PENBERTHY SERIES CTE AND TME FOR IN-TANK MIXING

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Low-cost alternatives to mechanical mixing methods which provide a more thorough mixing action than either mechanical mixing or air sparging

MODEL CTE

MODEL TME

FEATURES

- Simple design with no moving parts to wear out.
- Enable the use of a smaller recirculating/ transfer pump.
- Inherently non-clogging.
- No lubrication required.
- Virtually maintenance-free.
- Easy to install without special structures or foundations.
- Cast, fabricated or non-metallic constructions.
- Variety of materials to suit specific characteristics of the process liquids.

GENERAL APPLICATION

Applications include hazardous waste and waste water processing, cooling tower circulation, tank truck agitation, additive infusion, blended solution agitation, plating tank agitation and separation prevention of non-mixable liquids or stratification of dissimilar liquids.

TECHNICAL DATA

CTE:	Low lead bronze, iron, carbon steel, 316 SS, PVC, PP, PVDF
TME:	25% glass-filled PP
Sizes:	⅜" to 8"
Pressure:	10 - 100 psig (.7 to 6.9 barg)
Temperature (max):	to 220°F (104°C)

PRODUCT OVERVIEW

Penberthy Circulating Tank Eductors (CTE) and Tank Mixing Eductors (TME) provide an effective way to mix, improve the agitation and circulation of liquids or slurries in open or closed tanks. They produce an intimate mixing action between the components of a liquid, while keeping the contents of the tank in constant motion. In many cases, they produce a mixing action that cannot be duplicated using mechanical methods.

The CTE is available in a broad range of materials and in eight model sizes.
The TME is available in a glass-filled polypropylene construction and in five size options.

TABLE 1 - MODEL CONSTRUCTION DATA

Model	CTE	Standard materials	TME	Standard materials
Sizes available	⅜"-4"	Cast: Low lead bronze, iron, carbon steel, 316 STS	⅜", ½", ¾", 1", 1½"	Non-metallic: 25% glass-filled PP
	4" and up	Fabricated: Carbon steel, 316 STS		
	⅜"-3"	Non-metallic: PVC, PP PVDF (Kynar®)		

NOTE
Kynar® is a registered trademark of Arkema Inc.

TABLE 2 - MODEL SPECIFICATIONS

Model	CTE - Circulating Tank Eductor	TME - Tank Mixing Eductor
Pressure differential of inlet to tank pressure	10-100 psig (70-690 kPag)	10-50 psig (70-345 kPag)
Mixing ratio	3:1	4:1
Max. operating liquid viscosity	up to 2,000 cPs	up to 2,000 cPs

OPERATION

A predetermined amount of liquid (called operating fluid) is pumped through a header to one or more CTEs/TMEs submerged inside the tank. Depending on the application, the operating fluid can be liquid drawn from the tank or it can be a secondary liquid from another source that is to be mixed with the tank contents. As the operating fluid leaves the nozzle of the CTE/TME, it entrains material from the tank. The operating fluid and entrained material are mixed thoroughly inside the parallel section of the CTE/TME before being discharged. The discharge flow, or plume, continues the mixing, agitation and circulation of the liquid throughout the tank.

MODEL CTE

CTEs can handle a variety of viscosities and types of liquid, including slurries and suspensions. Their thorough mixing action makes them especially useful for maintaining uniform liquid characteristics such as temperature, pH or solids distribution throughout the tank contents.
The CTE is also used to prevent separation of non-mixable liquids or stratification of liquids having different specific gravities.
They allow the use of a smaller recirculating pump than normally would be needed to move a given volume of liquid. This saves energy while providing more effective mixing and circulation.
They are available in materials to suit a variety of applications in food, chemical, refining and other process industries.

DESIGN CONSIDERATIONS

Turnover rate

The rate at which fluid in the tank must be turned over completely will determine the overall capacity of the CTEs needed. When the inlet pressure supplied to the CTE is within a range of 20 to 71 psi (138 to 483 kPa), three gallons of tank contents can be mixed for every gallon of operating fluid passing through the CTE. That is, the volume of fluid discharged from the CTE will be four times greater than the volume of operating fluid entering the CTE inlet.
The ratio of tank contents that can be mixed for each gallon of operating fluid will be approximately 2.6:1 for pressures outside the 20 to 71 psi (138 to 483 kPa) range, listed in Table 3.

