Pi (π) Day with the American Institute of Chemical Engineers

Joseph Yurko

March 14, 2021

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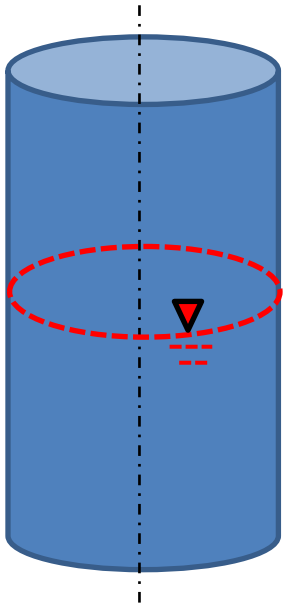
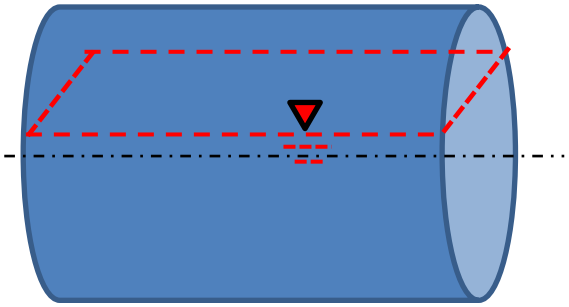
Pi Day with AIChE

Using Pi (π) to calculate the volumes of tanks that are either vertical or horizontal.



Vertical Tank



Horizontal Tank

Pi Day with AIChE

Beverage Production Facility: Where Pi is Applied

How Pi (π) is used in our Tank Volume Calculations:

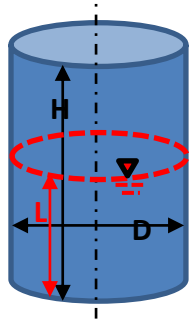
Find the tank volume:

1. Enter the tank diameter
2. Generate a liquid surface area
3. The tank diameter will tell you the floor area needed
4. Enter the tank height
5. Generate the tank volume
6. The tank height will tell you the ceiling height needed

Calculate the volume in a vertical tank knowing:

1. The tank height (H)
2. The tank diameter (D)
3. The partial liquid Level (L)

Vertical Tank Elevation



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Beverage Production Facility: Where Pi is Applied

How Pi (π) is used in our Tank Volume Calculations

Calculate the volume in a Vertical tank knowing:

1. The tank height (H)
2. The tank diameter (D)
3. The partial liquid Level (L)

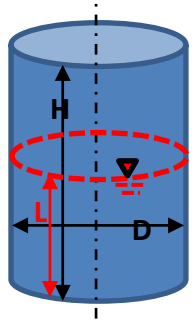
Liquid Surface Area:

As = π x R^2 = π x D^2 / 4

NOTE: Pi = π = 3.1416...

Vertical Tank			Units	INPUT	Units
Tank Height (H) =	(GIVEN)		Ft	10	Ft
Tank Diameter (D) =	(GIVEN)		Ft	5	Ft
Volume (V) =	$\frac{\pi D^2 H}{4}$	(FIND)	Cu Ft	196.4	Cu Ft
Level of Liquid (L) =	(GIVEN)		Ft	5	Ft
Volume Level (v) =	$\frac{\pi D^2 H}{4}$	(FIND)	Cu Ft	98.2	Cu Ft
Percent Full (%) =	V / v *100	(FIND)	%	50	%
Transfer Rate (t) =	Cu Ft / Minute	(FIND)	Cu Ft / Minute	3	Cu Ft / Minute
Fill Time (T) =	Volume / Transfer Rate	(FIND)	Minutes	32.7	Minutes

Vertical Tank Elevation



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Beverage Production Facility: Where Pi is Applied

How Pi (π) is used in our Tank Volume Calculations

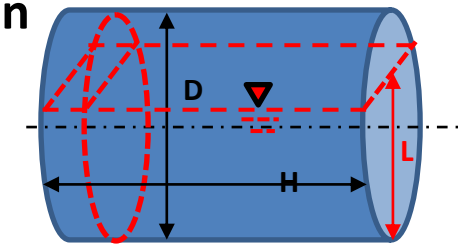
Given the tank volume needed:

1. Enter the tank diameter
2. Enter the tank height
3. The tank diameter and height will tell you the floor area needed
4. The tank diameter will tell you the ceiling height needed

Calculate the volume in a horizontal tank knowing:

1. The tank height (H)
2. The tank diameter (D)
3. The liquid Level (L)

Horizontal Tank Elevation



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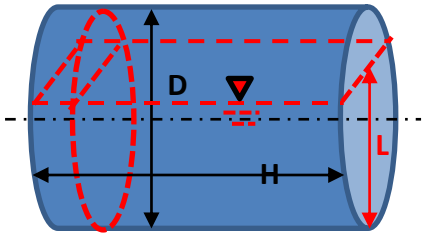
How Pi (π) is used in our Tank Volume Calculations

NOTE: Pi = π = 3.1416...

