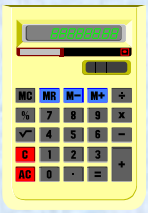
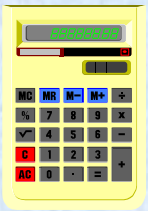
Clarifier Calculations

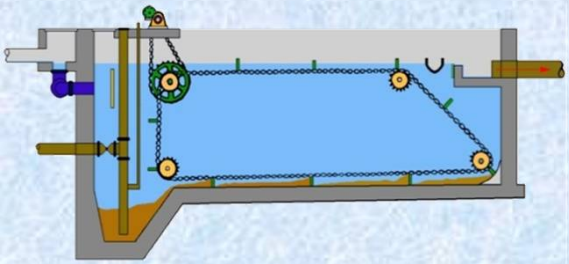


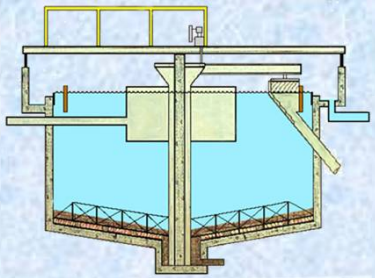
Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit

Clarifier Calculations



Hydraulic Loading
Solids Loading





Clarifier Loading Calculations

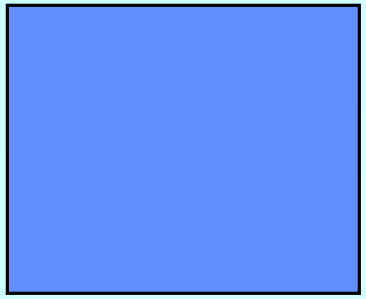
$$\text{Detention Time (DT)} = \frac{\text{Tank Volume, MG X 24}}{\text{Flow into Tank, MGD}}$$

$$\text{Surface Overflow Rate (SOR)} = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

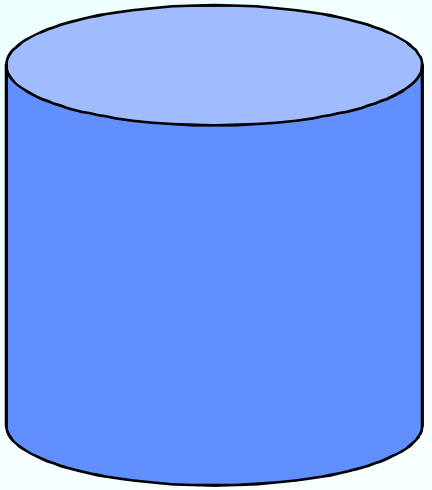
$$\text{Weir Overflow Rate (WOR)} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

$$\text{Solids Loading} = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

But First



Area and Volume Calculations



Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Example 1:

If a tank is 10 ft long and 5 ft wide, what is the surface area?

SA, ft^2 = 10 ft X 5 ft = 50 ft^2

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Example 2:

If a tank is 10 ft 6 inches long and 5 ft 9 inches wide, what is the surface area in sq. ft.?

NOT

SA, ft^2 = 10.6 ft X 5.9 ft

Converting Inches to Feet

$$6 \text{ inches} = \frac{6 \text{ inches}}{12 \text{ in/ft}} = 0.5 \text{ ft}$$

So: 10 ft 6 inches = 10.5 ft

$$9 \text{ inches} = \frac{9 \text{ inches}}{12 \text{ in/ft}} = 0.75 \text{ ft}$$

So: 5 ft 9 inches = 5.75 ft

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Example 2:

If a tank is 10 ft 6 inches long and 5 ft 9 inches wide, what is the surface area in sq. ft.?

SA, ft^2 = 10.5 ft X 5.75 ft = 60.4 ft^2

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1:

If a clarifier is 25 ft long and 9 ft wide, what is the surface area in sq. ft.?

Practice 2:

If a clarifier is 22 ft 3 inches long and 7 ft 7 inches wide, what is the surface area in sq. ft.?

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Practice 1:

If a clarifier is 25 ft long and 9 ft wide, what is the surface area in sq. ft.?

SA, ft^2 = 25 ft X 9 ft = 225 ft^2

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

Practice 2:

If a clarifier is 22 ft 3 inches long and 7 ft 7 inches wide, what is the surface area in sq. ft.?

Converting Inches to Feet

$$3 \text{ inches} = \frac{3 \text{ inches}}{12 \text{ in/ft}} = 0.25 \text{ ft}$$

So: 22 ft 6 inches = 22.25 ft

$$7 \text{ inches} = \frac{7 \text{ inches}}{12 \text{ in/ft}} = 0.58 \text{ ft}$$

So: 7 ft 7 inches = 7.58 ft

Surface Area Calculations

Rectangles

Surface Area, ft^2 = Length, ft X Width, ft

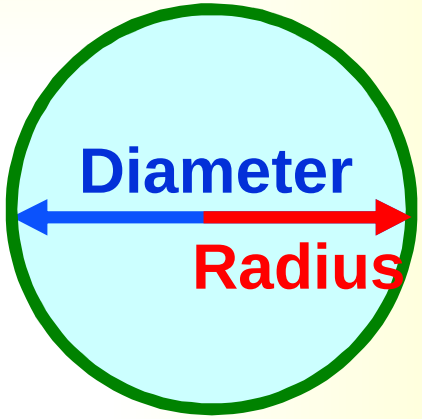
Practice 2:

If a clarifier is 22 ft 3 inches long and 7 ft 7 inches wide, what is the surface area in sq. ft.?

SA, ft^2 = 22.25 ft X 7.58 ft = 60.4 ft^2

Surface Area Calculations

Circles



Diameter:

The distance across a circle, going through the center.

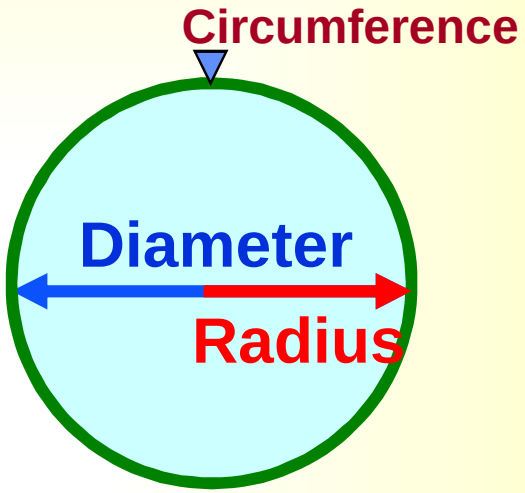
Radius:

The distance from the center a circle to the perimeter.

$$\text{Radius} = \frac{\text{Diameter}}{2}$$

Surface Area Calculations

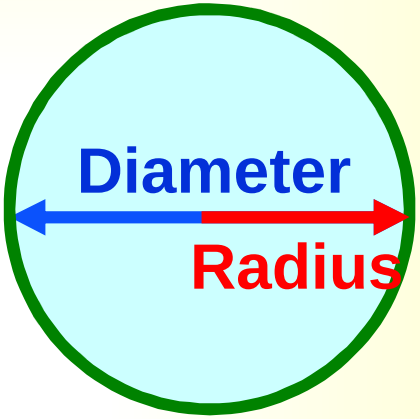
Circles



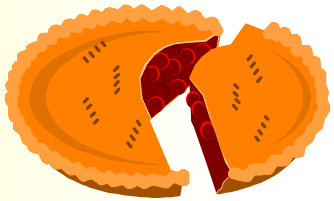
Circumference =
distance around circle

Surface Area Calculations

Circles

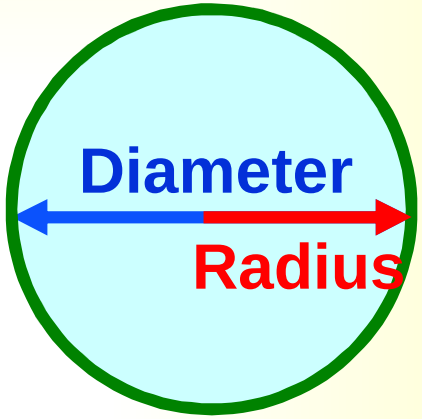


pie



Surface Area Calculations

Circles



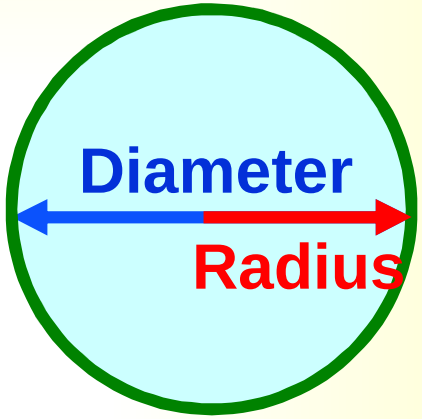
pi = π

$$= \frac{\text{Circumference}}{\text{Diameter}}$$

= 3.14 for any circle

Surface Area Calculations

Circles



Surface Area = π r^2

= 3.14 X radius X radius

Surface Area Calculations

Circles

Surface Area = πr^2 $= 3.14 \times r^2$

OR

$$A = 3.14 \times (D/2)^2 = 3.14 \times \frac{D^2}{2^2} = \frac{3.14 \times D^2}{4}$$

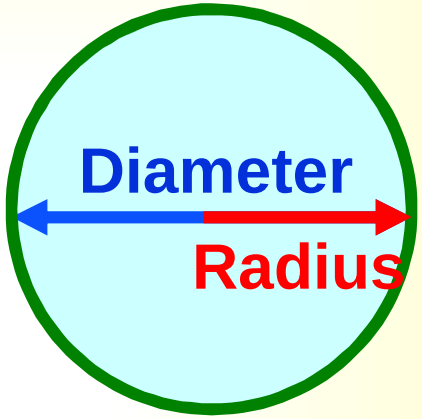
OR

$$A = \frac{3.14}{4} \times D^2 = 0.785 \times D^2$$

Any on the Three Formulas Can Be Used

Surface Area Calculations

Circles



Surface Area = πr^2

Example 1:

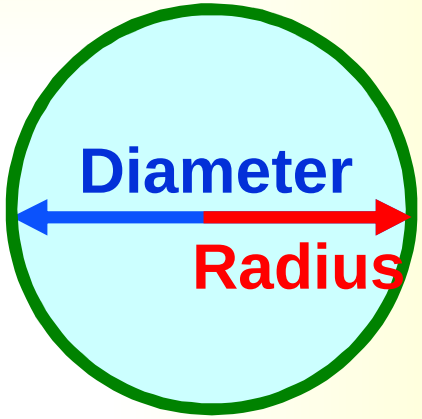
If a tank has a radius of 15 feet, what is the surface area?

