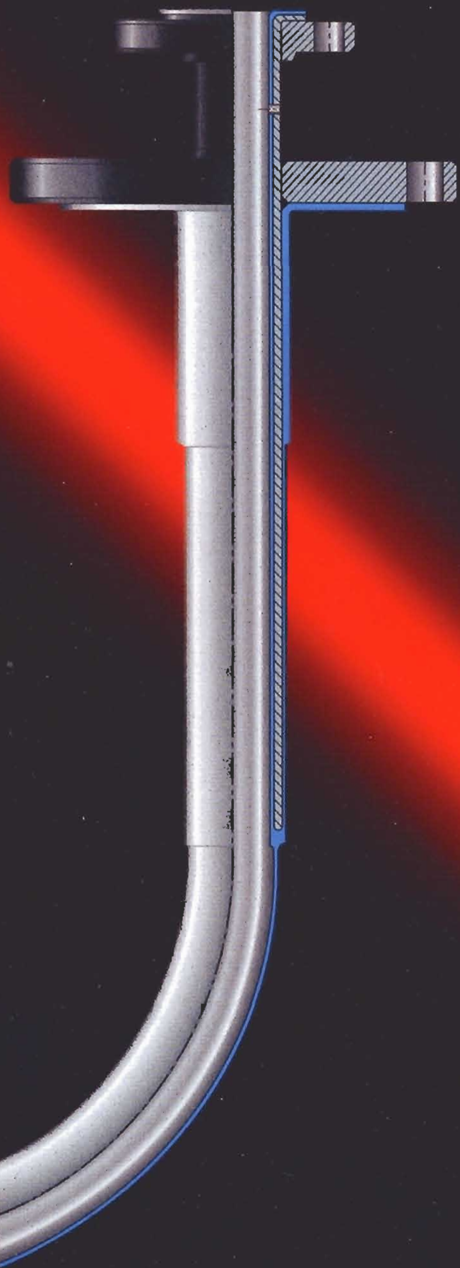
ETHYLARMOR®
Dip Pipes and Spargers



ETHYLENE

ETHYLARMOR® Dip Tube

High Temperature Corrosion Resistance

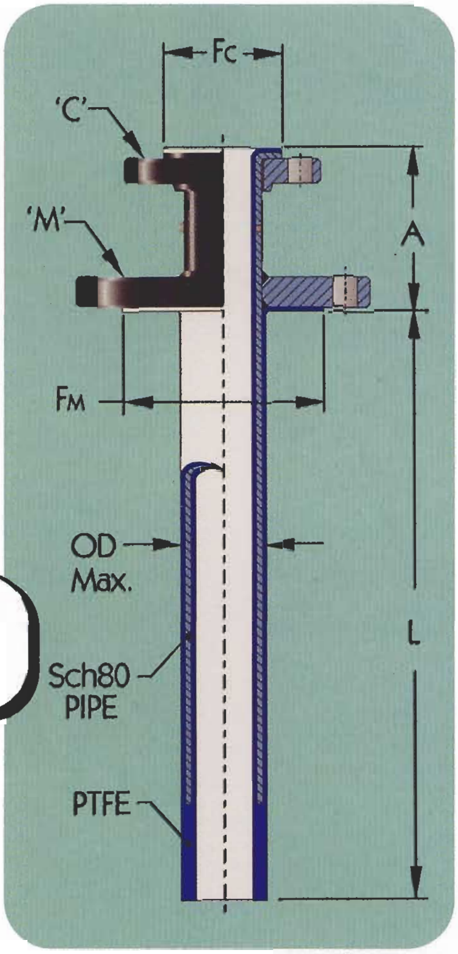
Ethylene Ethylarmor Dip Tubes and Spargers combine the high temperature, near universal corrosion resistance of Teflon® PTFE with the mechanical strength of an encapsulated Schedule 80 carbon steel pipe for tough applications such as agitated reactors.

Durability

Ethylarmor Dip Tubes and Spargers pass both the ASTM F423 steam-cold water cycle test and a 10,000 volt electrostatic spark test; the industry's most rigorous testing program. This virtually eliminates the possibility of heat-seal failure and resultant damage to the reactor's fragile glass lining.

Design

A broad range of optional features are available to meet your process requirements. These include Diverters (to direct liquid/gas flow away or towards vessel walls), Extended Flares (to eliminate additional reducing flanges), Sparger, Anti-Siphon Holes, etc..

