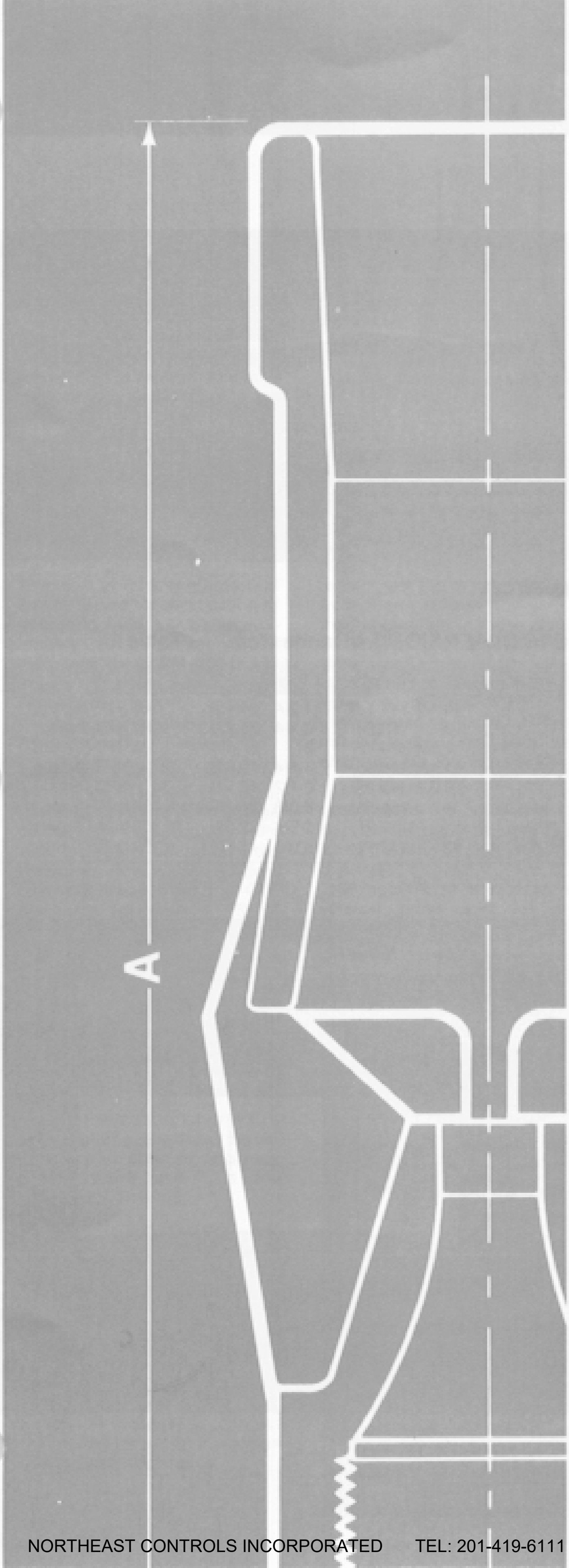
Section 1000
Bulletin 1401
Issued 9/87
Replaces 10/77



PENBERTHY

JET PUMP TECHNICAL DATA

mixing liquids

This technical bulletin includes general information about Penberthy Circulating Tank Eductors with specific details for selecting the proper unit. The Penberthy CTEs covered in this bulletin are used for mixing a variety of liquids in open or enclosed tanks.

introduction and operation

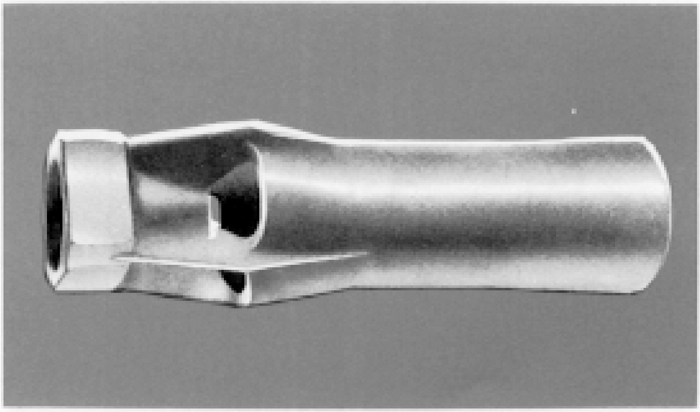
The advantages of using CTEs for mixing

Penberthy Circulating Tank Eductors (CTE) provide an effective way to mix liquids in open or enclosed 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. CTEs can handle a variety of viscosities and types of liquids, including slurries and suspensions. Their thorough mixing action makes them especially useful for maintaining uniform liquid characteristics throughout the tank contents, such as temperature, pH, or solids distribution. The CTE is also used to prevent separation of nonmixable liquids or stratification of liquids having different specific gravities.