S A = πr^2 = 3.14 X 15 ft. X 15 ft.

= 707 ft^2

Surface Area Calculations

Circles



Surface Area = πr^2

Example 2:

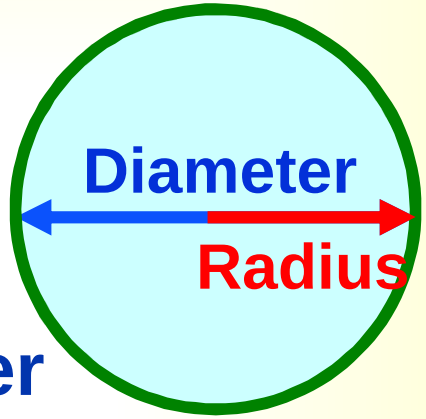
If a tank has a diameter of 25 feet, what is the surface area?

S A = πr^2 = 3.14 X 12.5 ft. X 12.5 ft.

= 491 ft^2

Surface Area Calculations

Circles



Surface Area = πr^2

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1:

If a tank has a diameter of 50.5 feet, what is the surface area?

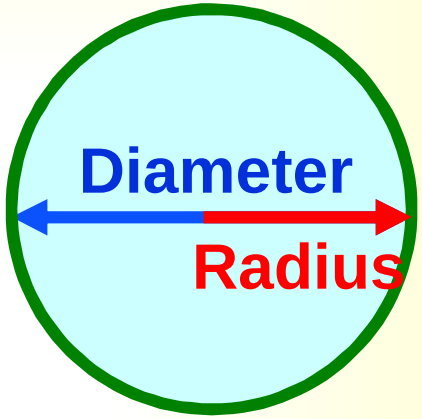
Practice 2:

If a tank has a diameter of 50 feet 7 inches, what is the surface area?

Surface Area Calculations

Circles

Surface Area = πr^2



Practice 1:

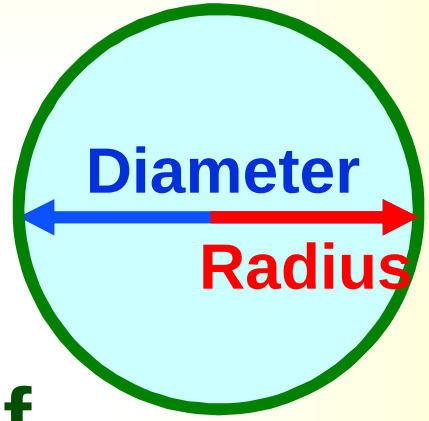
If a tank has a diameter of 50.5 feet, what is the surface area?

S A = πr^2 = 3.14 X 25.25 ft. X 25.25 ft.

= 2002 ft^2

Surface Area Calculations

Circles



Surface Area = πr^2

Practice 2:

If a tank has a diameter of 50 feet 7 inches, what is the surface area?

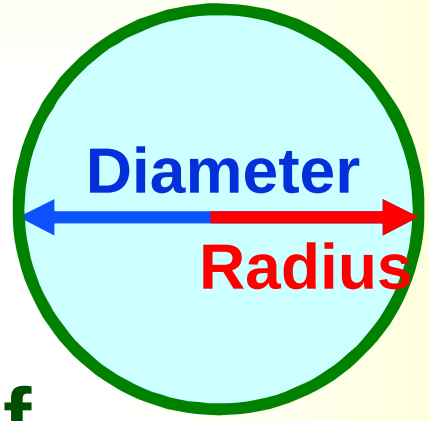
$$7 \text{ inches} = \frac{7 \text{ inches}}{12 \text{ in/ft}} = 0.58 \text{ ft}$$

50 feet 8 inches = 50.58 ft

Radius = 50.58 ft ÷ 2 = 25.29 ft

Surface Area Calculations

Circles



Surface Area = πr^2

Practice 2:

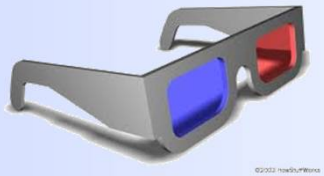
If a tank has a diameter of 50 feet 7 inches, what is the surface area?

S A = πr^2 = 3.14 X 25.29 ft. X 25.29 ft.

= 2008 ft^2

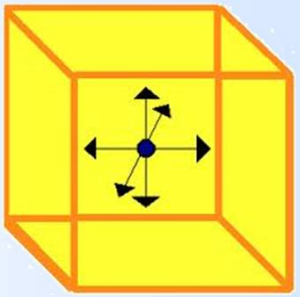
Volume Calculations

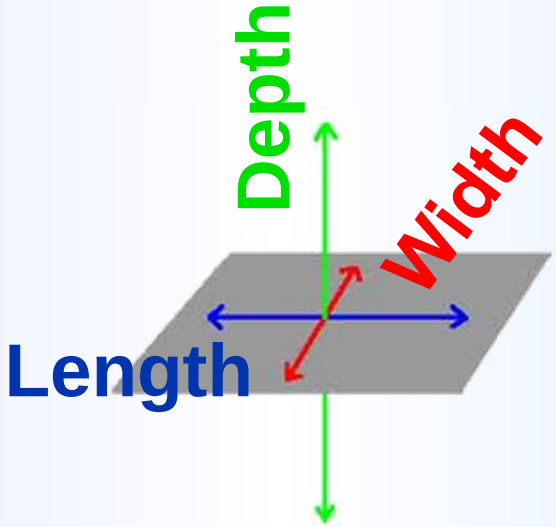
Volume – Three D

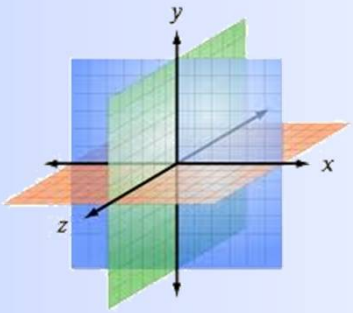


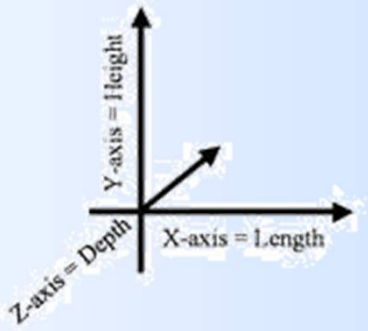
Volume Calculations

Volume – Three Dimensions



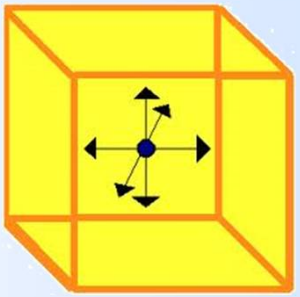






Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

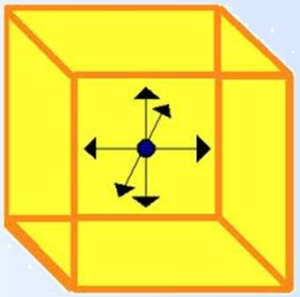
Example 1:

If a tank is 10 feet long, 5 feet wide, and 5 feet deep, what is the volume in cubic feet?

Vol. = 10 ft X 5 ft X 5 ft = 250 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

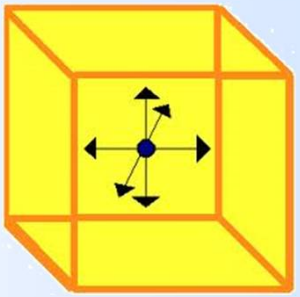
Example 2:

If a tank is 20 ft. long, 7 ft. wide, and 5.5 ft. deep, what is the volume in cubic feet?

Vol. = 20 ft X 7 ft X 5.5 ft = 770 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

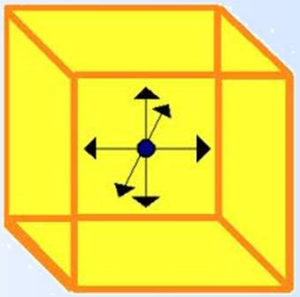
Example 3:

If a tank is 25 ft. long, 9 ft. 3 inches wide, and 7.5 ft. deep, what is the volume in gallons?

Vol. = 25 ft X 9.25 ft X 7.5 ft = 1734 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

Example 3:

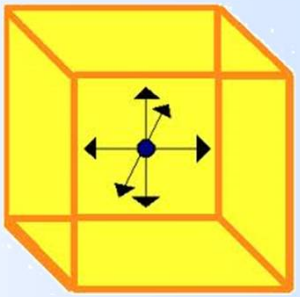
If a tank is 25 ft. long, 9 ft. 3 inches wide, and 7.5 ft. deep, what is the volume in gallons?

There are 7.48 gallons in one cubic foot

OR 7.48 gal/ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

Example 3:

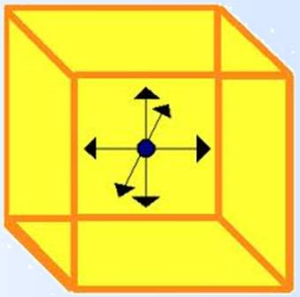
If a tank is 25 ft. long, 9 ft. 3 inches wide, and 7.5 ft. deep, what is the volume in gallons?

Vol. = 25 ft X 9.25 ft X 7.5 ft = 1734 ft^3

1734 ft^3 x 7.48 gal/ft^3 = 12,970 gallons

Volume Calculations

Rectangular Tanks



Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1:

If a tank is 21 feet long, 9 feet wide, and 7 feet deep, what is the volume in cubic feet?

Practice 2:

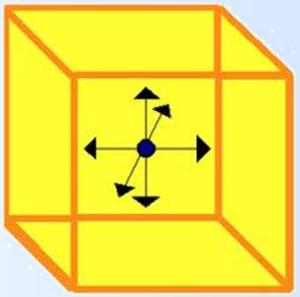
If a tank is 22 ft. long, 9 ft. wide, and 7.5 ft. deep, what is the volume in cubic feet?

Practice 3:

If a tank is 35 ft. long, 12 ft. 3 inches wide, and 9.5 ft. deep, what is the volume in gallons?

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

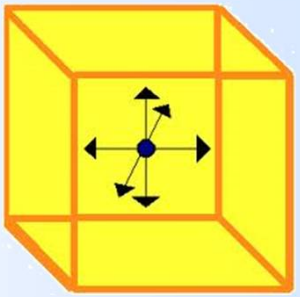
Practice 1:

If a tank is 21 feet long, 9 feet wide, and 7 feet deep, what is the volume in cubic feet?