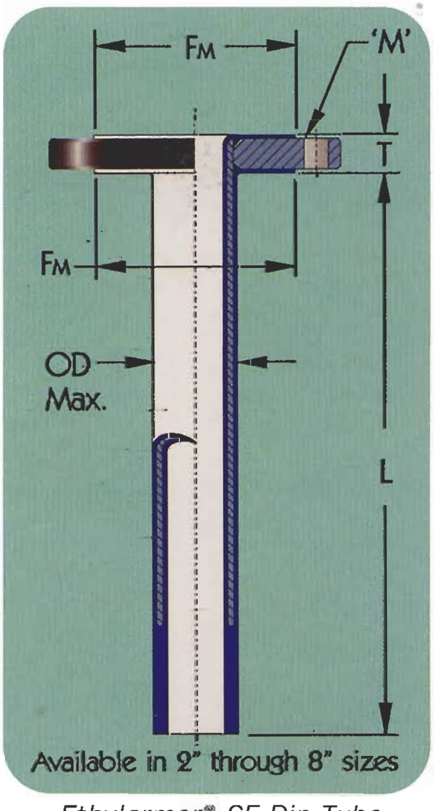


Ethylarmor® DF Dip Tube

ETHYLENE Dip Tubes and Spargers Withstand The Heat, Corrosion and Stress of Your Most Demanding Process

ETHYLARMOR® DF and SF Dip Tubes

These standard dip tubes can be supplied in a variety of diameters and length configurations. Maximum recommended unsupported length for agitated service is shown in Table 1 (a general guide only). Ethylene will review your specific service conditions (please see pages 6 and 7 of this bulletin: Bending Moment Calculations) and advise a suitable dip tube construction. See Table 1 and Table 2 for available sizes and lengths.



Ethylarmor® SF Dip Tube

Table 1: Ethylarmor SF and DF Dip Tube Data

Nominal Size	PTFE Wall	Connecting Flange 'C'	Mounting Flange 'M'	PTFE Flare F_C	PTFE Flare F_M	A	T	Max. OD	Max. L	Max. Unsupported Length for Agitation
3/4	.090	3/4	1 1/2	1 11/16	2 7/8	5	-	1 3/8	20'-0"	3'-0"
1	.090	1	2	2	3 7/8	5	-	1 5/8	20'-0"	3'-6"
1 1/2	.125	1 1/2	3 4 6 8	2 7/8	5 6 3/16 8 1/2 10 5/8	5	-	2 1/4	20'-0"	5'-0"
2	.125	2	3* 4 6 8	3 5/8	5 6 3/16 8 1/2 10 5/8	5	1	2 13/16	20'-0"	6'-0"
3	.125	3	4* 6 8	5	6 3/16 8 1/2 10 5/8	5	1 3/16	3 15/16	15'-0"	8'-0"
4	.150	4	6* 8	6 3/16	8 1/2 10 5/8	6	1 1/4	4 15/16	15'-0"	10'-0"
6	.150	6	8	8 1/2	10 5/8	6	1 3/8	7 1/16	10'-0"	10'-0"
8	.170	8	10	10 5/8	12 3/4	6	1 9/16	9 3/16	9'-6"	9'-6"

