
2-10 gpm/ft^2
These loadings are based on the cross-sectional area of the scrubber as seen by the liquid. In counter-current scrubbers, this area corresponds to the cross-section of the tower. In cross-flow scrubbers, it corresponds to the cross-section on a vertical plane of the packed bed.

Packing Size
For random packings, optimum size scrubber diameter/packing size ratio is 12:1.

pH
pH needs to be specified and controlled for any absorption involving contaminants which can dissociate in aqueous solution. Contact Jaeger for your specific application.

Pressure Drop
Packed bed pressure drop in new scrubbers should be between 0.02" and 0.2" water/ft. of packed bed depth for optimum design.

Blowdown and Makeup Rates
These two variables need to be determined by process design and material balance considerations within the constraints shown above. Consult Jaeger for the proper values for your application.

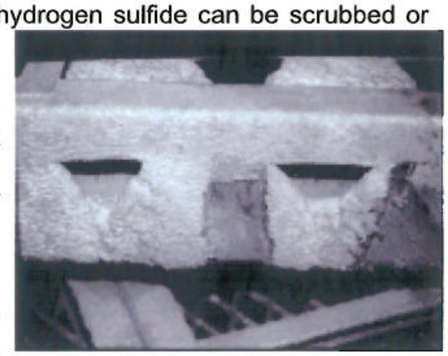
Jaeger Understands Your Water Treatment Needs

Among the biggest long term maintenance problems facing personnel charged with operating scrubbers and strippers are *scaling, fouling, and disinfection. Scaling* is the precipitation and deposition of water-insoluble salts onto column internals and packing. Scaling is distinct from *fouling*, which involves the formation of deposits other than salts and which may be due to corrosion or biological growth. Finally, operators must consider *disinfection* if the water being treated is ultimately destined for human or animal consumption.

Scaling is especially troublesome when the contaminant being dealt with can dissociate or needs to dissociate in water to effect its efficient removal. For these contaminants, water pH is adjusted by adding strong acids or bases to prevent or enhance dissociation. Generally speaking, dissociation needs to be prevented when the contaminant is to be stripped from water; it needs to be enhanced when the contaminant is to be scrubbed from air. Unfortunately, when these pH adjustments are performed on "hard" water, one is often forced to cross the solubility envelopes for sparingly soluble salts of calcium, iron, or magnesium (among others). If these solubility phase boundaries are crossed, precipitation is a thermodynamic inevitability. Contrary to popular belief, **packing geometry plays little or no role in the scaling process**. The rate at which a packing scales, therefore, depends primarily upon the initial water "hardness" and the "pH driving force", i.e. the difference between the operating pH and the pH at the solubility limit for the salt in question, with secondary effects caused by liquid and gas loading.

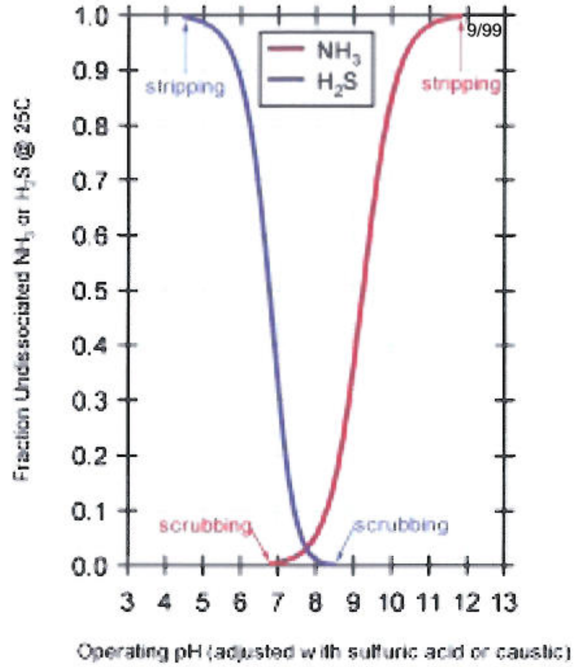
The pictures shown are of actual packings and internals taken from different air stripping towers in the field. The picture on the top right is of 3 1/2" Lanpac®, claimed by its manufacturer to be "scaling and fouling resistant". It came from an air stripper located in an area where the groundwater is high in iron.The middle picture is of a conventional Pall® ring that also fouled severely in an air stripping application. Finally, the bottom right picture is of the distributor removed from the same tower which held the Pall7 rings of the center photo.