Vol. = 21 ft X 9 ft X 7 ft = 1323 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

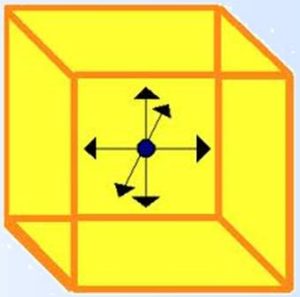
Practice 2:

If a tank is 22 ft. long, 9 ft. wide, and 7.5 ft. deep, what is the volume in cubic feet?

Vol. = 22 ft X 9 ft X 7.5 ft = 1485 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

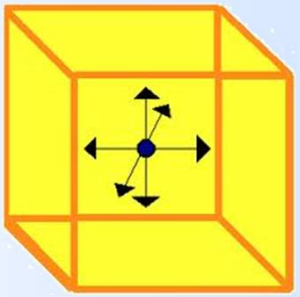
Practice 3:

If a tank is 35 ft. long, 12 ft. 3 inches wide, and 9.5 ft. deep, what is the volume in gallons?

Vol. = 35 ft X 12.25 ft X 9.5 ft = 4073 ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

Practice 3:

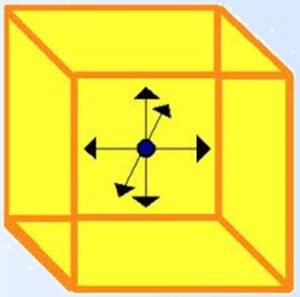
If a tank is 35 ft. long, 12 ft. 3 inches wide, and 9.5 ft. deep, what is the volume in gallons?

There are 7.48 gallons in one cubic foot

OR 7.48 gal/ft^3

Volume Calculations

Rectangular Tanks



Volume = Length X Width X Height (or Depth)

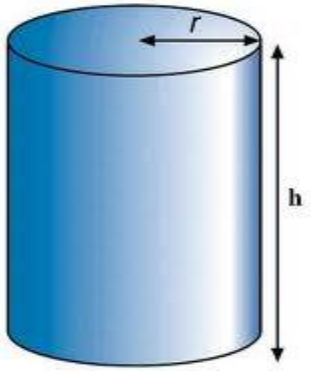
Practice 3:

If a tank is 35 ft. long, 12 ft. 3 inches wide, and 9.5 ft. deep, what is the volume in gallons?

Vol. = 35 ft X 12.25 ft X 9.5 ft = 4073 ft^3

4073 ft^3 x 7.48 gal/ft^3 = 30,466 gallons

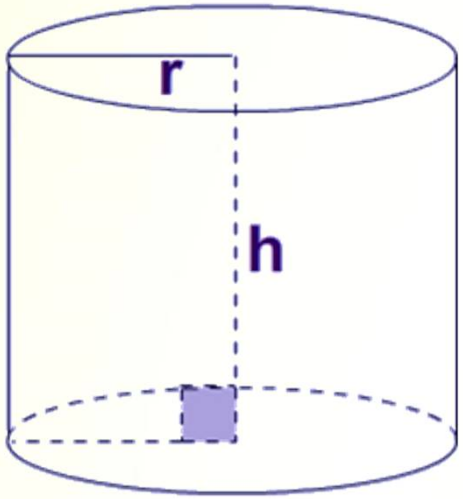
Volume Calculations



Round (Cylinder) Tanks

Volume – Three Dimensions

$$V = \pi r^2 h$$



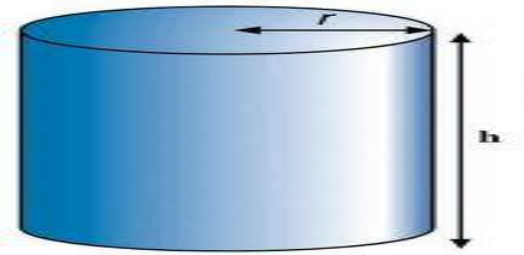
$\pi = 3.14$

r = Radius of circle

h = Height (or Depth)

Volume Calculations

Round (Cylinder) Tanks



Example 1

Find the Volume in cubic feet of a tank having a radius of 10 feet and a depth of 8 feet.

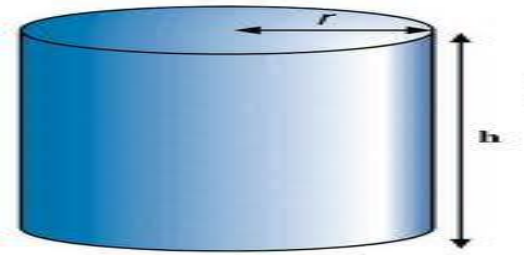
$$V = \pi r^2 h = 3.14 \text{ X } 10 \text{ ft X } 10 \text{ ft X } 8 \text{ ft}$$

$$= 3.14 \text{ X } 800 \text{ ft}^3$$

$$= 2512 \text{ ft}^3$$

Volume Calculations

Round (Cylinder) Tanks



Example 2

Find the Volume in cubic feet of a tank having a diameter of 30 feet and a depth of 8 feet.

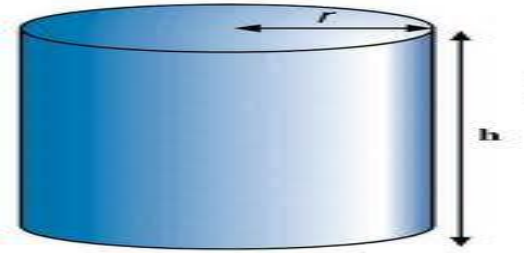
$$V = \pi r^2 h = 3.14 \text{ X } 15 \text{ ft X } 15 \text{ ft X } 8 \text{ ft}$$

$$= 3.14 \text{ X } 1800 \text{ ft}^3$$

$$= 5652 \text{ ft}^3$$

Volume Calculations

Round (Cylinder) Tanks



Example 3

Find the Volume in gallons of a tank having a diameter of 50 feet and a depth of 9 feet.

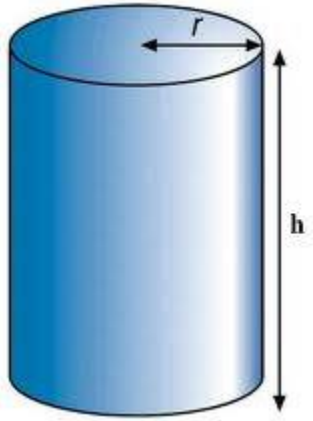
$$V = \pi r^2 h = 3.14 \times 25 \text{ ft} \times 25 \text{ ft} \times 9 \text{ ft}$$

$$= 17{,}662.5 \text{ ft}^3$$

$$\times 7.48 \text{ gal/ft}^3$$

$$= 132{,}116 \text{ gallons}$$

Volume Calculations



Round (Cylinder) Tanks

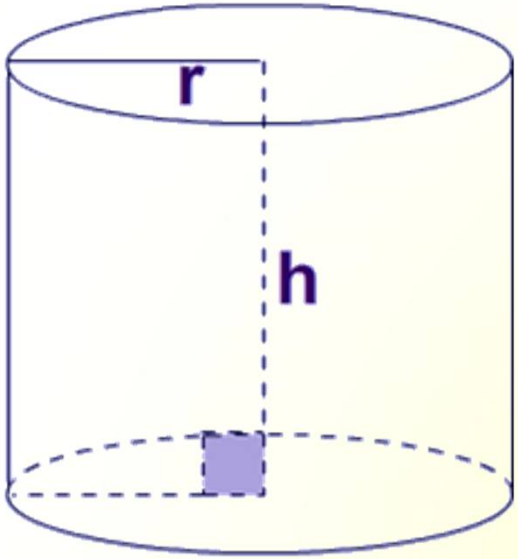
Volume – Three Dimensions

$$V = \pi r^2 h$$

$\pi = 3.14$

r = Radius of circle

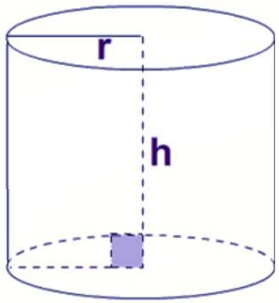
h = Height (or Depth)



Volume Calculations

Round (Cylinder) Tanks

$$V = \pi r^2 h$$



Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1

Find the Volume in cubic feet of a tank having a radius of 22 feet and a depth of 10 feet.

Practice 2

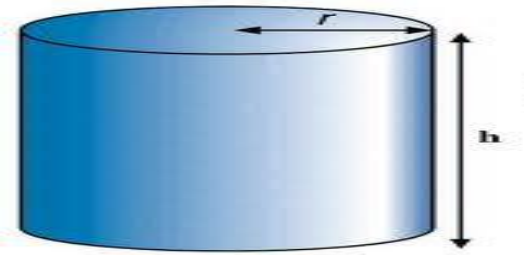
Find the Volume in cubic feet of a tank having a diameter of 28 feet and a depth of 7.5 feet.

Practice 3

Find the Volume in gallons of a tank having a diameter of 48 feet and a depth of 7 feet.

Volume Calculations

Round (Cylinder) Tanks



Practice 1

Find the Volume in cubic feet of a tank having a radius of 22 feet and a depth of 10 feet.

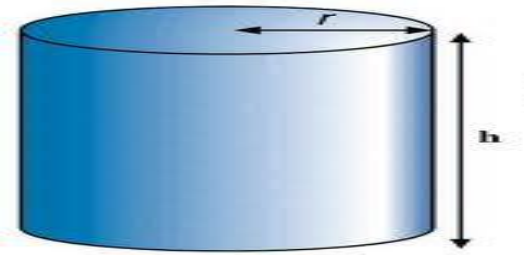
$$V = \pi r^2 h = 3.14 \text{ X } 22 \text{ ft X } 22 \text{ ft X } 10 \text{ ft}$$

$$= 3.14 \text{ X } 4840 \text{ ft}^3$$

$$= 15{,}198 \text{ ft}^3$$

Volume Calculations

Round (Cylinder) Tanks



Practice 2

Find the Volume in cubic feet of a tank having a diameter of 28 feet and a depth of 7.5 feet.

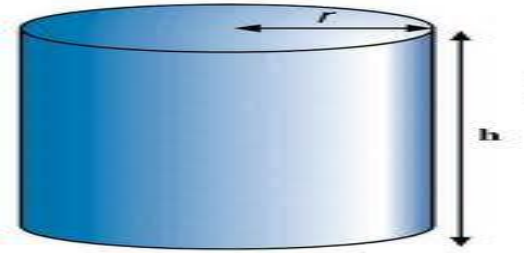
$$V = \pi r^2 h = 3.14 \text{ X } 14 \text{ ft X } 14 \text{ ft X } 7.5 \text{ ft}$$

$$= 3.14 \text{ X } 1470 \text{ ft}^3$$

$$= 4616 \text{ ft}^3$$

Volume Calculations

Round (Cylinder) Tanks



Practice 3

Find the Volume in gallons of a tank having a diameter of 48 feet and a depth of 7 feet.