Fluid viscosity

In fluids such as water or mineral oil (Newtonian fluids), the length of the CTE discharge plume increases proportionally with increased operating fluid pressure. Flow will be evident one foot away from the CTE discharge for every 1 psi of pressure drop across the nozzle (or one meter away for every 23 kPa pressure drop).

l in feet = ΔP in psi

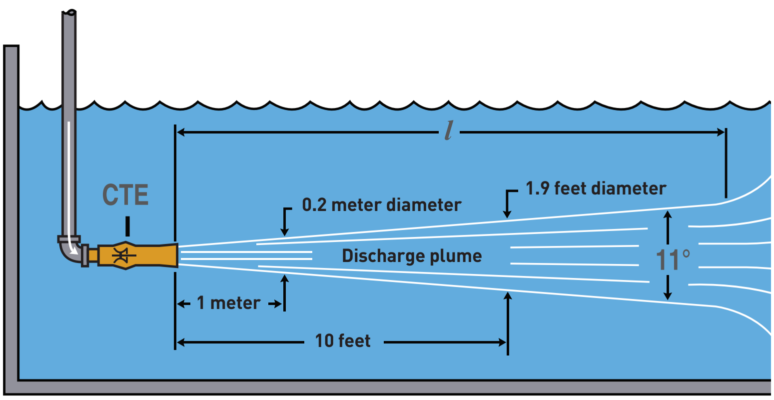
$$l \text{ in meters} = \frac{\Delta P \text{ in kPa}}{23}$$

where
l is length of discharge plume
ΔP is pressure drop across the CTE nozzle

An approximation of the discharge plume length can be obtained by substituting operating fluid pressure for ΔP in the relationships above.

In dilatent fluids, the length of the discharge plume decreases as the operating fluid pressure is increased. In thixotropic fluids, very little flow will be evident at the CTE discharge until the operating fluid pressure is increased beyond a critical value, after which flow increases rapidly.
If necessary, contact the factory for assistance when dealing with such fluids.

DISCHARGE PLUME



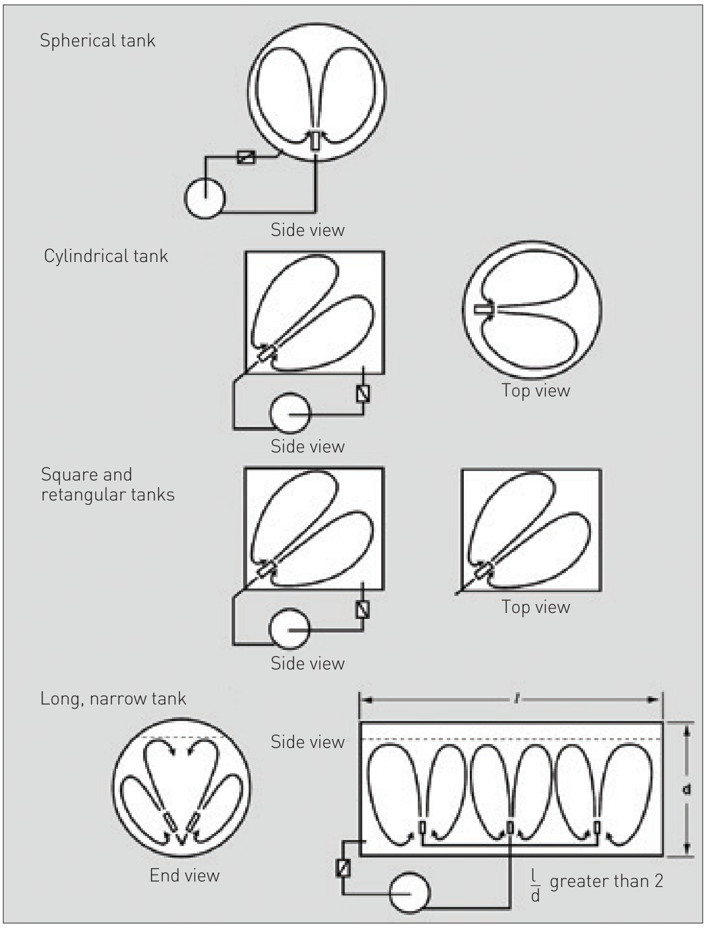
Tank shape and size
Tank shape and size influence the placement and number of CTEs required to assure even agitation of the entire volume of fluid. A spherical tank with a single CTE mounted as shown below makes the best use of the mixing and flow characteristics of the CTE. With no corners to impede fluid flow, the fluid circulates evenly and naturally. A single CTE will often be sufficient to circulate the entire tank contents.