Calculate the volume in a Horizontal tank knowing:

1. The tank height (H)
2. The tank diameter (D)
3. The partial liquid Level (L)



Horizontal Tank Elevation

Determine the volume of a horizontal vessel given the diameter of the vessel and the liquid level inside the vessel

Solution Steps		Run #1	Run #2	Units
Enter Inside Tank Diameter:		5	2.5	= d
Calculate Tank Radius:		2.5	1.25	=r
Calculate r2:		0.5	0.25	= r2
Feet down from Tank Top to Liquid Surface =		2	1	Ft
Depth of Liquid from surface (D) =		3	1.5	Ft
Area - A	=	0.61	0.15	Sq. Ft.
Area - B	=	0.61	0.15	Sq. Ft.
COS Th	=	0.20	0.20	
Th	=	78.46	78.46	degrees
Al	=	11.54	11.54	degrees
Area - C	=	11.08	2.77	Sq. Ft.
Total Area (A + B + C) =		12.30	3.08	Sq. Ft.
Length (H) =		10.00	10.00	Ft.
Liquid Volume (Cu Ft) =		123.01	30.75	Cu Ft.
Liquid Volume (Gal) =		920.22	230.05	Gal
Transfer Rate (t) =	Cu Ft / Minute (FIND)	Cu Ft / Minute	3	3	Cu Ft / Minute
Fill Time (T) =	Volume / Transfer Rate (FIND)	Minutes	41.0	10.3	Minutes

HORIZONTAL VESSEL PARTIALLY FILLED WITH LIQUID

DETERMINE THE VOLUME OF THE LIQUID

FIND:
The volume in cubic feet of the Horizontal Vessel

RH = (cross sectional flow area) / (wetted perimeter)

COS (Th) = 4 / r= (D-r) / r

(A) = 90 - COS^-1)(COS (Th))

AREA C = pi * d^2 /4 *[(180-(2*A))/360]

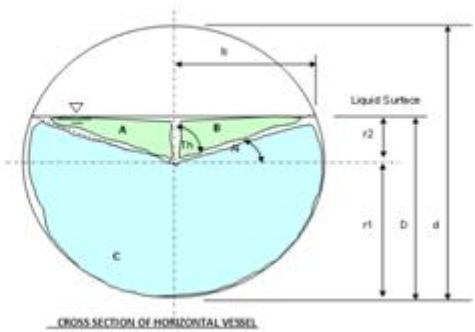
b = (r^2 - (D-r))^(-0.5)

AREA A = AREAB = 0.5 * ((D-r) * b)

Total Cross Sectional Area = A + B + C

d^2 = 4 * (Total Cross Sectional Area) / pi

Multiply the total cross sectional area by the length of the vessel



CROSS SECTION OF HORIZONTAL VESSEL

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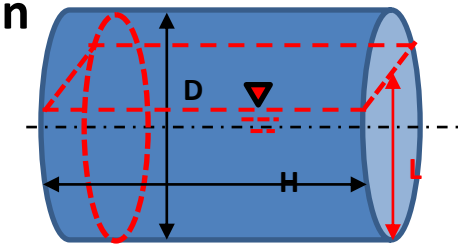
How Pi (π) is used in our Tank Volume Calculations

NOTE: Pi = π = 3.1416…

Horizontal Tank			INPUT	Units
Tank Height (H) =	(GIVEN)		10	Ft
Tank Diameter (D) =	(GIVEN)		5	Ft
Total Volume (V) =	$\frac{\pi d^2 h}{4}$	(FIND)	196.4	Cu Ft
Level of Liquid (L) =	(GIVEN)		3	Ft
Partial Volume (p) =	(below)	(FIND)	123.0	Cu Ft
Percent Full (%) =	V / v*10	(FIND)	62.6	%
Transfer Rate (t) =	Cu Ft / Minute	(FIND)	Cu Ft / Minute	3	Cu Ft / Minute
Fill Time (T) =	Volume / Transfer Rate	(FIND)	Minutes	41.0	Minutes