$V = \pi r^2 h = 3.14 \times 24 \text{ ft} \times 24 \text{ ft} \times 7 \text{ ft}$

$= 12{,}660 \text{ ft}^3$

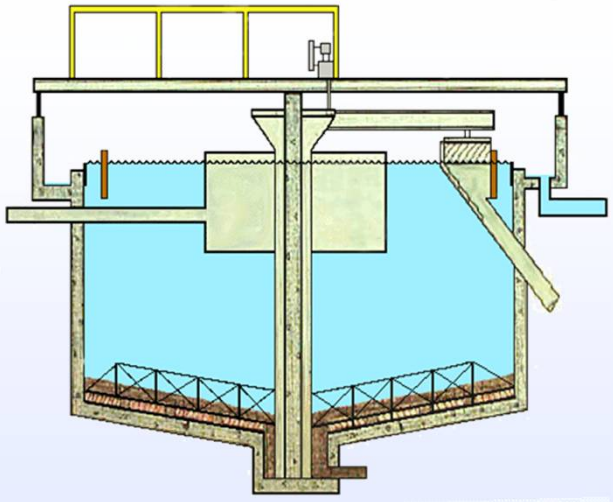
$\times 7.48 \text{ gal/ft}^3$

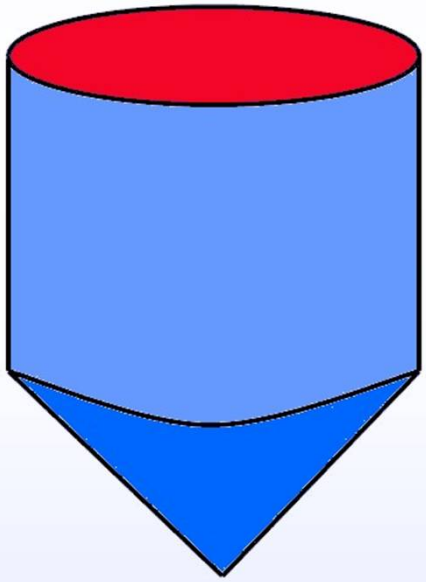
$= 94{,}700 \text{ gallons}$

Volume Calculations

What about a Round Tank with a Cone Bottom

?

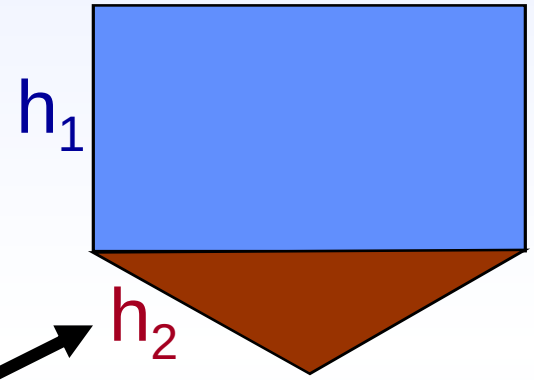




Volume Calculations

Cylinder with Cone Bottom

$$V_{cylinder} = \pi r^2 h_1$$

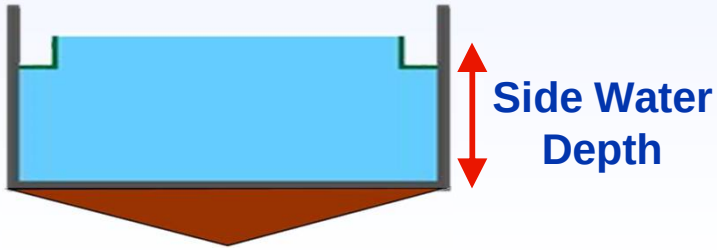


$$V_{cone} = 1/3\ \pi r^2 h \quad \text{or} \quad \frac{\pi r^2 h_2}{3}$$

$$V_{total} = V_{cylinder} + V_{cone}$$

Volume Calculations

Cylinder with Cone Bottom



For Secondary Clarifiers
Volume of Cone Not Considered

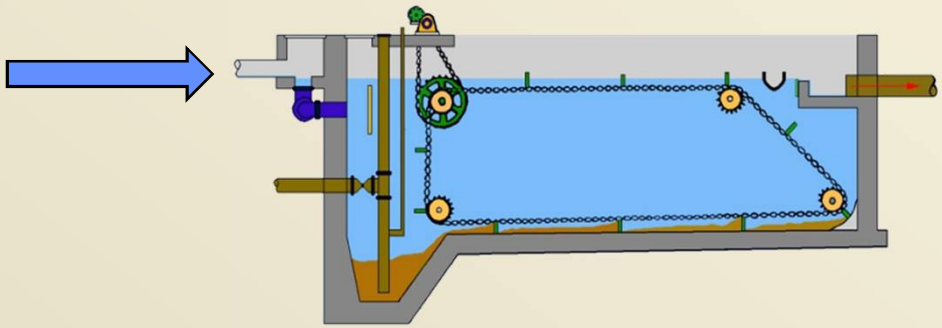
Insignificant Compared to Total Volume
(Filled with Sludge)

Clarifier Loading

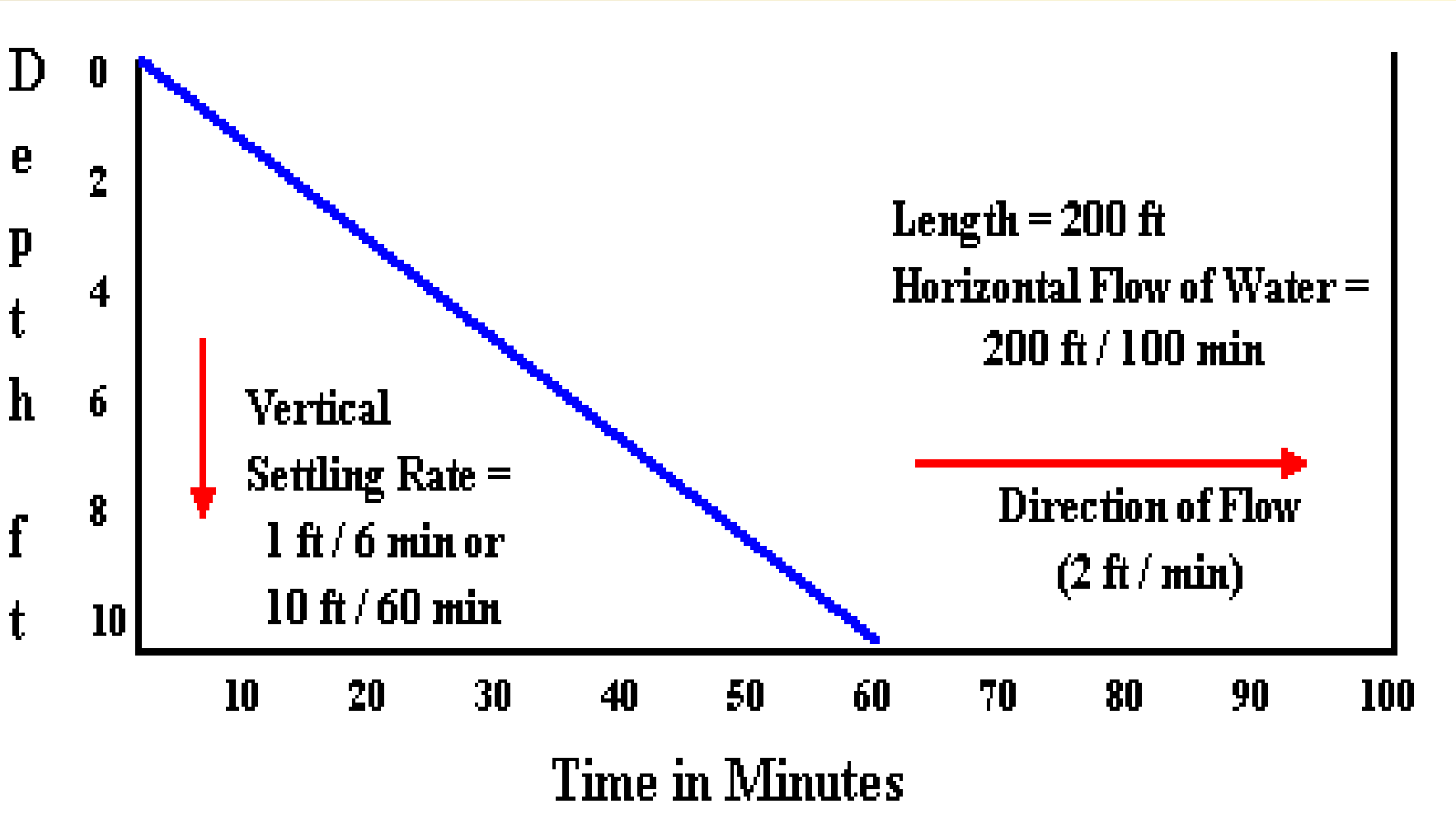
Hydraulic Loading

Detention Time (DT)