Penberthy CTEs offer low initial cost, light weight and easy installation. They are inherently nonclogging and with no moving parts, require little or no maintenance. Penberthy CTEs 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.

How CTEs work

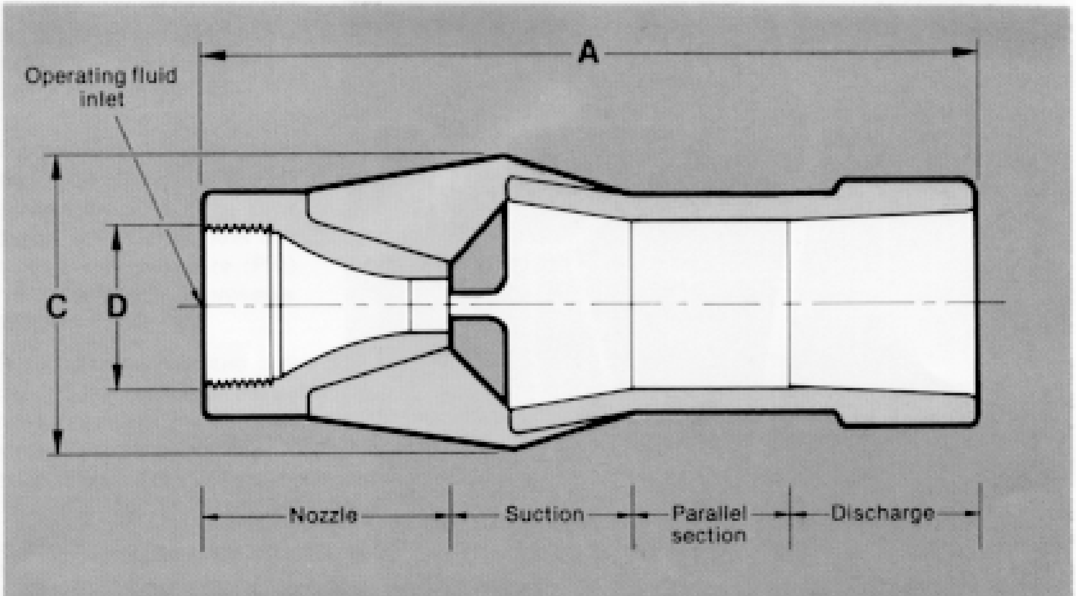
A predetermined amount of liquid (called operating fluid) is pumped through a header to one or more CTEs submerged inside the tank. Depending upon the application, the operating fluid can be liquid drawn from the tank, or it can be a second liquid from another source that is to be mixed with the tank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



Model CTE

CTE DIMENSIONS in inches *(cm)* **— Table 1**

SIZE	A	C	D
3/8	4 1/2 *(11.43)*	1 3/4 *(4.45)*	3/8 NPT male
3/4	6 *(15.24)*	2 1/4 *(5.72)*	3/4 NPT male
1 1/2	7 1/4 *(18.42)*	3 *(7.62)*	1 1/2 NPT female
2	11 1/4 *(28.58)*	4 1/4 *(10.80)*	2 NPT female
3	19 3/8 *(49.23)*	6 1/2 *(16.51)*	3 NPT female
4	34 *(86.36)*	8 3/8 *(21.29)*	4 150 lb RF flange
6	52 *(132.08)*	12 5/8 *(32.08)*	6 150 lb RF flange
8	68 *(172.72)*	16 3/8 *(41.60)*	8 150 lb RF flange



Cross section

design considerations

Turnover rate

The rate at which fluid in the tank must be completely turned over will determine the overall capacity of the CTEs needed. When the inlet pressure supplied to the CTE is within a range of 20 to 70 PSI (133 to 483 kPa), three gallons of tank contents can be mixed for avery 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 70 PSI (138 to 483 kPa) range, listed in the capacity chart on page 4.

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).

$$l_{\text{in feet}} = \Delta P_{\text{in PSI}}$$

$$l_{\text{in meters}} = \frac{\Delta P_{\text{in kPa}}}{23}$$

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 above relationships.

In some fluids (dilatent), the length of the discharge plume decreases as the operating fluid pressure is increased. In still other fluids (thixotropic), 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.