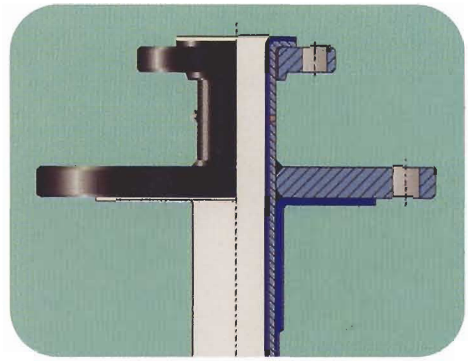
All Dimensions in inches

** Denotes size Mounting Flanges available on SF type dip tubes.*

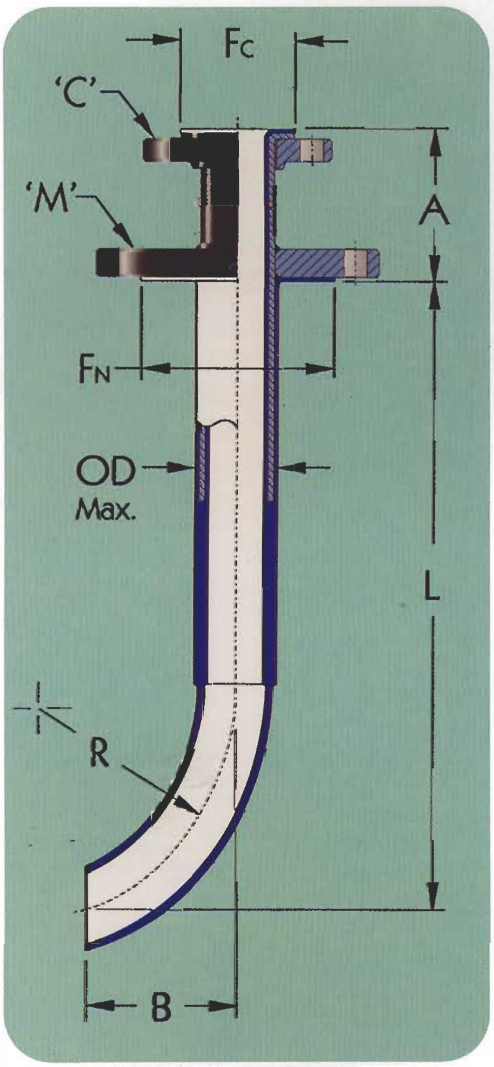
Extended Flare Technology

Ethylene's Extended Flare Face technology eliminates costly reducing flanges by allowing oversized mounting flanges to be integrated into dip tube fabrication. This is also an important factor in the reduction of fugitive emissions; fewer connections mean fewer leak points. The extended flare is subjected to the same rigorous steam-cold water and a 10,000 voltage tests as other Ethylarmor products.

Table 1 gives the mounting and connecting flange combinations available on DF Dip Tubes.



DF Dip Tube with Extended Flare



Ethylarmor® Diverter Tube

ETHYLARMOR® Diverter Tube

A unique tight radius bend capability is ideal when a diverter is required to deflect liquid or gas either toward or away from a vessel wall. The curvature at the bottom of the tube simplifies the installation of the dip tube in reactors with limited overhead space. Variations of the standard diverter's geometry can be accommodated in most cases, please contact the factory for assistance.

Table 2 below gives standard bend radii and offsets available.

Table 2: Diverter Data

Nominal Size	B (Nom.)	R (Nom.)	A (Nom.)	Max. OD	L (Nom.)
1	4"	6"	5"	1⅝	18"
1½	5"	8"	5"	2¼	21"
2	6"	10"	5"	2 13/16	27"
3	6"	16"	5"	3 15/16	30"
4	8"	20"	6"	4 15/16	36"

All Dimensions in inches. See Table 1 for Connection and Mounting Flange Data.

Color Legend

Carbon Steel

PTFE

Special Orders

Ethylene prides itself on its' ability to respond to customer needs. Please consult the factory for information on items not shown in this catalog.

ETHYLARMOR® AGI Dip Tube

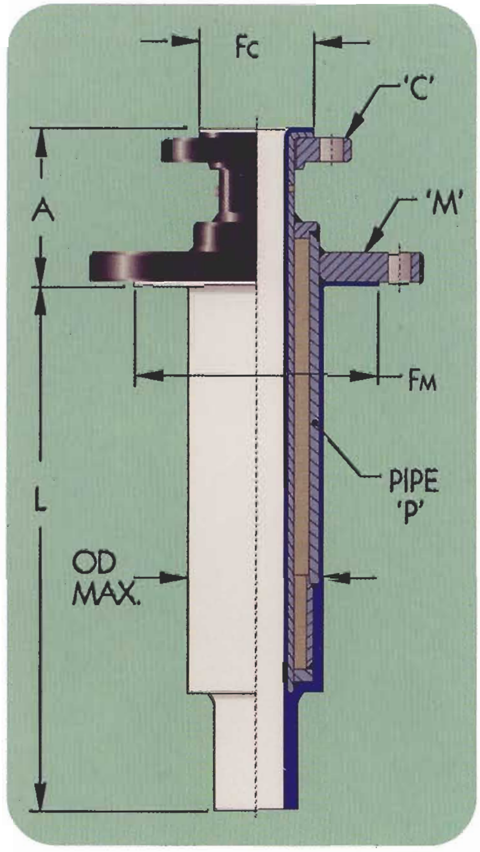
for Severe Agitation Service.

The AGI Dip Tube is intended for use in services where the combination of length and loading prohibit the use of standard Ethylarmor DF Dip Tubes. The larger outer diameter reinforcing pipe significantly increases the ability of the dip tube to withstand external loading. Severe agitation applications of smaller diameter Ethylarmor dip tubes may require additional reinforcement of the Dip Tube. Ethylene can offer Schedule 120 or even Schedule 160 reinforcing pipe for special applications.