The time it takes for a drop of water to travel from inlet to outlet

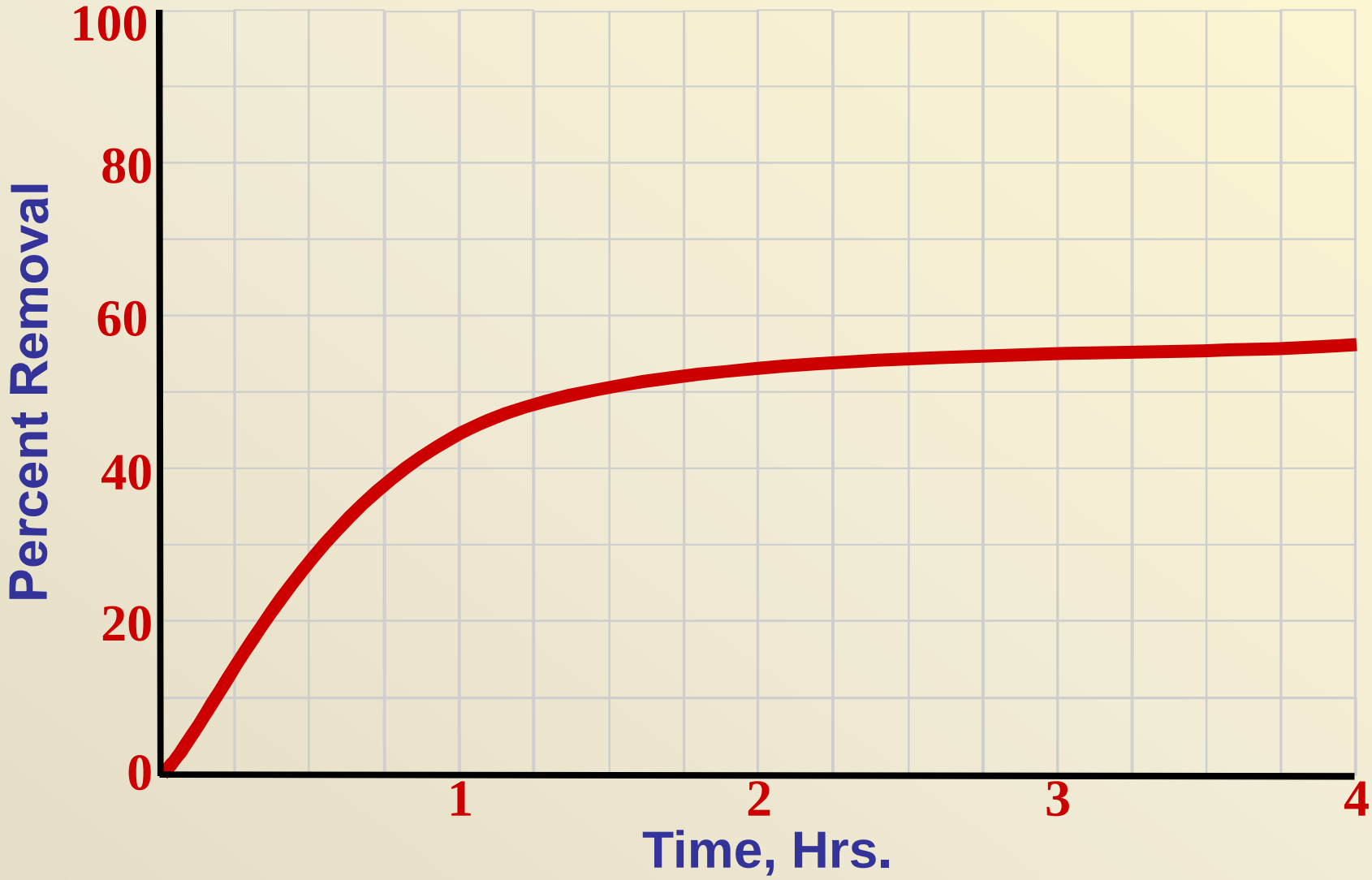


Clarifier Detention Time



Must Have Detention Time Long Enough for Solids to Settle

Sedimentation Efficiency



Too Long – No Increase in Removal

Clarifier Loading

Hydraulic Loading

Detention Time (DT)

The time it takes for a drop of water to travel from inlet to outlet

Typical Design Value = 2 – 3 Hours

Hydraulic Loading

$$\text{Detention Time} = \frac{\text{Tank Volume}}{\text{Influent Rate}}$$

Example 1a:

Calculate the Detention Time in for a clarifier with a volume of 25,000 gallons that receives a flow of 310,000 gal/day.

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

$$= \frac{25{,}000 \text{ gallons}}{310{,}000 \text{ gallons/day}} = 0.08 \text{ Days}$$

Hydraulic Loading

$$\text{Detention Time} = \frac{\text{Tank Volume}}{\text{Influent Rate}}$$

Example 1b:

Calculate the Detention Time in HOURS for a clarifier with a volume of 25,000 gallons that receives a flow of 310,000 gal/day.

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

$$= \frac{25{,}000 \text{ gallons}}{310{,}000 \text{ gallons/day}} = 0.08 \text{ Days}$$

$$0.08 \text{ Days} \times 24 \text{ hours/days} = 1.9 \text{ Hours}$$

Clarifier Loading

Hydraulic Loading

Detention Time (DT)

The time it takes for a drop of water to travel from inlet to outlet

$$\text{Detention Time} = \frac{\text{Tank Volume}}{\text{Flow into Tank}}$$

Clarifier Loading

Hydraulic Loading

Detention Time (DT)

The time it takes for a drop of water to travel from inlet to outlet

$$\text{DT, hrs} = \frac{\text{Tank Volume, (MG or Gallons) X 24}}{\text{Flow into Tank, (MG/D or Gal/D)}}$$

Detention Time

Example 1. Find the detention time in hours of a circular sedimentation tank having a volume of 75,000 gallons and a flow of 900,000 gallons per day.

$$DT, hrs = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

$$DT, hrs = \frac{\text{75,000 gallons X 24 hr/day}}{\text{900,000 gallons/day}}$$

$$= 2 \text{ hour}$$

Detention Time

Example 2. Find the detention time in hours of a circular sedimentation tank having a volume of 55,000 gallons and a flow of 0.75 MGD.

$$\text{DT, hrs} = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

0.75 MGD = 750,000 gal/day

Detention Time

Example 2. Find the detention time in hours of a circular sedimentation tank having a volume of 55,000 gallons and a flow of 0.75 MGD.

$$\text{DT, hrs} = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

$$\text{DT, hrs} = \frac{\text{55,000 gallons X 24 hr/day}}{\text{750,000 gallons/day}}$$

$$= 1.8 \text{ hour}$$

Detention Time

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1. Find the detention time in hours of a clarifier having a volume of 52,000 gallons and a flow of 520,000 gallons per day.

Practice 2. Find the detention time in hours of a rectangular sedimentation tank having a volume of 16,400 gallons and a flow of 0.225 MGD.

Detention Time

Practice 1. Find the detention time in hours of a clarifier having a volume of 52,000 gallons and a flow of 520,000 gallons per day.

$$DT, hrs = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

$$DT, hrs = \frac{\text{52,000 gallons X 24 hr/day}}{\text{520,000 gallons/day}}$$

$$= 2.4 \text{ hour}$$

Detention Time

Practice 2. Find the detention time in hours of a rectangular sedimentation tank having a volume of 16,400 gallons and a flow of 0.225 MGD.

$$\text{DT, hrs} = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

0.225 MGD = 220,000 gal/day

Detention Time

Practice 2. Find the detention time in hours of a rectangular sedimentation tank having a volume of 16,400 gallons and a flow of 0.225 MGD.

$$\text{DT, hrs} = \frac{\text{Tank Volume, gallons X 24 hr/day}}{\text{Flow into Tank, gallons/day}}$$

$$\text{DT, hrs} = \frac{\text{16,400 gallons X 24 hr/day}}{\text{225,000 gallons/day}}$$

$$= 1.75 \text{ hour}$$

Clarifier Loading

Hydraulic Loading

Detention Time (DT)

The time it takes for a drop of water to travel from inlet to outlet

$$\text{Detention Time} = \frac{\text{Tank Volume}}{\text{Flow into Tank}}$$

$$\text{DT, hrs} = \frac{\text{Tank Volume, (MG or Gallons) X 24}}{\text{Flow into Tank, (MG/D or Gal/D)}}$$

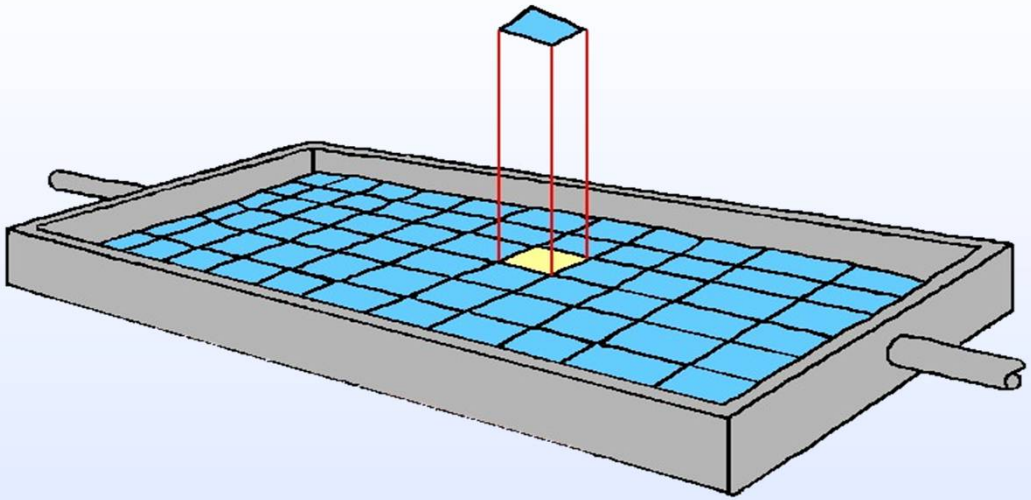
Typical Design Value = 2 – 3 Hours

Clarifier Loading

Hydraulic Loading

Surface Overflow Rate (SOR)
OR
Surface Loading Rate (SLR)

The flow in gallons per day into the clarifier per square foot of surface area



Clarifier Loading

Hydraulic Loading

Surface Overflow Rate (SOR)
OR
Surface Loading Rate (SLR)

The flow in gallons per day into the clarifier per square foot of surface area

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

Clarifier Loading

Hydraulic Loading

Surface Overflow Rate (SOR)

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

Need:

Flow in gallons/day

and

Surface Area, ft^2

$SA = L \times W$

$SA = \pi r^2$

Clarifier Loading

Hydraulic Loading

Surface Overflow Rate (SOR)

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

Typical Design Value = 400 - 800 gal/day/ft^2

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Example 1.

Calculate the Surface Overflow Rate for a clarifier that is 50 ft long, 15 ft wide, 12 ft deep, and receives a flow of 338,000 gallons per day.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{Surface Area, ft}^2 = 50 \text{ ft} \times 15 \text{ ft} = 750 \text{ ft}^2$$

$$\text{SOR, gpd/ft}^2 = \frac{338{,}000 \text{ gallons per day}}{750 \text{ ft}^2}$$

$$= 451 \text{ gpd/ft}^2$$

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Example 2.

Calculate the Surface Overflow Rate for a clarifier that has a diameter of 60 ft, and receives an influent flow of 1.65 MGD.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{Flow, gallons/day} = 1.65 \text{ MGD} \times 1{,}000{,}000$$

$$= 1{,}650{,}000 \text{ gallons per day}$$

$$\text{Surface Area, ft}^2 = \pi r^2 = 3.14 \times 30 \text{ ft} \times 30 \text{ ft}$$

$$= 2826 \text{ ft}^2$$

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Example 2.