Two very common contaminants - ammonia and hydrogen sulfide - require that water pH be adjusted for effective stripping or scrubbing to take place. Ammonia is a weak base while hydrogen sulfide is a weak acid. Vapor/liquid equilibrium considerations make ammonia normally amenable only to scrubbing while hydrogen sulfide can be scrubbed or stripped. The top graph on the opposite page illustrates the effect of pH on the dissociation of these two compounds. The bottom graph is a solubility phase diagram for three of the more common cations found in "hard" water. Comparison of these two graphs illustrates that there can be significant overlap of the regions of best "operational" pH into regions of high scaling potential for these two example compounds. Similar analyses could be done for other compounds and/or other cations.

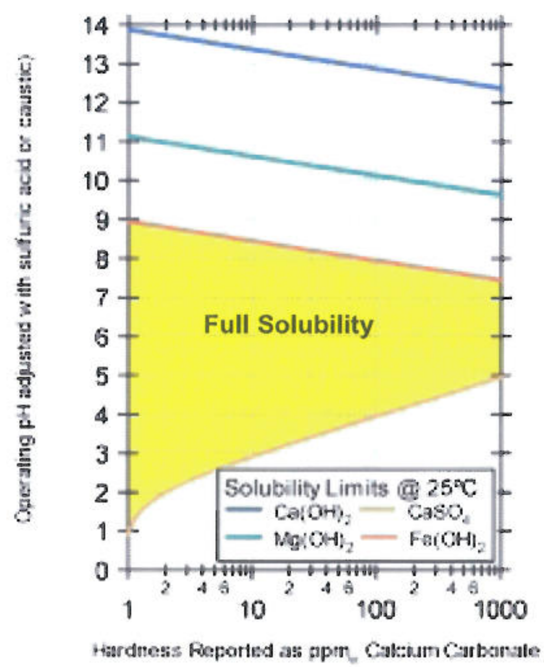


Clearly, the best way to avoid costly shutdowns from scaling is to prevent them. Addition of sequestering agents or other appropriate chemicals can drastically minimize column down time. In situations where chemical addition is inappropriate, or perhaps even prohibited, a proper maintenance and cleaning program should be implemented, which might include *in situ* acid or caustic washing of the packing and internals. These measures will also help to reduce fouling.

Disinfection refers to the killing of microorganisms. Most forms of disinfection, including chlorination and ozonation, kill organisms by oxidation. The exception is UV disinfection, which kills organisms with ultraviolet radiation. Chlorination is by far the most common disinfectant in use in the United States. One concern associated with chlorine use is its potential to react with suspended or soluble organic matter to produce *trihalomethanes* (*THMs*). These compounds appear to be potent carcinogens. The *trihalomethane formation potential* (*THMFP*) is a measure of the tendency of a water source to produce THMs. Unfortunately, the effectiveness of chlorine is decreased by high pH and low temperature. For these reasons, ozone is becoming a more common disinfectant. Ozone is a much more powerful oxidant than chlorine. It is also naturally unstable, with half-life of approximately 20 minutes. It, therefore, must be generated at its point of use. Ozonation is very common in Europe. It has received increased attention recently because it is the only disinfectant that appears to be effective against *cryptosporidium*.



Today, Jaeger is the only packing supplier offering you more than just rhetoric on the subjects of scaling, fouling, and disinfection. For example, our non-toxic pretreatment product, JP-7, is a proven technology based on polyphosphate chemistry. Polyphosphates sequester "hard" cations in solution by complexing with them to form large, soluble clusters. In addition, JP-7 has been approved by the EPA, the Department of Agriculture, and several state health agencies for use in potable water systems. Where water comes in contact with metals JP-7 has the added benefit of acting as a corrosion inhibitor. Contact Jaeger for additional information about scaling, fouling, and disinfection and how we might help you to overcome these difficulties.