The angular intersection of surfaces in cylindrical, square or rectangular tanks can interrupt fluid flow patterns and cause fluid stagnation in these areas. A single CTE mounted as shown will tend to minimize this effect. However, multiple CTEs can often produce more efficient mixing when using these tank shapes.

Long, narrow tanks such as tank trucks or railroad cars normally require multiple CTEs when their ratio of length to diameter is greater than 2:1. This applies to horizontal or vertical tanks and for any shape of tank cross-section.

Larger tanks of any shape may require multiple CTEs to maintain agitation in all parts of the tank.

PLAN AND ELEVATION VIEWS OF SPHERICAL, CYLINDRICAL AND SQUARE TANKS



SELECTION

Select the capacity of the CTE in Table 3 based on the turnover rate required. The total volume of liquid mixed per minute will be approximately four times the capacity of the CTE shown in the table.

One CTE handling the entire capacity can be used or the total capacity can be divided among several CTEs, as appropriate.

Example
Capacity required: 1200 gpm (4.54 m^3/min) operating fluid flow

Use one CTE 6 at 40 psi (276 kPa) or
Use six CTE 3 at 30 psi (207 kPa) or
Use six CTE 2 at 100 psi (689 kPa) (yields longer plume)

The use of multiple CTEs should be considered when one or more of the following conditions is present:
- Dilatent fluids are involved and operating fluid pressure exceeds 50 psi (345 kPa).
- The tank sides meet at 90° or less.
- The tank is large and the required length of discharge plume exceeds the capacity of the CTEs available.
- A long, narrow tank has a length to diameter ratio greater than 2:1.

TABLE 3 - CAPACITIES OF CIRCULATING TANK EDUCTORS

	Operating fluid flow, gpm (m³/min)									
	Pressure differential - inlet to tank pressure, psi (kPa)									
Size	10 (69)	20 (138)	30 (207)	40 (275)	50 (345)	60 (414)	70 (483)	80 (552)	90 (621)	100 (689)
⅜	7 (.027)	11 (.042)	13 (.049)	15 (.057)	16 (.061)	18 (.068)	20 (.076)	21 (.079)	22 (.083)	23 (.087)
½	11 (.042)	15 (.057)	19 (.072)	22 (.083)	24 (.091)	27 (.10)	29 (.11)	31 (.12)	33 (.12)	34 (.13)
¾	15 (.057)	22 (.083)	27 (.10)	31 (.12)	35 (.13)	38 (.14)	41 (.16)	44 (.17)	47 (.18)	50 (.19)
1	23 (.087)	32 (.12)	40 (.15)	46 (.17)	51 (.19)	56 (.21)	61 (.23)	65 (.25)	69 (.26)	72 (.27)
1½	32 (.12)	45 (.17)	55 (.21)	64 (.24)	71 (.27)	78 (.30)	84 (.32)	90 (.34)	95 (.36)	100 (.39)
2	62 (.23)	87 (.33)	105 (.40)	120 (.45)	140 (.53)	150 (.57)	160 (.61)	175 (.66)	185 (.70)	200 (.76)
3	150 (.57)	210 (.79)	255 (.97)	290 (1.10)	330 (1.25)	360 (1.36)	390 (1.45)	415 (1.57)	440 (1.67)	460 (1.74)
4	251 (.95)	355 (1.24)	435 (1.65)	502 (1.90)	561 (2.12)	615 (2.33)	664 (2.51)	710 (2.69)	753 (2.85)	794 (3.01)
6	601 (2.27)	850 (3.22)	1041 (3.94)	1202 (4.55)	1345 (5.09)	1473 (5.58)	1591 (6.02)	1700 (6.43)	1803 (6.82)	1901 (7.20)
8	1005 (3.50)	1422 (5.38)	1742 (6.59)	2011 (7.61)	2249 (8.51)	2463 (9.32)	2660 (10.07)	2844 (10.76)	3016 (11.42)	3180 (12.04)