Calculate the Surface Overflow Rate for a clarifier that has a diameter of 60 ft, and receives an influent flow of 1.65 MGD.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{SOR, gpd/ft}^2 = \frac{1{,}650{,}000 \text{ gallons per day}}{2826 \text{ ft}^2}$$

= 584 gpd/

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1.

Calculate the Surface Overflow Rate for a clarifier that is 35 ft long, 9 ft wide, 7 ft deep, and receives a flow of 235,000 gallons per day.

Practice 2.

Calculate the Surface Overflow Rate for a clarifier that has a diameter of 45 ft. and receives an influent flow of 0.65 MGD.

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Practice 1.

Calculate the Surface Overflow Rate for a clarifier that is 35 ft long, 9 ft wide, 7 ft deep, and receives a flow of 235,000 gallons per day.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{Surface Area, ft}^2 = 35 \text{ ft} \times 9 \text{ ft} = 315 \text{ ft}^2$$

$$\text{SOR, gpd/ft}^2 = \frac{235{,}000 \text{ gallons per day}}{315 \text{ ft}^2}$$

$$= 746 \text{ gpd/ft}^2$$

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Practice 2.

Calculate the Surface Overflow Rate for a clarifier that has a diameter of 45 ft. and receives an influent flow of 0.65 MGD.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{Flow, gallons/day} = 0.65 \text{ MGD} \times 1{,}000{,}000$$

$$= 650{,}000 \text{ gallons per day}$$

$$\text{Surface Area, ft}^2 = \pi r^2 = 3.14 \times 22.5 \text{ ft} \times 22.5 \text{ ft}$$

$$= 1590 \text{ ft}^2$$

Clarifier Loading

Hydraulic Loading - Surface Overflow Rate (SOR)

Practice 2.

Calculate the Surface Overflow Rate for a clarifier that has a diameter of 45 ft, and receives an influent flow of 0.65 MGD.

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

$$\text{SOR, gpd/ft}^2 = \frac{650{,}000 \text{ gallons per day}}{1590 \text{ ft}^2}$$

$$= 409 \text{ gpd/ft}^2$$

Clarifier Loading

Hydraulic Loading

Surface Overflow Rate (SOR)

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

Typical Design Value = 300 - 1200 gal/day/ft^2
(800 gal/day/ft^2)

Clarifier Loading

Hydraulic Loading

Weir Overflow Rate (WOR)

The flow in gallons per day per linear foot of weir

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

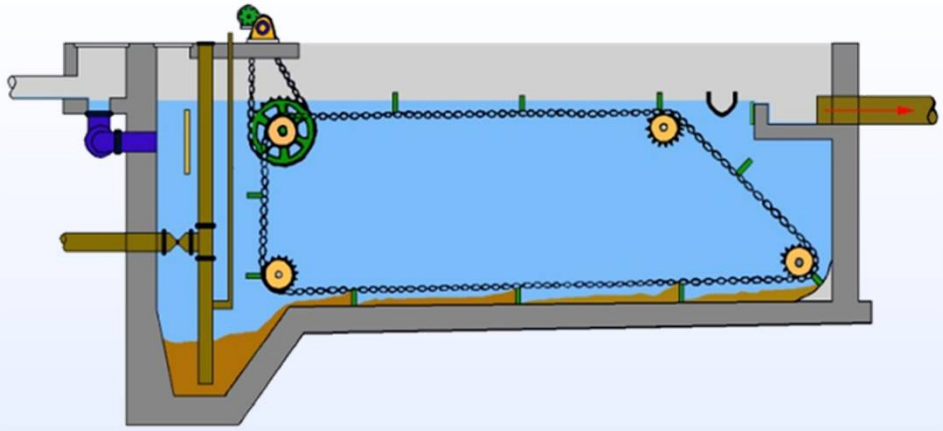
Typical Design Value = ~10,000 gal/day/ft

Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Rectangular Tanks - Length of Weir, ft



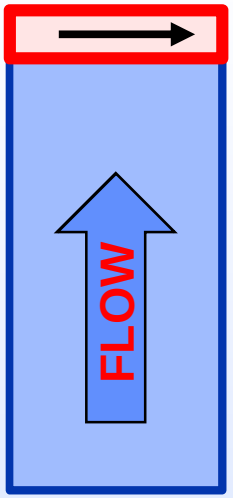
Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

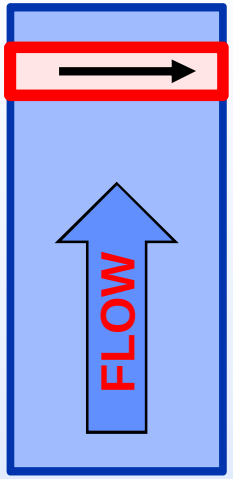
$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Rectangular Tanks - Length of Weir, ft

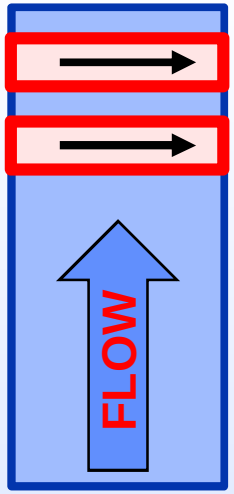
= Width



= 2 X Width



= 4 X Width



Clarifier Loading

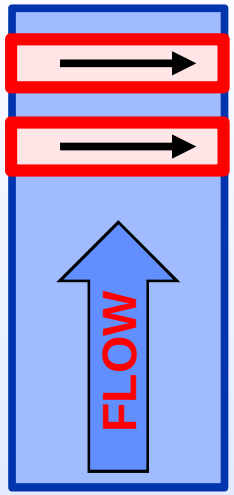
Hydraulic Loading - Weir Overflow Rate (WOR)

Example 1

A primary clarifier is 20 feet wide, 60 feet long, and has a SWD of 12 feet. The clarifier has two effluent troughs across the width that allow the water to flow over both sides of each trough. The average flow to the clarifier is 0.65 MGD. Calculate the weir over flow rate for this clarifier.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Flow, gallons/day = 0. 65 MGD X 1,000,000 = 650,000 gal/day



Length of Weir, ft = 4 X Width

= 4 X 20 ft

= 80 ft

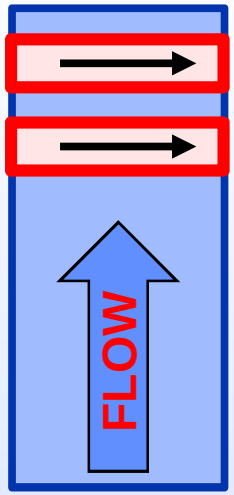
Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

Example 1

A primary clarifier is 12 feet wide, 40 feet long, and has a SWD of 8 feet. The clarifier has two effluent troughs across the width that allow the water to flow over both sides of each trough. The average flow to the clarifier is 0.65 MGD. Calculate the weir over flow rate for this clarifier.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$



$$= \frac{650{,}000 \text{ gal/day}}{80 \text{ ft}}$$

$$= 8{,}125 \text{ gal/day/ft}$$

Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1

A primary clarifier is 18 feet wide, 45 feet long, and has a SWD of 9 feet. The clarifier has an effluent trough across the end. The average flow to the clarifier is 0.085 MGD. Calculate the weir over flow rate for this clarifier.

Practice 2

A primary clarifier is 12 foot wide, 40 foot long, and has a SWD of 8 feet. The clarifier has two effluent troughs across the width that allow the water to flow over both sides of each trough. The average flow to the clarifier is 0.41 MGD. Calculate the weir over flow rate for this clarifier.

Clarifier Loading

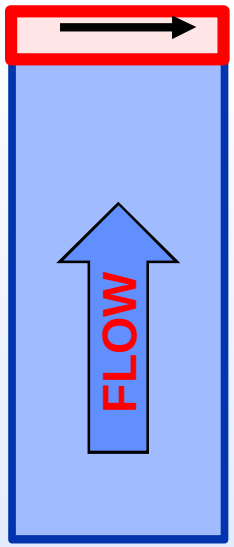
Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 1

A primary clarifier is 18 feet wide, 45 feet long, and has a SWD of 9 feet. The clarifier has an effluent trough across the end. The average flow to the clarifier is 0.085 MGD. Calculate the weir over flow rate for this clarifier.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Flow, gallons/day = 0. 085MGD X 1,000,000 = 85,000 gal/day



Length of Weir, ft = Width

$$\text{WOR, gal/d/ft} = \frac{85{,}000 \text{ gal/day}}{9 \text{ ft}}$$

= 9,444 gal/day/ft

Clarifier Loading

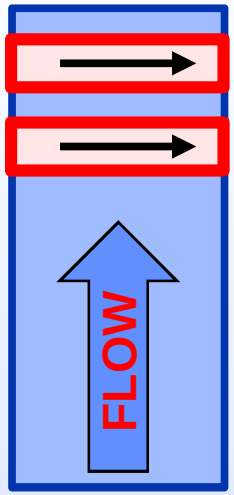
Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 2

A primary clarifier is 12 foot wide, 40 foot long, and has a SWD of 8 feet. The clarifier has two effluent troughs across the width that allow the water to flow over both sides of each trough. The average flow to the clarifier is 0.41 MGD. Calculate the weir over flow rate for this clarifier.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Flow, gallons/day = 0. 41 MGD X 1,000,000 = 410,000 gal/day



Length of Weir, ft = 4 X Width

= 4 X 12 ft

= 48 ft

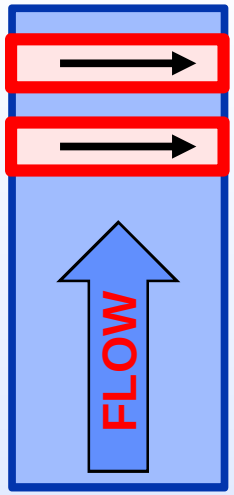
Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 2

A primary clarifier is 12 foot wide, 40 foot long, and has a SWD of 8 feet. The clarifier has two effluent troughs across the width that allow the water to flow over both sides of each trough. The average flow to the clarifier is 0.41 MGD. Calculate the weir over flow rate for this clarifier.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$



$$= \frac{410{,}000 \text{ gal/day}}{48 \text{ ft}}$$

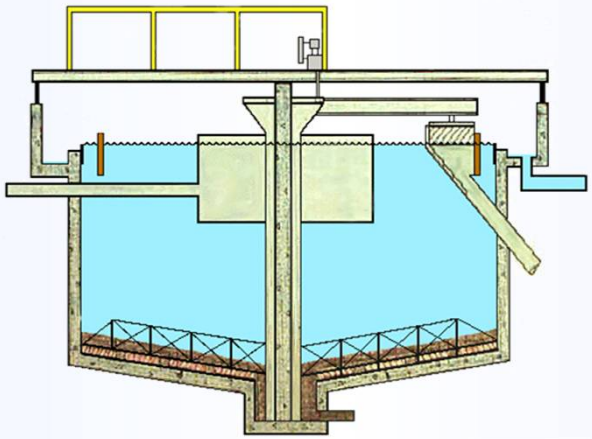
$$= 8{,}542 \text{ gal/day/ft}$$

Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

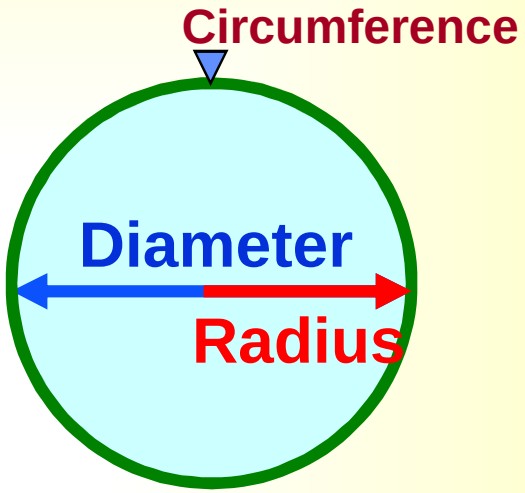
$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Weir Length for a Circular Clarifier ?