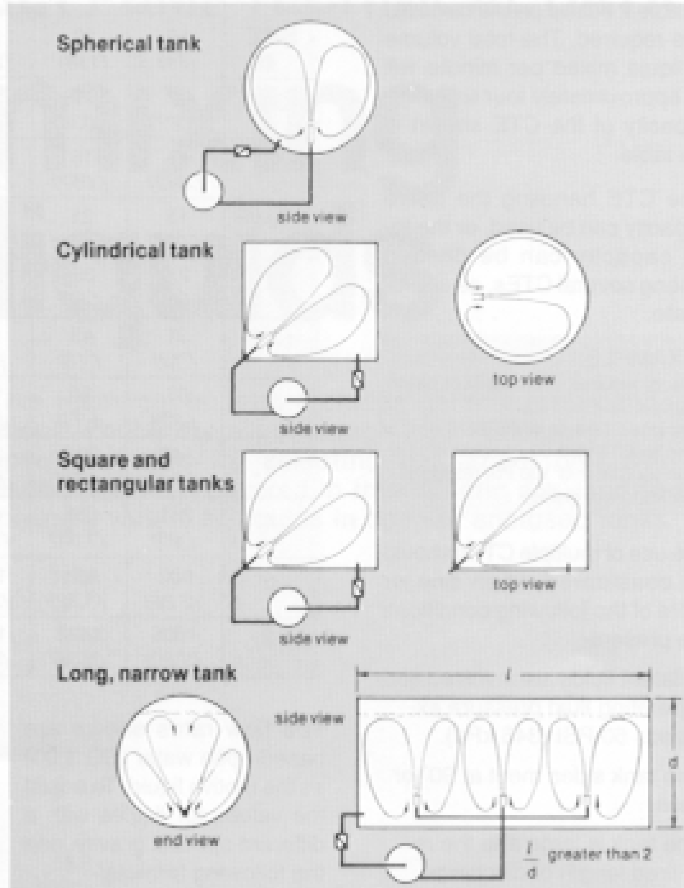
Tank shape and size

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 in the illustration 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.

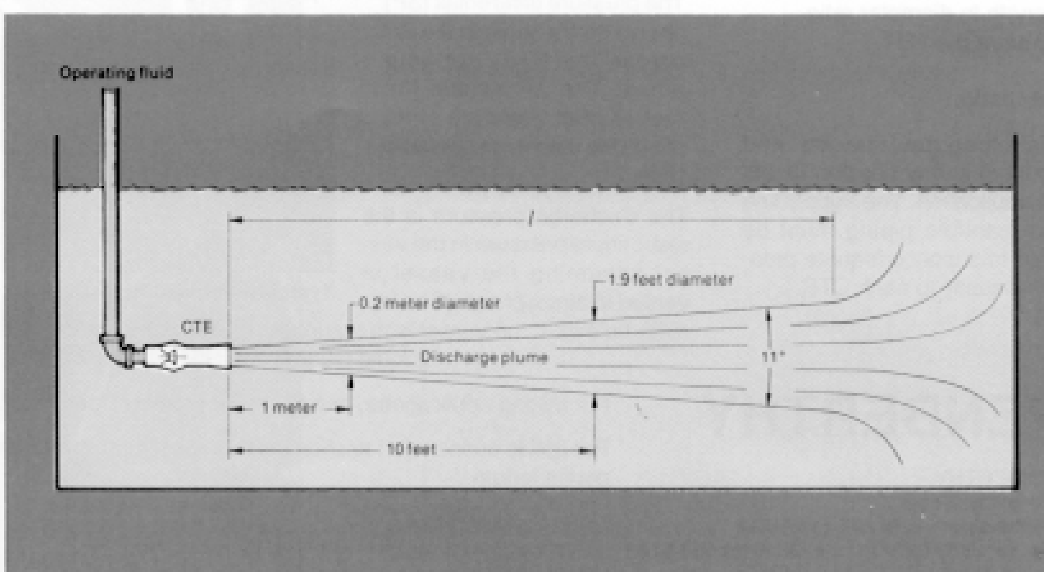
The angular intersection of surfaces in cylindrical, square or rectangular tanks can interrupt fluid flow patterns and cause fluid stagnation in these areas. A single CTE, mounted as shown in the illustration, will tend to minimize this effect. However, multiple CTEs can often produce more efficient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

Long, narrow tanks such as tank trucks or railroad cars, normally require multiple CTEs when the ratio of their 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



Discharge plume

selection and installation

CTE selection

Select the capacity of the CTE in table 2 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 @ 40 PSI (276 kPa) or
use six CTE 3 @ 30 PSI (207 kPa) or
use six CTE 2 @ 100 PSI (689 kPa) (yields longer plume)

The use of multiple CTEs should be considered when one or more of the following conditions are 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.

Installation

CTEs can be spaced and mounted in any position to suit the application. The supply line and manifold piping must be sized to supply adequate pressure equally to each CTE.