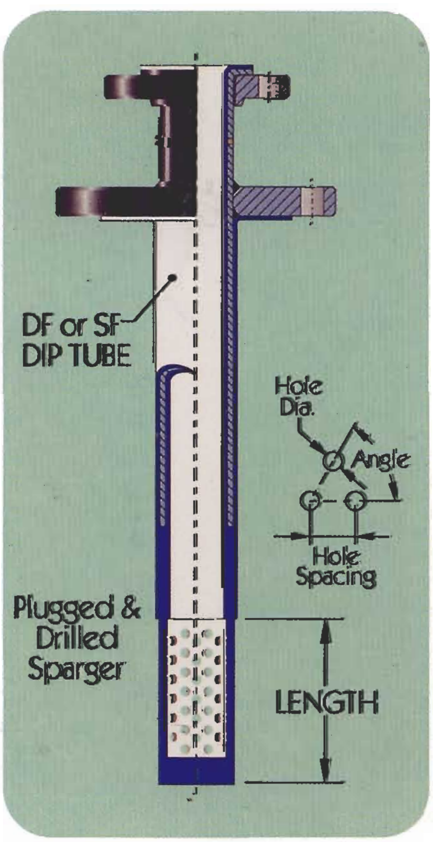
Table 3: Ethylarmor AGI Dip Tube Data

Nominal Size	Connecting Flange 'C'	Mounting Flange 'M'	Reinforcing Pipe 'P'	PTFE Flare F_C	PTFE Flare F_M	A	Max. OD	Max. Entry Length L
1	1"	4" 6" 8"	3"	2	6 3/16" 8 ½" 10 ½"	5"	3 15/16" 4 ¼" 4 ¼"	15'-0"
1½	1½"	4" 6" 8"	3"	2 7/8	6 3/16" 8 ½" 10 ½"	5"	3 15/16" 4 ¼" 4 ¼"	15'-0"
1½	1½"	6" 8"	4"	2 7/8	8 ½" 10 ½"	6"	4 15/16" 5 3/8"	15'-0"
2	2"	6" 8"	4"	3 5/8	8 ½" 10 ½"	6"	4 15/16" 5 3/8"	15'-0"

All Dimensions in inches



Ethylarmor® AGI Dip Tube



Ethylarmor® DF Sparger

ETHYLARMOR® Spargers

Ethylarmor Spargers are ideal for steam entrainment or other applications where diffusion of the process fluid is desired. The bottom section of the sparger is an integral part of the encapsulating PTFE liner. It is designed to provide a radial spray that can be tailored to your exact requirements. Spargers can be drilled to your specifications; number and diameter of holes, distance from the end of the tube and length of drilled section can all be specified.

If not otherwise specified the drilling shown in Table 4 below is provided.

Table 4: Sparger Dimensions

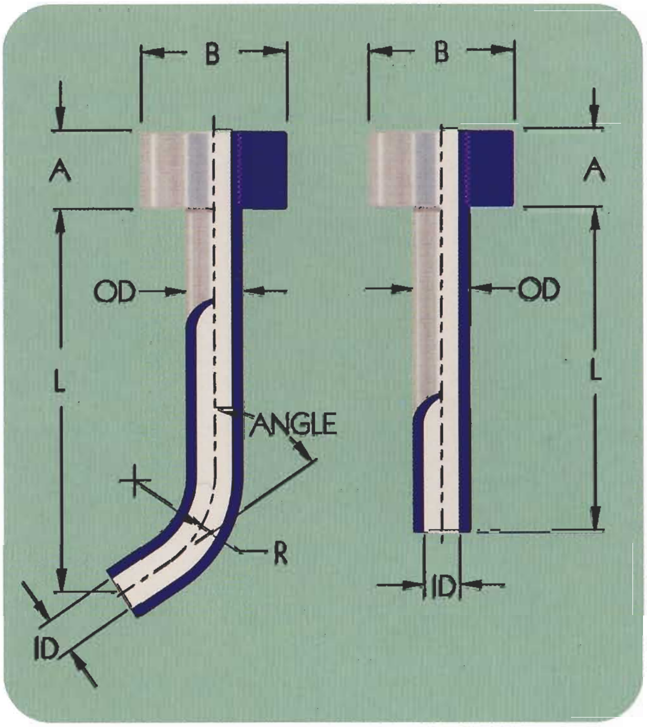
Nominal Size	Length	Hole Number	Hole Diameter	Hole Spacing	Angle
1	6	16	¼"	1.02	60°
1½	6	16	3/8"	1.47	60°
2	6	32	3/8"	1.25	60°
3	8	40	½"	1.38	60°
4	10	64	½"	1.77	60°