Surface Area Calculations

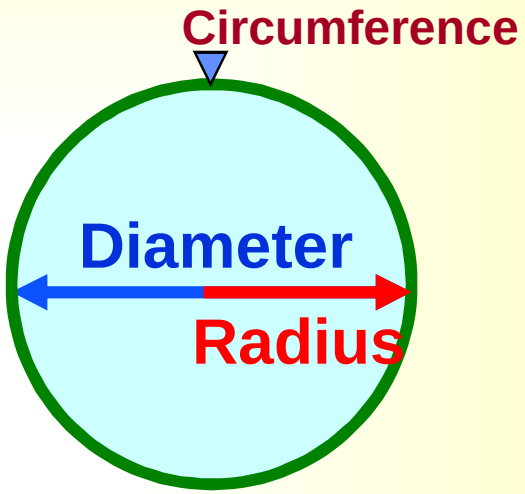
Circles



Circumference =
distance around circle

Surface Area Calculations

Circles



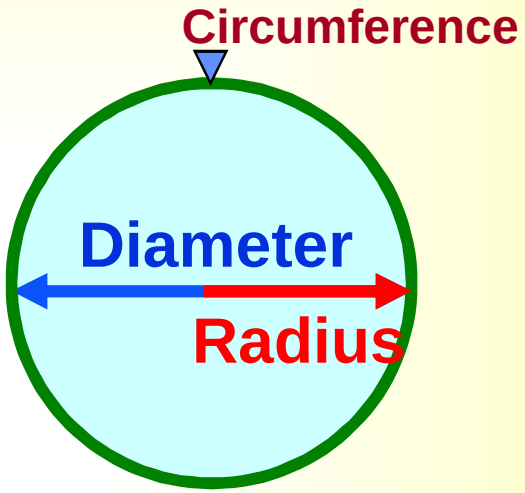
Circumference =
distance around circle

$$\frac{\text{Circumference}}{\text{Diameter}} = \frac{C}{D} = \pi = 3.14 \text{ for any circle}$$

$$C = \pi D$$

Surface Area Calculations

Circles



Circumference =
distance around circle

For Weir Length
D = Diameter of the Weir
(May Not be same as Tank)

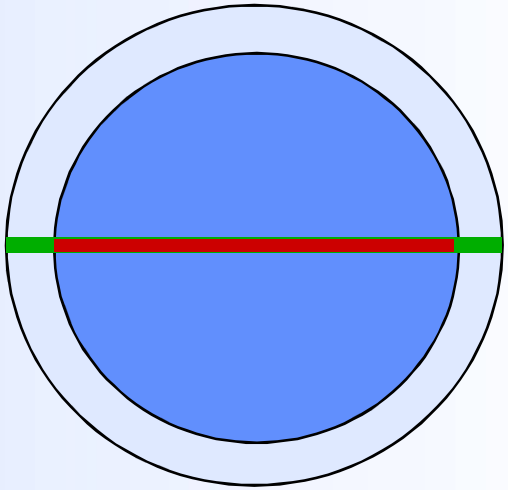
$$C = \pi D$$

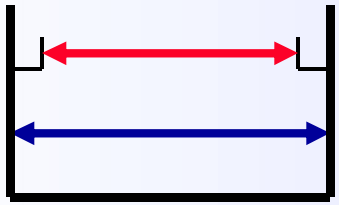
Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Weir Length for a Circular Clarifier



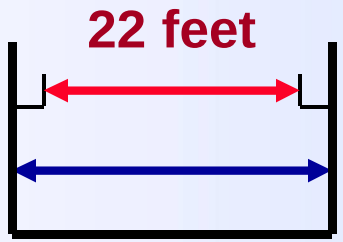


Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

Example 1.

The flow to a circular clarifier is 690,000 gallons per day. The clarifier is 24 feet in diameter with the weirs set 1 foot from the outside wall, for a weir diameter of 22 feet. Calculate the weir overflow rate.



$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

$$\text{Length of Weir, ft} = \pi \times \text{Weir Diameter}$$

$$= 3.14 \times 22 \text{ ft}$$

$$= 69.08 \text{ ft}$$

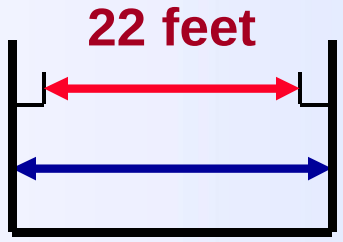
Clarifier Loading

Hydraulic Loading - Weir Overflow Rate (WOR)

Example 1.

The flow to a circular clarifier is 690,000 gallons per day. The clarifier is 24 feet in diameter with the weirs set 1 foot from the outside wall, for a weir diameter of 22 feet. Calculate the weir overflow rate.

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$



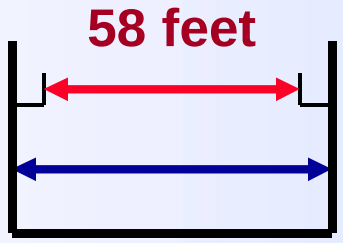
$$\text{WOR, gpd/ft} = \frac{690{,}000 \text{ gpd}}{69.08 \text{ ft}}$$

$$= 9{,}988 \text{ gpd/ft}$$

Hydraulic Loading - Weir Overflow Rate (WOR)

Example 2.

The flow to a circular clarifier is 1.65 MGD. The clarifier is 60 feet in diameter with the weir set in 1 foot from the outside wall. Calculate the weir overflow rate.



$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

$$\text{Length of Weir, ft} = \pi \times \text{Weir Diameter}$$
$$= 3.14 \times 58 \text{ ft}$$
$$= 182 \text{ ft}$$

$$\text{WOR, gpd/ft} = \frac{1{,}650{,}000 \text{ gpd}}{182 \text{ ft}} = 9{,}066 \text{ gpd/ft}$$

Hydraulic Loading - Weir Overflow Rate (WOR)

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1.

The flow to a circular clarifier is 0.80 MGD. The clarifier is 30 feet in diameter with the weir set in 1 foot from the outside wall. Calculate the weir overflow rate.

Practice 2.

The flow to a circular clarifier is 1.4 MGD. The clarifier is 54 feet in diameter with the weir set in 1 foot from the outside wall. Calculate the weir overflow rate.

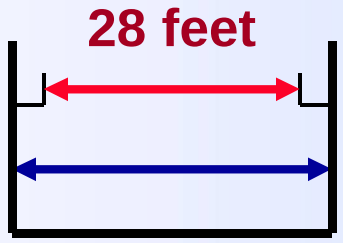
Practice 3.

The flow to a circular clarifier is 2.1 MGD. The clarifier is 75 feet in diameter with the weir set in 18 inches from the outside wall. Calculate the weir overflow rate.

Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 1.

The flow to a circular clarifier is 0.80 MGD. The clarifier is 30 feet in diameter with the weir set in 1 foot from the outside wall. Calculate the weir overflow rate.



$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

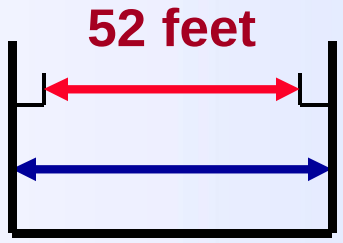
$$\text{Length of Weir, ft} = \pi \times \text{Weir Diameter}$$
$$= 3.14 \times 28 \text{ ft}$$
$$= 88 \text{ ft}$$

$$\text{WOR, gpd/ft} = \frac{800{,}000 \text{ gpd}}{88 \text{ ft}} = 9{,}091 \text{ gpd/ft}$$

Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 2.

The flow to a circular clarifier is 1.4 MGD. The clarifier is 54 feet in diameter with the weir set in 1 foot from the outside wall. Calculate the weir overflow rate.



$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

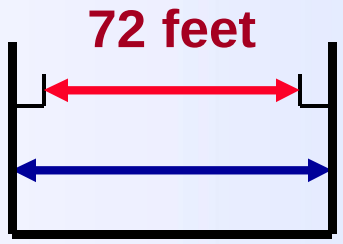
$$\text{Length of Weir, ft} = \pi \times \text{Weir Diameter}$$
$$= 3.14 \times 52 \text{ ft}$$
$$= 163 \text{ ft}$$

$$\text{WOR, gpd/ft} = \frac{1{,}400{,}000 \text{ gpd}}{163 \text{ ft}} = 8{,}589 \text{ gpd/ft}$$

Hydraulic Loading - Weir Overflow Rate (WOR)

Practice 3.

The flow to a circular clarifier is 2.1 MGD. The clarifier is 75 feet in diameter with the weir set in 18 inches from the outside wall. Calculate the weir overflow rate.