MODEL TME

Penberthy Tank Mixing Eductors (TME) offer an inexpensive yet highly effective way to improve the circulation and agitation of liquids in tanks. In agrochemical storage tanks, often the TME can be used effectively utilizing the existing transfer pump. No additional motors or gear boxes are necessary. In all cases, the TME's 'multiplying effect' on fluid flow allows the use of a much smaller pump with greatly improved agitation and circulation in the tank. These benefits, together with durable, lightweight and abrasion/corrosion-resistant glass-filled polypropylene construction make the TME ideal for two applications in particular:

1. Electrocoat and pre-treatment tanks, to eliminate setting, improve surface preparation with enhanced flow over metal and to suspend sludge for better filtration. The TME provides the low electrical conductivity and smooth flow characteristics long sought by E-coat operators.

2. Agricultural fertilizer and agrochemical tanks, to agitate the solutions thoroughly and maintain uniform liquid characteristics throughout the tank. The TME offers users a lightweight, low-maintenance and inexpensive alternative to mechanical methods.

TABLE 4 - TME NOMINAL CAPABILITIES - DIFFERENTIAL PRESSURE

	gpm (m³/hour)									
	⅜"		½"		¾"		1"		1½"	
psid* (kPad)	**Motive**	**Discharge**	**Motive**	**Discharge**	**Motive**	**Discharge**	**Motive**	**Discharge**	**Motive**	**Discharge**
10 (68.93)	7.3 (1.67)	36.5 (8.35)	10.7 (2.43)	53.5 (12.15)	13.7 (3.12)	69 (15.60)	24.4 (5.54)	122 (27.71)	34 (7.74)	170 (38.70)
15 (103.39)	9.0 (2.04)	45.0 (10.20)	13.1 (2.98)	65.5 (14.88)	16.8 (3.82)	84 (19.10)	29.9 (6.79)	149.5 (33.96)	42 (9.48)	210 (47.40)
20 (137.86)	10.4 (2.36)	52.0 (11.75)	15.2 (3.45)	76 (17.26)	19.4 (4.41)	97 (22.05)	34.5 (7.84)	172.5 (39.18)	48 (10.95)	240 (54.75)
25 (172.32)	11.6 (2.63)	58.0 (13.15)	17 (3.86)	85 (19.30)	21.7 (4.93)	109 (24.65)	38.5 (8.74)	192.5 (43.72)	54 (12.25)	270 (61.25)
30 (206.79)	12.7 (2.89)	63.5 (14.45)	18.5 (4.20)	92.5 (21.01)	23.8 (5.40)	119 (27.00)	42.2 (9.58)	211 (47.92)	59 (13.41)	295 (67.05)
35 (241.25)	13.7 (3.12)	68.5 (15.60)	20.1 (4.57)	100.5 (22.83)	26.7 (6.06)	133 (30.30)	45.6 (10.36)	228 (51.78)	64 (14.49)	320 (72.45)
40 (275.71)	14.7 (3.33)	73.5 (16.65)	21.5 (4.88)	107.5 (24.42)	27.5 (6.23)	137 (31.15)	48.8 (11.08)	244 (55.42)	68 (15.49)	340 (77.45)
45 (310.18)	15.6 (3.54)	78.0 (17.70)	22.7 (5.16)	113.5 (25.78)	29.1 (6.61)	146 (33.05)	51.7 (11.74)	258.5 (58.71)	72 (16.43)	360 (82.15)
50 (344.64)	16.4 (3.73)	82.0 (18.65)	24 (5.45)	120 (27.25)	30.7 (6.97)	153 (34.85)	54.5 (12.38)	272.5 (61.89)	76 (17.32)	380 (86.60)

* Differential pressure - TME inlet psi less tank psi

AGITATION APPLICATION CONSIDERATIONS

Turnover rate

The desired turnover rate determines the motive flow rate required. Turnover rate as it applies to the TME is the time necessary to move the entire tank contents one time. For example, in a 60,000 gallon tank with a required turnover rate of once per hour, it would be necessary to move 1,000 gallons per minute. Each TME can mix four gallons of tank contents for every motive gallon passing through the TME, so the volume of fluid discharged is four times greater than the volume of motive fluid entering the TME inlet. Thus, the amount of motive fluid required for the 60,000 gallon tank would only be 200 gallons per minute to achieve the desired turnover rate. Refer to Table 4 to match the TME sizes and capacities with the application.