All Dimensions in inches

Solid PTFE Dip Tubes and Spargers

Ethylene LLC. solid PTFE Dip Tubes and Spargers are fabricated from heavy-walled virgin PTFE tubes. All flanges are threaded onto the tube and pinned in place. Spargers are drilled to your specifications; number and diameter of holes, distance from the end of the tube and length of drilled section.

Consult Ethylene for applications involving nonstandard sizes or multiple bend configurations. Table 5 below gives dimensions.

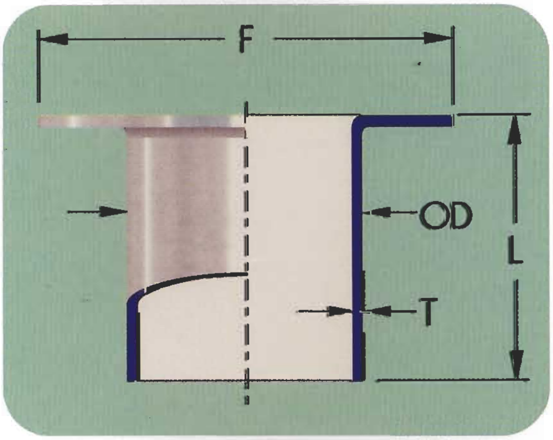


Solid Dip Tubes, Diverter and Spargers

Table 5: Solid Dip Tube Dimensions

Nominal Dia.	Nozzle Size	OD	ID	A	B	R
½	1	1	½	1	2	4
1	1½	1⅜	⅞	1½	2⅞	6
1½	2	1⅞	1⅛	1¾	3⅝	8
2	3	2¾	2	2	5	10
3	4	3½	2½	2¾	6¼	16
4	6	4	3	3	8½	20

All Dimensions in inches



Nozzle Liners

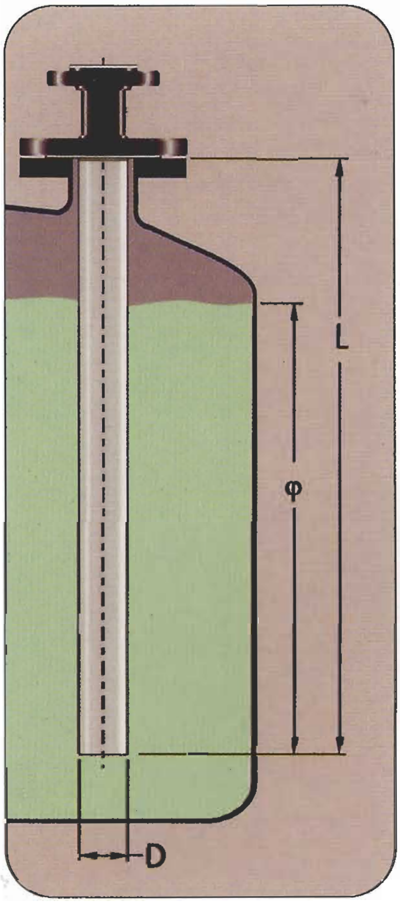
Used in glass lined steel reactors and vessels, Ethylene nozzle liners eliminate damage to fragile nozzles during the insertion and operation of dip tubes, spargers and instrumentation. Nozzle liners also reduce erosion of the glass or alloy vessel nozzles by steam or abrasive materials; preventing process contamination and expensive repairs. Solids build-up is also reduced. They are provided in lengths to meet your exact requirements.

Table 6: Nozzle Liner Dimensions

Nozzle Size	OD	Flare F	Wall T	Nozzle Size	OD	Flare F	Wall T
½	½	1⅜	1/16	4	3 13/16	6 3/16	⅛
¾	¾	1 11/16	1/16	6	5¾	8½	⅛
1	15/16	2	1/16	8	7¾	10⅝	⅛
1½	1 7/16	2⅞	1/16	10	9¾	12¾	5/32
2	1 15/16	3⅝	1/16	12	11¾	15	5/32
3	2 15/16	5	⅛	14	13¾	16¼	5/32

Diameters through 36" are available. Please consult the factory for diameters over 14" not listed. Note: Nominal dimensions shown.