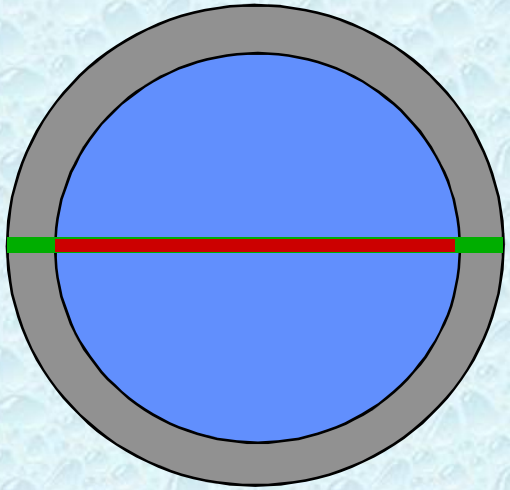


$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

$$\text{Length of Weir, ft} = \pi \times \text{Weir Diameter}$$
$$= 3.14 \times 72 \text{ ft}$$
$$= 226 \text{ ft}$$

$$\text{WOR, gpd/ft} = \frac{2{,}100{,}000 \text{ gpd}}{226 \text{ ft}} = 9{,}292 \text{ gpd/ft}$$

Clarifier Loading



Hydraulic Loading

Weir Overflow Rate (WOR)

The flow in gallons per day per linear foot of weir

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

Typical Design Value = ~10,000 gal/day/ft

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

The pounds per day of solids in the clarifier influent per square foot of surface area

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

Same Calculations as for Hydraulic Loading

$SA = L \times W$

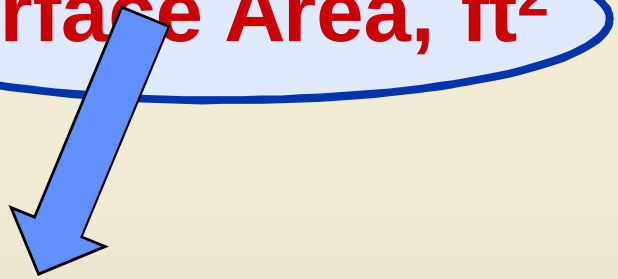
$SA = \pi r^2$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

The pounds per day of solids in the clarifier influent per square foot of surface area

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$



“Pounds Equation”

“Pounds Equation”

Pounds =

Conc. x Flow (or Volume) x 8.34 Lbs/gallon

Concentration Of STUFF In the Water **X** **Quantity Of Water The STUFF Is In** **X** **Weight Of The Water**

“Pounds Equation”

Flow (volume) and concentration must be expressed in specific units.

Flow or volume must be expressed as millions of gallons:

$$\frac{\text{gallons}}{1{,}000{,}000\ \text{gal/MG}} = \text{MG}$$

i.e.) A tank contains 1,125,000 gallons of water. How many million gallons are there?

$$\frac{1{,}125{,}000\ \text{gal}}{1{,}000{,}000\ \text{gal/MG}} = 1.125\ \text{MG}$$

“Pounds Equation”

Concentration must be expressed as parts per million parts.

Concentration usually reported as milligrams per liter.
This unit is equivalent to ppm.

$$\frac{1\text{ mg}}{\text{liter}} = \frac{1\text{ mg}}{1000\text{ grams}} = \frac{1\text{ mg}}{1{,}000{,}000\text{ mg}} = \text{ppm}$$

$$\text{ppm} = \frac{\text{Parts}}{\text{Mil Parts}} = \frac{\text{Lbs.}}{\text{Mil Lbs.}}$$

“Pounds Equation”

When flow (volume) is expressed as MG and conc. is in ppm, the units cancel to leave only *pounds*.

Lbs. =

Concentration x Flow (or volume) x 8.34 lbs/gallon

$$\frac{\cancel{\text{Lbs.}}}{\cancel{\text{M}}\ \cancel{\text{Lbs.}}} \times \cancel{\text{M gal}} \times \frac{\text{Lbs.}}{\cancel{\text{gal}}}$$

"Pounds Equation"

If the flow rate is entered in M gal per day (MG/D), the answer will be in lbs/day.

Example:

The flow to a clarifier is 1.2 MGD and the concentration of suspended solids in the flow is 2500 mg/L. How many pounds of suspended solids come into the clarifier each day?

$$\text{Lbs/day} = \text{conc. (mg/L)} \times \text{flow (MGD)} \times \frac{8.34 \text{ lbs}}{\text{gal}}$$

$$\text{Lbs/day} = 2500 \text{ mg/L} \times \frac{1{,}200{,}000 \text{ gal/day}}{1{,}000{,}000 \text{ gal/MG}} \times \frac{8.34 \text{ lbs}}{\text{gal}}$$

$$= 2500 \times 1.2 \times 8.34$$

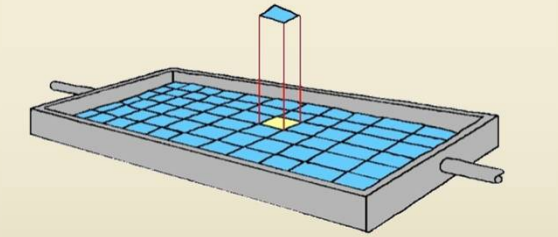
$$= 25{,}020 \text{ Lbs/day}$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

The pounds per day of solids in the clarifier influent per square foot of surface area

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$



Typical Design Value = Max 30 lbs/d/ft^2

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Example 1.

Calculate the Solids Loading Rate for a clarifier with a 50 ft diameter and a depth of 12 feet, and receives a flow of 2.4 MGD with a suspended solids concentration of 1800 mg/L.

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

Solids, lbs/day =

1800 mg/L X 2.4 MGD X 8.34 lbs/gal = 36,029 lbs/d

SA = 3.14 X 25 ft X 25 ft = 1962.5 ft^2

$$\text{SLR, lbs/d/ft}^2 = \frac{36{,}029 \text{ lbs/day}}{1962.5 \text{ ft}^2} = 18.4 \text{ lbs/d/ft}^2$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Example 2.

Calculate the Solids Loading Rate for a clarifier with a 31 ft diameter and a depth of 9 feet, and receives a flow of 750,000 gallons per day with a suspended solids concentration of 2600 mg/L.

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

Solids, lbs/day =

2600 mg/L X 0.75 MGD X 8.34 lbs/gal = 16,263 lbs/d

SA = 3.14 X 15.5 ft X 15.5 ft = 754 ft^2

$$\text{SLR, lbs/d/ft}^2 = \frac{16{,}263 \text{ lbs/day}}{754 \text{ ft}^2} = 21.6 \text{ lbs/d/ft}^2$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Work Calculations on Separate Paper
Answers Given on Next Slides

Practice 1.

Calculate the Solids Loading Rate for a clarifier with a 12 ft width and a length of 50 feet, and receives a flow of 600,000 gallons per day with a suspended solids concentration of 3400 mg/L.

Practice 2.

Calculate the Solids Loading Rate for a clarifier with a 22 ft radius and a depth of 8.5 feet, and receives a flow of 1,450,000 gallons per day with a suspended solids concentration of 3400 mg/L.

Practice 3.

Calculate the Solids Loading Rate for a clarifier with a 22 ft diameter and a depth of 7 feet, and receives a flow of 0.82 MGD
with a suspended solids concentration of 1950 mg/L.

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Practice 1.

Calculate the Solids Loading Rate for a clarifier with a 12 ft width and a length of 50 feet, and receives a flow of 600,000 gallons per day with a suspended solids concentration of 3400 mg/L.

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

$$3400 \text{ mg/L} \times 0.6 \text{ MGD} \times 8.34 \text{ lbs/gal} = 17{,}014 \text{ lbs/d}$$

$$\text{SA} = 12 \text{ ft} \times 50 \text{ ft} = 600 \text{ ft}^2$$

$$\text{SLR, lbs/d/ft}^2 = \frac{17{,}014 \text{ lbs/day}}{600 \text{ ft}^2} = 28.4 \text{ lbs/d/ft}^2$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Practice 2.

Calculate the Solids Loading Rate for a clarifier with a 22 ft radius and a depth of 8.5 feet, and receives a flow of 1,450,000 gallons per day with a suspended solids concentration of 3400 mg/L.

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

$$3400 \text{ mg/L} \times 1.45 \text{ MGD} \times 8.34 \text{ lbs/gal} = 41{,}116 \text{ lbs/d}$$

$$SA = 3.14 \times 22 \text{ ft} \times 22 \text{ ft} = 1520 \text{ ft}^2$$

$$\text{SLR, lbs/d/ft}^2 = \frac{41{,}116 \text{ lbs/day}}{1520 \text{ ft}^2} = 27.1 \text{ lbs/d/ft}^2$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

Practice 3.

Calculate the Solids Loading Rate for a clarifier with a 22 ft diameter and a depth of 7 feet, and receives a flow of 0.82 MGD with a suspended solids concentration of 1950 mg/L.

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

$$1950 \text{ mg/L} \times 0.82 \text{ MGD} \times 8.34 \text{ lbs/gal} = 13{,}336 \text{ lbs/d}$$

$$\text{SA} = 3.14 \times 11 \text{ ft} \times 11 \text{ ft} = 380 \text{ ft}^2$$

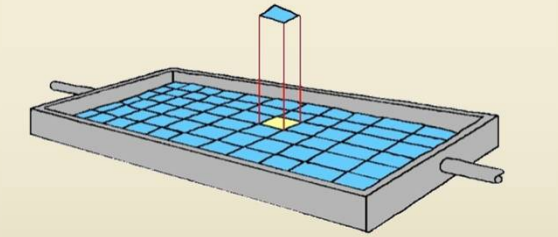
$$\text{SLR, lbs/d/ft}^2 = \frac{13{,}336 \text{ lbs/day}}{380 \text{ ft}^2} = 35.1 \text{ lbs/d/ft}^2$$

Clarifier Loading

Solids Loading - Solids Loading Rate (SLR)

The pounds per day of solids in the clarifier influent per square foot of surface area

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$



Typical Design Value = 25 - 30 lbs/d/ft^2

Clarifier Loading Calculations

Detention Time (DT)

$$\text{DT, hrs} = \frac{\text{Tank Volume, MG X 24}}{\text{Flow into Tank, MGD}}$$

Typical Design Value = 2 – 3 Hours

Surface Overflow Rate (SOR)

$$\text{SOR, gpd/ft}^2 = \frac{\text{Flow, gallons/day}}{\text{Surface Area, ft}^2}$$

Typical Design Value = 400 - 800 gal/d/ft^2

Weir Overflow Rate (WOR)

$$\text{WOR, gal/d/ft} = \frac{\text{Flow, gallons/day}}{\text{Length of Weir, ft}}$$

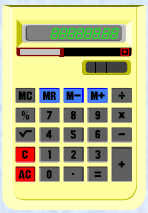
Typical Design Value = ~10,000 gal/d/ft

Solids Loading

$$\text{SLR, lbs/d/ft}^2 = \frac{\text{Solids, lbs/day}}{\text{Surface Area, ft}^2}$$

Typical Design Value = 25 - 30 lbs/d/ft^2

Clarifier Calculations



Prepared By
Michigan Department of Environmental Quality
Operator Training and Certification Unit