Tank contents

Contents influence the TME application as follows:

TABLE 5 - TME APPLICATION BY CONTENTS

Contents	Desired results	No. of TMEs required
Only liquids	Effectively agitate and achieve homogenity	Usually requires only one TME
Suspended solids	Maintain suspension	Usually requires only one TME
	Sweep solids off bottom	Multiple TMEs

Discharge plume

Significant agitation occurs in the plume exiting the TME. The plume is cone-shaped from the TME discharge diverging at an 11° angle. Plume length varies with differential pressure (ΔP) across the TME. The plume length needed to achieve effective agitation can be calculated as follows:

TABLE 6 - CALCULATING PLUME LENGTH

	Multiply ΔP	
Tank contents	in psi by	in $\frac{kPa}{23}$ by
Containing only liquids	1 ft.	1 meter
To maintain solids in suspension	1 ft.	1 meter
To sweep solids off the tank bottom	½ ft.	½ meter

Plume positioning

To agitate with liquid(s) only or liquids with solids in suspension, the plume is directed from the bottom of one side of the tank toward the highest likely liquid level on the farthest point from the TME. The ΔP should be sufficient to create a plume that reaches that point.
To sweep solids from the tank bottom, the plume is directed to contact every point on the tank bottom with particular attention paid to the angular intersections where the tank bottom and sides are joined.

MODEL CTE

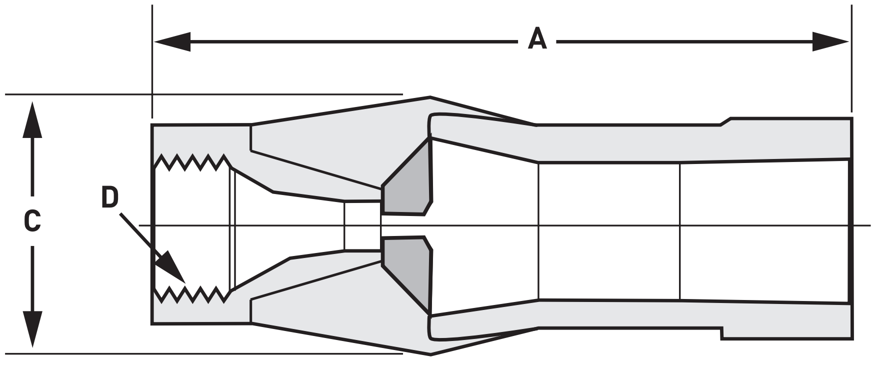


TABLE 7 - CTE DIMENSIONS IN INCHES (mm)

Size	A	C	D
3⁄8	4½ (114.3)	1¾ (44.5)	3⁄8 *
½	5 (127)	2 (50.8)	½ *
¾	6 (152.4)	2¼ (57.2)	¾ *
1	6½ (165.1)	2¾ (69.8)	1 *
1½	7¼ (184.2)	3 (76.2)	1½ **
2	11¼ (285.8)	4¼ (108.0)	2 **
3	19⅜ (492.3)	6½ (165.1)	3 **
4	34 (863.6)	8⅜ (212.9)	4 ❖
6	52 (1320.8)	12⅝ (320.8)	6 ❖
8	68 (1727.2)	16⅜ (416.0)	8 ❖