Dip Tube Calculation



Dip Tubes and spargers used in agitated service are subject to loads which under certain conditions can be so great that bending or complete failure of the unit can occur. Therefore, it is important that these loads be considered when designing or specifying a dip tube or sparger for use in highly agitated service or service with highly viscous materials.

To determine these loads, the following must be known

- V - Velocity of the process fluid past the tip of the dip tube (ft/sec)
- D - Outside diameter of the dip tube (ft) See Table 7
- L - Entry Length of the dip tube (ft)
- φ - Length of the dip tube immersed in fluid (ft)
- μ - Dynamic viscosity of the process fluid (lbs sec/ft^2)
- ρ - Mass density of the process fluid (slugs/ft^3) [(1slug/ft^3 = 32.17 lb/ft^3)]

The total force exerted on the tube, F_T, can be determined from the above information. F_T is the resultant of the drag and lift forces acting on the tube, F_D and F_L respectively. F_T is given by Equation 1.

$$F_T = \sqrt{F_D{}^2 + F_L{}^2}$$ *Equation 1*

the viscous drag force, F_D , is defined by Equation 2.

when: $A = \varphi D$ $$F_D = \frac{C_D + V^2 \rho A}{2}$$ *Equation 2*

the lift force, F_L , created by alternate vortex shedding on the back surface of the immersed tube is given by Equation 3.

$$F_L = \frac{C_L \rho V^2 A}{2}$$ *Equation 3*

The coefficients for lift and drag, C_D and C_L, are based on the Reynolds number which can be calculated using Equation 4.

Reynolds Number, $$R = \rho \frac{D V}{\mu}$$ *Equation 4*

NOTE:
These equations are provided as a guide only and do not constitute a warranty, expressed or implied, for the fitness of an Ethylarmor® Dip Tube in specific service

C_D can be gotten from Figure 1 shown below.

C_L is as follows:	when:
$C_L = 0.8$	**$(R < 10^5)$**
$C_L = 2.4 - 0.4\log_{10}R$	**$(10^5 \le R \le 10^6)$**
$C_L = 0.4$	**$(R > 10^6)$**

Figure 1: Factor C_L

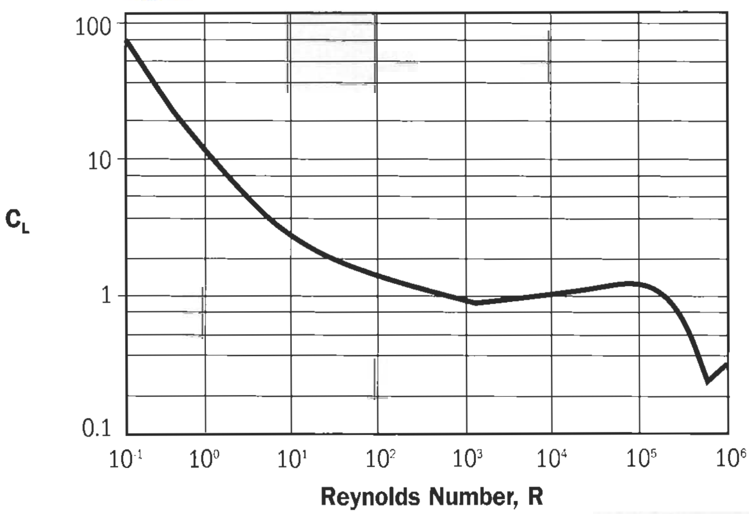


Table 7: Factors W_D, H and D

Nominal Size	W_D	H	D
¾	1,877	11.75	0.101
1	3,533	18.79	0.123
1½	9,064	41.62	0.179
2	16,080	66.79	0.219
3	48,970	147.02	0.312
4	93,940	247.88	0.401
6	187,000	573.19	0.583
8	369,820	981.23	0.760

Equation 1 can be rewritten as:

$$F_T = \frac{\rho V^2 A\sqrt{C_D^2 + C_L^2}}{2} \qquad \textit{Equation 5}$$

The value obtained by Equation 5 must be less than or equal to the maximum allowable load recommended by Ethylene Corporation for the selected unit. The maximum load, Sm, for a dip tube or sparger is given by Equation 6:

$$Sm = \frac{W_D}{12(L - 0.5\phi)} \qquad \textit{Equation 6}$$

where W_D if the factor given in Table 7

If $F_T \leq Sm$, the unit is sufficiently strong for the intended service. However, a check for resonance should be made.