Conversion Factors

FROM	TO	MULTIPLY BY	ADD OFFSET
mg/ml	ppm_W	1.0	
1/ft	1/m	3.2808	
atm	psia	14.696	
atm	psig	14.696	-14.696
atm	torr	760	
C	F	1.8	32
C	K	1	273.15
C-factor (air/water @70°F) ft/se	lb/hr ft²	7776.2	
F	K	.5556	255.3722
ft	cm	30.48	
ft	m	.3048	
ft²/ft³	m²/m³	3.2808	
ft³	gal (US)	7.4805	
ft³	m³	.0283	
g/cm³	lb/ft³	62.428	
gm/cm³	kg/m³	1000	
gpm/ft²	lb/hr ft² (water @ 70°F)	499.7	
hr	sec	3600	
in	m	.0254	
in wc/ft	dyne/cm³	81.5617	
in wc/ft	Pa/m	815.6168	
kg	gm	1000	
kg	lb	2.2046	
kg/m²*sec	lb/ft²*hr	737.3402	
kg/sec	lb/hr	7936.6829	
kg mole/m²*sec	lbmole/ft²*hr	737.3402	
kW	hp	1.341	
lb	gm	453.59	
m²	cm²	10000	
m²	ft²	10.7639	
m²/m³	cm²/cm³	.01	
m³	liters	1000	
mg/l	ppm_W	1.0	
Millions of Gallons/Day	gpm	694.46	
min	sec	60	
ppm_W	ppb_W	1000	

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PHYSICAL PROPERTIES OF JAEGER PACKINGS

	Size (nominal)	Packing Factor (1/ft)	Weight (lb/ft^3)	Surface Area (ft^2/ft^3)	Void Space (%)
Plastic Packing					
Jaeger Tri-Packs®	1" 1 1/4" 2" 3 1/2"	28 25 16 12	6.2 5.6 4.2 3.3	85 70 48 38	90 92 93.5 95
Cascade Mini-Rings®	1" 2" 3 1/2"	26 16 12	4.0 3.5 3.2	85 50 40	92 93 94
Jaeger Rings	5/8" 1" 1 1/2 " 2" 3 1/2"	97 52 32 25 16	7.8 5.9 4.8 4.3 3.8	108 64 44 33 26	86 90 91 92 93
Jaeger Saddles	1" 2" 3"	33 21 16	4.7 3.3 2.8	60 30 20	91 94 95
Bio-Ring™	3 1/2"	NA	2.8	32	95
Cascade Bio-Ring™	7"	NA	2.2	30	95
Metal Random Packing					
VSP®	25 mm 40 mm 50 mm	32 21 20	11.9 10.6 10.0	62.5 40.2 33.5	97.5 98 98
Top-Pak®	75 mm	16	10.0	24.4	98
Interpack®	10 mm 15 mm 20 mm	246 122 73	40.5 21.5 21.8	189 110 79.5	90 94 96
Metal Structured Packing					
Max-Pak™	1/2"	19-22	12.8	77	97
Ceramic Packing					
Novalox® Saddles	1/2" 3/4 " 1" 1 1/2 " 2" 3"	201 131 97 52 40 22	43.0 41.0 40.3 40.3 36.8 35.9	190 102 78 61 37 28	73 74 74 75 77 77

weights of plastic based on polypropylene
weights of metal based on 300 series stainless steel
all weights are dry weights

For More Information:

General Brochure
Series 100

Metal VSP® & Metal Top-Pak®
Series 200

Metal Random Packing
Series 300 - Future Publication

CoFlo™ Trays
Series 400

Fractionation Trays
Series 450 - Future Publication

Metal Max-Pak™
Series 500

Plastic Jaeger Tri-Packs®
Series 600

Plastic Rings & Saddles
Series 700

Plastic Cascade Mini-Rings®
Series 800

Biological Products & Chemicals
Series 900 - Future Publication

Ceramic Packing
Series 1000

Column Internals
Series 1100

-- Complete Technical Catolog includes all of the above along with other technical and performance information.

NOTE: The information presented in this brochure is believed to be accurate and reliable. However, it is based on test results which may not apply to your application. Therefore, the data is presented without guarantee or warranty. We recommend that you contact Jaeger's engineering department or your local representative to discuss the details of your specific application.

Manufactured and Marketed by:

Jaeger Products, Inc.
1611 Peachleaf Street
Houston, TX 77039
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