CTE CAPACITIES - Table 2

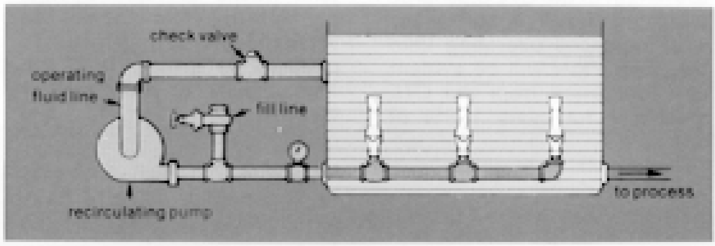
SIZE	OPERATING LIQUID FLOW - GPM (m3/min) — PRESSURE DIFFERENTIAL - PSI (kPa)									
	10 (69)	20 (138)	30 (207)	40 (276)	50 (345)	60 (414)	70 (483)	80 (552)	90 (621)	100 (689)
3/8	7 (.027)	10 (.038)	13 (.049)	14 (.053)	16 (.061)	18 (.068)	19 (.073)	20 (.069)	22 (.083)	23 (.087)
1/2	11 (.042)	15 (.057)	19 (.072)	22 (.083)	24 (.091)	27 (.10)	29 (.11)	31 (.12)	33 (.125)	34 (.13)
3/4	15 (.057)	21 (.079)	26 (.098)	30 (.11)	34 (.13)	37 (.14)	40 (.15)	43 (.16)	45 (.17)	48 (.18)
1	23 (.087)	32 (.12)	40 (.15)	46 (.17)	51 (.19)	56 (.21)	61 (.23)	65 (.25)	69 (.26)	72 (.27)
1-1/2	31 (.12)	43 (.16)	53 (.20)	61 (.23)	69 (.26)	75 (.28)	81 (.31)	87 (.33)	92 (.35)	97 (.37)
2	61 (.23)	86 (.33)	105 (.40)	121 (.46)	135 (.51)	148 (.56)	160 (.61)	171 (.65)	182 (.69)	192 (.73)
3	143 (.54)	203 (.77)	248 (.94)	286 (1.08)	320 (1.21)	351 (1.33)	379 (1.43)	405 (1.53)	430 (1.63)	453 (1.71)
4	251 (.95)	355 (1.34)	435 (1.65)	503 (1.90)	562 (2.13)	616 (2.33)	665 (2.52)	711 (2.69)	754 (2.85)	795 (3.01)
6	602 (2.28)	851 (3.22)	1042 (3.94)	1203 (4.55)	1345 (5.09)	1473 (5.58)	1591 (6.02)	1701 (6.44)	1805 (6.83)	1902 (7.20)
8	1005 (3.80)	1422 (5.38)	1741 (6.59)	2010 (7.61)	2248 (8.51)	2462 (9.32)	2660 (10.07)	2843 (10.76)	3016 (11.42)	3179 (12.04)

The flow rates shown are based upon water (SG 1.00) as the motive liquid. To adjust the values for liquids with a different specific gravity, use the following formula: $[\sqrt{(1 \div \text{SG of actual motive liquid})}] \times$ table value.

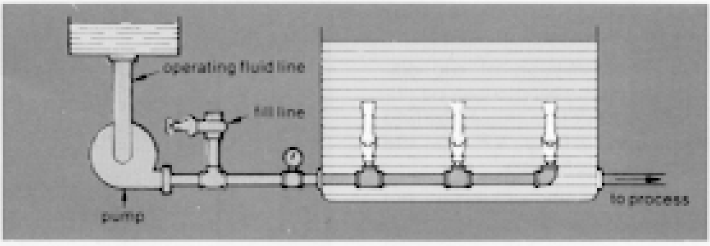
The pressure differential (ΔP) shown on the table is the ΔP across the CTE, not your pump. The ΔP equals the motive inlet pressure (Pm) minus the discharge pressure (Pd).

The discharge pressure is the static liquid pressure in the vessel assuming the vessel is vented to atmosphere. (See formula below). If the vessel is pressurized, the Pd is that value plus the static liquid pressure.

(Liquid height x specific gravity) x 0.43 = Pd



Typical multiple CTE installation for recirculating tank contents



Typical multiple CTE installation for mixing two liquids

For mixing applications, one psi of ΔP produces one foot of effective discharge plume length.

For solids suspension applications, one psi of ΔP produces six inches of effective discharge plume length.

PENBERTHY

PENBERTHY
320 Locust Street
Prophetstown, IL 61277-1147 USA
TEL: (815) 537-2311 FAX: (815) 537-5764

Printed in U.S.A.