If the natural frequency of the dip tube is too close to the wake frequency, resonance can occur in the dip tube causing stresses much greater than expected. The natural and wake frequency must be calculated and the ratio of these frequencies must be greater than $\sqrt{2}$ or less than 0.5.

The natural frequency of the dip tube can be calculated using Equation 7 where the value of factor H is taken from Table 7.

$$Wn = 135\sqrt{H/L^4} \qquad \textit{Equation 7}$$

The wake frequency, W, is calculated using Equation 8.

$$W = 0.22\frac{V}{D} \qquad \textit{Equation 8}$$

The ratio W/Wn should be less than 0.5 or greater than $\sqrt{2}$

Example 1: Dip Tube is Adequate

V, fluid velocity	=	15 (ft/sec)
Dip tube size	=	3" or 0.312 (ft) from Table 7
L, entry length	=	80" or 6.67 (ft)
φ, immersed length	=	65" or 5.52 (ft)
μ, dynamic viscosity	=	1.10 centipoise or 2.298×10^5 sec/ft²
ρ, fluid mass density	=	2.10 slugs/ft³

Step 1:

Determine Reynolds number,

$R = (2.10 \cdot 0.312 \cdot 15)/2.298 \times 10^5 = 4.277 \times 10^5$

Step 2:

Determine C_D and C_L

$C_D = 0.90$ (Fig.1), $C_L = 2.4 - \log_{10}(4.277 \times 10^5) = 0.148$

Step 3:

Calculate Force F_T using Equation 5,

$F_T = 0.5 \cdot 2.10 \cdot 15^2 \cdot (.312 \cdot 5.42) \times \sqrt{0.9^2 \cdot 0.148^2}$
$= 364$ lbs

Step 4:

Calculate allowable force, Sm using Equation 6,

$Sm = 48{,}970/(12 \cdot (6.67 - 0.5 \cdot 5.41))$
$= 1{,}030$ lbs

Since 364 < 1,030 a 3" dip tube would be adequate for this application.

Step 5:

Determine the natural frequency, Wn, of the dip tube from Equation 7,

$Wn = 135\sqrt{147.024/6.67^4} = 36.8$ Hz

Step 6:

Determine wake frequency, W, using Equation 8,

$WD = 0.22 \cdot 15 / 0.312 = 10.6$ Hz

Step 7:

Test ratio of W/ Wn = 10.6 / 36.8 = 0.29

Since 0.29 < 0.5, the dip tube passes the test

Example 2: Dip Tube is Inadequate

V, fluid velocity	=	15 (ft/sec)
Dip tube size	=	1½" or 0.179 (ft) from Table 7
L, entry length	=	80" or 6.67 (ft)
φ, immersed length	=	65" or 5.42 (ft)
μ, dynamic viscosity	=	1.10 centipoise or 2.298×10^5 sec/ft²
ρ, fluid mass density	=	2.10 slugs/ft³

Step 1:

Determine Reynolds number,

$R = (2.10 \cdot 0.179 \cdot 15)/2.298 \times 10^5 = 2.454 \times 10^5$

Step 2:

Determine C_D and C_L

$C_D = 0.90$ (Fig.1), $C_L = 2.4 - \log_{10}(2.454 \times 10^5) = 0.244$

Step 3:

Calculate force F_T using Equation 5,

$F_T = 0.5 \cdot 2.10 \cdot 15^2 \cdot (.179 \cdot 5.42) \times \sqrt{0.9^2 \cdot 0.244^2}$
$= 214$ lbs

Step 4:

Calculate allowable force, Sm using Equation 6,

$Sm = 9064/(12 \cdot (6.67 - 0.5 \cdot 5.41))$
$= 191$ lbs

Since 214 < 191 a 1½" dip tube would NOT be suitable for this application.

Step 5:

Determine the natural frequency, Wn, of the dip tube from Equation 7,

$Wn = 135\sqrt{41.62/6.67^4} = 24.8$ Hz

Step 6:

Determine wake frequency, W, using Equation 8,

$WD = 0.22 \cdot 15 / 0.179 = 15.1$ Hz

Step 7:

Test ratio of W/ Wn = 15.1 / 24.8 = 0.61

Since 0.5 < 0.61 < $\sqrt{2}$, the dip tube fails the test

pHampler®

Ethylene's pHampler Dip Tube is useful for gaining multiple entry into vessels through a single nozzle. This is extremely valuable in maximization of vessel nozzles and simplification of piping for external pump around sampling loops (see Fig. 1). The inner, PTFE lined tubes of the pHampler dip tube are integrated into the outer PTFE encapsulation. The dip tube's steel reinforcement gives it significant rigidity; enough to allow for use in agitated services. Available in sizes from 2" to 6". Table 9 gives dimensional information for standard pHampler dip tubes. As usual, contact Ethylene Corporation with your special requirements.