* NPT male
** NPT female
❖ 150 lb RF flange

TABLE 8 - MAX. PARTICLE CLEARANCE IN INCHES

Size	Max. particle clearance
3⁄8	3⁄8
½	½
¾	½
1	¾
1½	⅞
2	1⅛
3	1¾
4	2⅞
6	4½
8	5⅞

MODEL TME

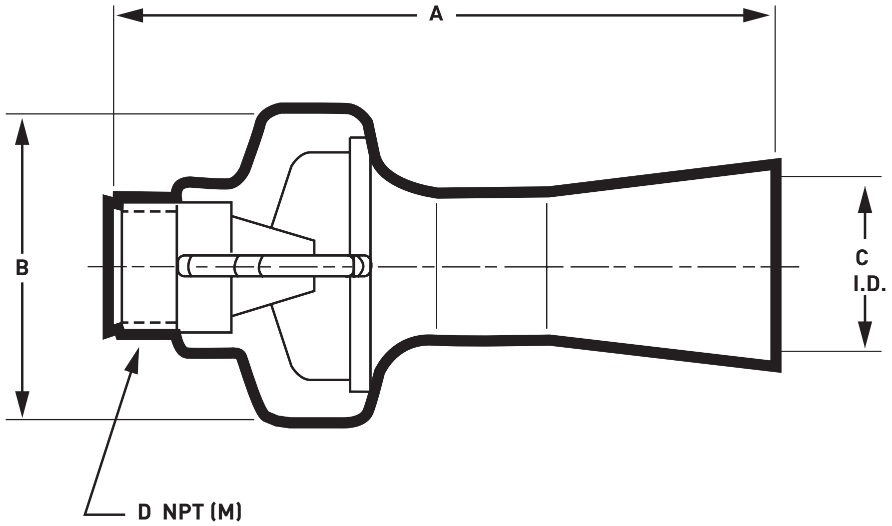


TABLE 9 - TME DIMENSIONS IN INCHES (mm)

Size	A	B	C	D
⅜	4½ (114.30)	2⅛ (53.98)	1¼ (31.75)	⅜ (9.52)
½	6 9/16 (166.69)	2½ (63.50)	1 7/16 (36.51)	½ (12.70)
¾	6⅜ (161.90)	2⅞ (73.02)	1⅝ (41.28)	¾ (19.05)
1	9 11/16 (246.06)	3⅞ (98.42)	2 3/16 (55.56)	1 (25.40)
1½	9¾ (247.60)	4½ (114.30)	2 9/16 (65.09)	1½ (38.10)

SELECTION GUIDE

To determine the correct in-tank mixer for a specific application, make note of the required specification data listed below. Consult the tables within this datasheet, then contact your sales representative who will be able to help select the optimum in-tank mixer based on the data you provide.

Motive
- Operating liquid(s) involved
- Pressure (available)
- Flow rate (volume available)
- Temperature
- Specific gravity/viscosity

Tank
- Tank size (dimensions)
- Tank shape
- Maximum volume (total amount to be mixed)

Time
- Time required to achieve uniformity (Turnover rate)

Other
- Solids that are involved for suspension

SELECTION GUIDE - MODEL CTE

Example:		CTE	03	CS	C	NT	- 01
Model							
CTE	Model CTE						
Jet size							
03	⅜"						
04	½"						
06	¾"						
08	1"						
12	1½"						
16	2"						
24	3"						
32	4"						
48	6"						
64	8"						
Material of construction							
CS	Carbon steel						
IR	Cast iron (⅜" - 3" only)						
SS	316 SST						
HC	Hastelloy C (⅜" - 4" only)						
MO	Monel (⅜" - 4" only)						
BZ	Bronze (⅜" - 3" only)						
PP	PPL (⅜",¾",1½" only)						
PV	PVC (⅜" - 3" only)						
KY	Kynar (⅜" - 4" only)						
Style of construction							
C	Metal cast						
F	Metal fabricated (4" - 8" CTE) (flanged only)						
B	Metal or polymer barstock						
M	Polymer molded						
Inlet connection style							
NT	NPT						
RS	Raised face slip on #150 flange						
Variation							
01	Catalog standard						

SELECTION GUIDE - MODEL TME

Example:	TME	03	P	NT	- 01
Model					
TME Model TME					
Eductor size					
03 ⅜"					
04 ½"					
06 ¾"					
08 1"					
12 1½"					
Material of construction					
P Glass-filled polypropylene					
Connection style					
NT NPT					
Variation					
01 Catalog standard					