Horizontal Tank Elevation



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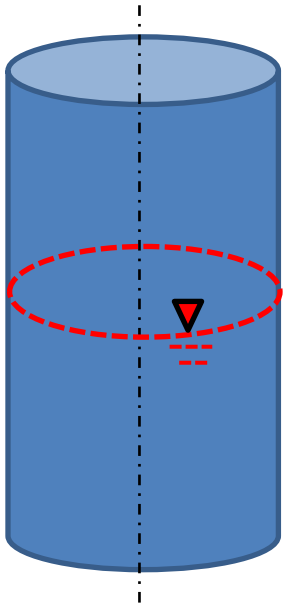
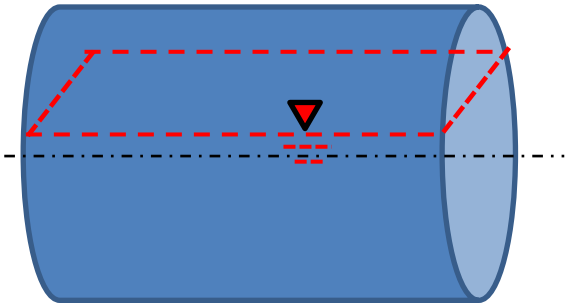
Using Pi (π) to calculate the volumes of tanks that are either vertical or horizontal.



Vertical Tank



Horizontal Tank

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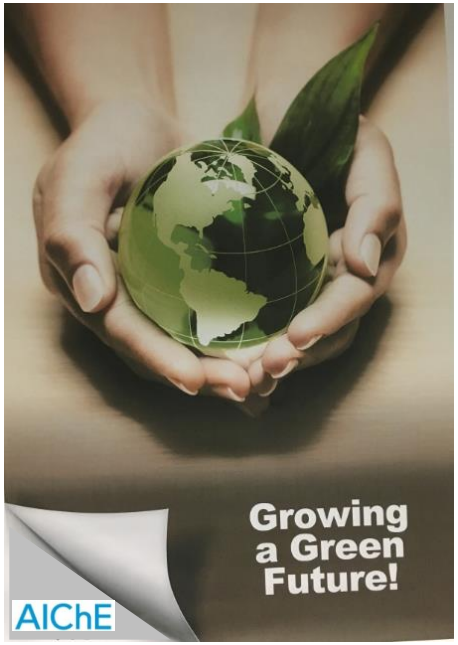
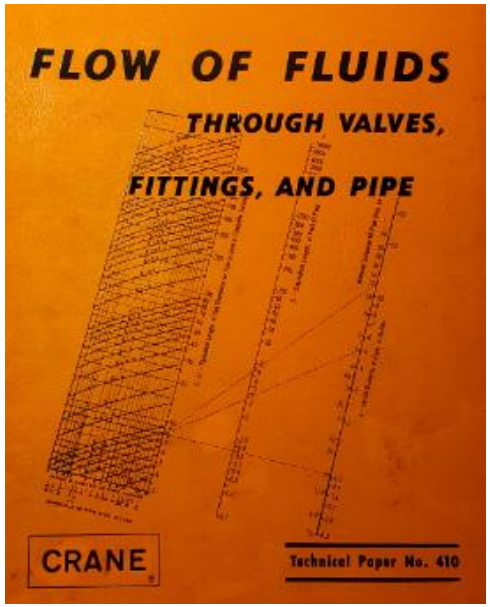
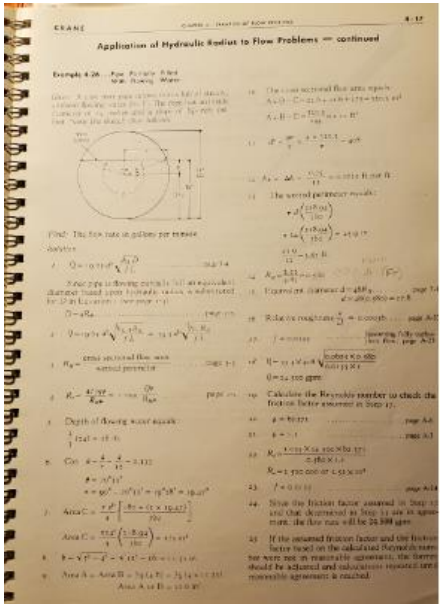


Reference:

Crane Technical Paper # 410, pg. 4-17





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Joseph Yurko, P.E. Background:

Process Consultant with JAY of Northeast Ohio, LLC

- Xellia Pharmaceuticals USA, LLC (Novo Nordisk S/A), Cleveland, Ohio
- Kraft-Heinz Company, Frozen Foods Division, Massilon, Ohio
- Ben Venue Laboratories, Inc. (Boehringer-Ingelheim GmbH), Cleveland, Ohio
- Morrison Knudsen Corporation, Cleveland, Ohio

Licensed Professional Engineer

Emeritus member and Fellow of AIChE

Member of ACS, NSPE, and ISPE

Cleveland State University, Fenn College of Engineering

- Bachelor of Chemical Engineering
- Bachelor of Engineering Science
    - Distinction in Bioengineering