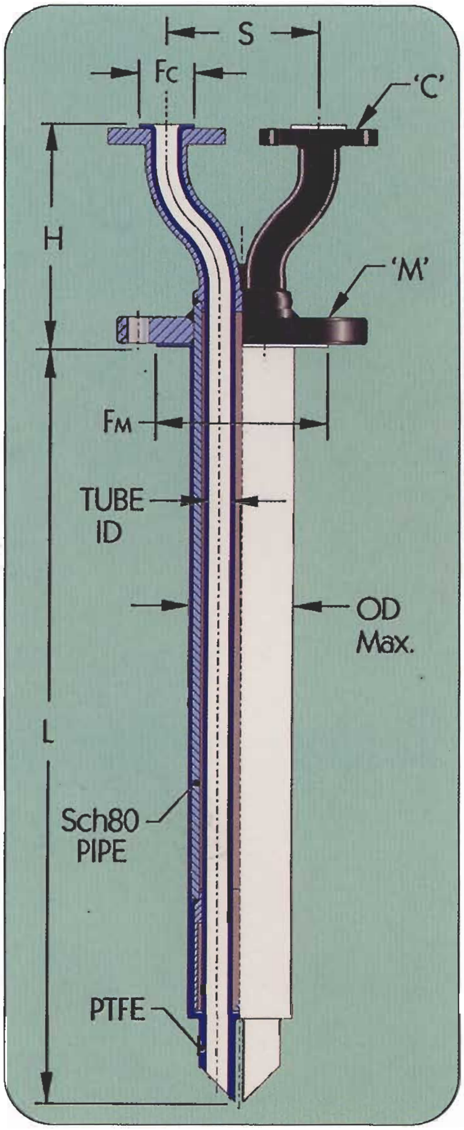


Table 9: Ethylarmor pHampler Dip Tube Information

Nominal Size	PTFE Wall	Connecting Flange 'C'	Mounting Flange 'M'	PTFE Flare F_C	PTFE Flare F_M	S	Max. OD	Max. L	Dim. H
2	.125	1	3	2	5	5½	2 13/16	20'-0"	8"
3	.125	1	4	2	6 3/16	5½	3 15/16	15'-0"	8"
4	.150	1	6	2	8½	5½	4 15/16	15'-0"	8½"
6	.150	2	8	3⅝	10⅝	7½	7 1/16	10'-0"	12"

Custom Designed and Fabricated Sampling Loops

Ethylene Corporation can design and fabricate piping loops to work in conjunction with the Phampler dip tube. Loops can be designed for inline sampling, analytical measurement or virtually any other need. All loop piping is lined with PTFE, PFA or ETFE. Contact the Ethylene Sales force for additional information or technical assistance.

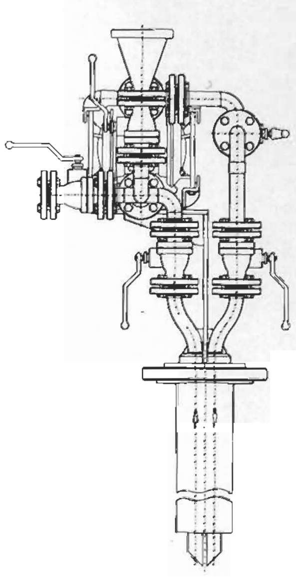


Figure 1: Circulation type sampling loop built on a 4" pHampler dip tube.

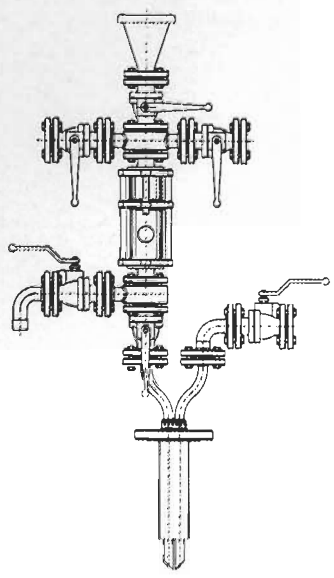


Figure 2: Vacuum sampling system on a 2" pHampler dip tube.

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