Hydraulics for Distribution System Operators*

OTCO Water Workshop Webinar

OTCO-D527025-OM **0.75 contact hours**

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*From a set of operator training videos posted on YouTube

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Archiving – A Time Honored Tradition

- As operators, we used to pass around - from generation to generation - lots of sample test questions and procedures that were on paper
- We made copies of copies of copies
- When a new operator came on board, or when an operator needed to prepare for exams, we cranked up various types of mimeograph machines

Mimeograph Machine Issues

Scene from the 1970's

The side-effects

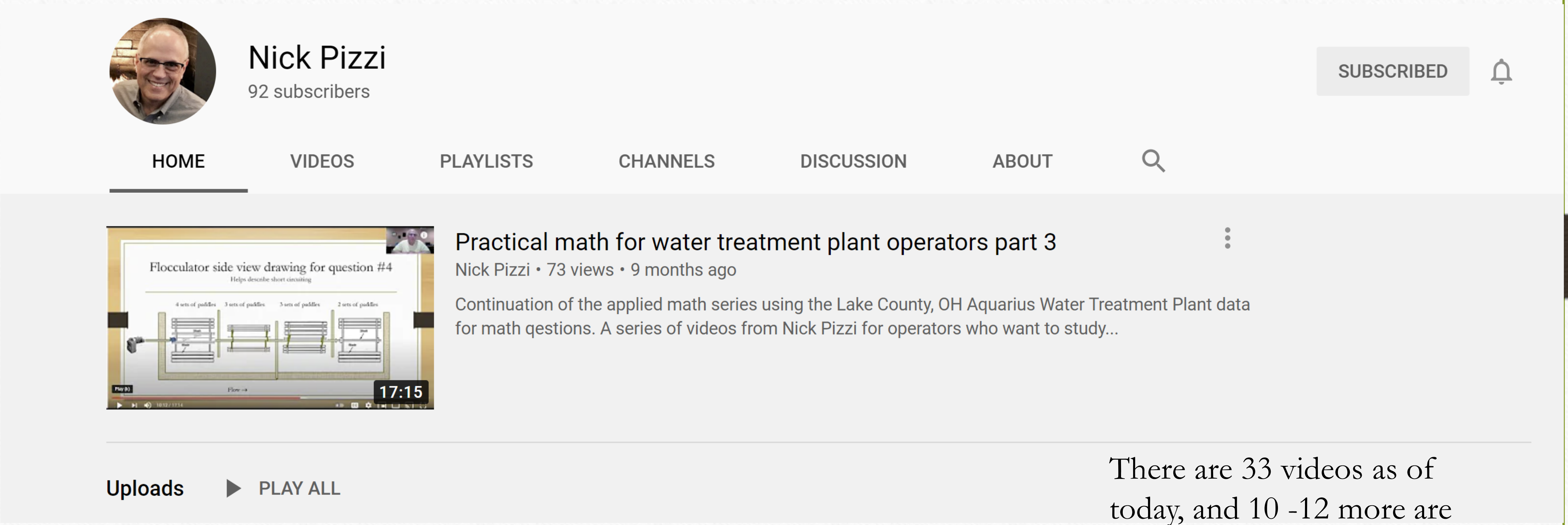
What's Been Lost

- I've heard some plant superintendents complain that today's operating environment with its high-tech drivers has eaten up much of their traditional training time
  - They mention that the more complicated regulatory structure, and the time spent in online meetings during these difficult times, has made it more problematic to train staff
- To that end, I've been trying to make videos that preserve some of the older knowledge for future operators to view when they want to
- I'm also talking to some of the long-time operators I've known to get them to make a few videos with me
- Curtis wanted me to mention that I have been putting some of these training videos on You Tube for those operators who want to sharpen their math and operating skills

Videos Made From Slide Decks

Their structure and purpose

- All of the videos start out as a PowerPoint presentation that contains the material used for the topic
- The slide deck covers the topic in some detail, and supports the topic with appropriate figures and tables, and usually has several example math or theory problems that the viewer can use to test themselves
- The videos are structured by starting out with some lecture and when applicable, tables of data and conversion factors, along with line diagrams, are supplied
  - The viewer is then instructed to listen to the question or problems presented and then to pause the video in order to work the problem on their own if they choose, or to do a screen grab, or to rewind to hear parts of the lecture repeated
  - Starting the video up again then reveals the answers
- Much of the material comes from actual operating and design data provided by the Lake County Department of Utilities
- A lot of it comes from the old exam study materials and from long – lost procedures we used to do
  - So: this is a form of ***archiving*** – memorializing material so it won't be lost over time



There are 33 videos as of today, and 10 -12 more are planned. Email me if you have ideas for what you'd like to see

https://www.youtube.com/channel/UCEhTLd3bNZAjz3E3BaGYUGg

More About the Site

- The channel is public and no passwords or any type of permission is needed
- Subscriptions are open in you want to do so, and that will automatically notify you when new videos are posted
- Comments are disabled, and you can subscribe anonymously
- There are no fees or agreements you must adhere to, and all of the material is kept in the public domain
- What follows is a basic hydraulics topic from which a video was made and posted

Definition of "Hydraulics"

"Hydraulics is the study of fluids in motion"

Distribution of Drinking Water

- As system operators, we can confine our study of fluids to drinking water
- The basics that most distribution operators should familiarize themselves with are these 6 hydraulic concepts we will discuss today:
  - Volume
  - Flow rate
  - Detention time
  - Velocity
  - Head and Pressure
  - Horsepower for Pumping

Terminology: Hydraulics for Operators Using 8 Hydraulic Terms

- In order to provide drinking water to our customers, we must move water from one point to another, and sometimes from a lower elevation to a higher elevation
- To describe our work, we need to know the terminology, math and characteristics about that movement, such as:
  - How much water is being moved from one point to another? (Volume) (Flow rate)
  - How fast is it getting to where we want it to go? (Velocity) (Detention Time)
  - What size is the cross-sectional area of pipes and tanks that the flow moves across? (Area)
  - How much energy do we need to move water? (Horsepower) (Pressure) (Head)

(So there are those 8 terms we should discuss today)

Symbols Used for the Terminology

Math Shorthand for the Eight Terms

Terminology	Symbols	Expressions	Formulas
Area	A	in^2, ft^2, M^2	Length x width, 0.785 x D^2, ΠR^2
Volume	Vol	ft^3, gals	Area x length or width
Flow rate	Q	gpm, cfs	Area x Velocity
Velocity	V	fps, fpm, m/sec	V = Q/A
Detention Time	D_t	sec, min, hr, day	V / Q
Head	H’	ft	2.31 x psi, psi/0.433
Pressure	psi	lbs/in^2	(gals x 8.34) / in^2
Horsepower	HP	HP	(gpm x H’) / 3,960

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Velocity	**V**	fps, fpm, m/sec	V = Q/A
Detention Time	**D_t**	sec, min, hr, day	V / Q
Head	**H'**	ft	2.31 x psi, psi/0.433
Pressure	**psi**	lbs/in^2	(gals x 8.34) / in^2
Horsepower	**HP**	HP	(gpm x H') / 3,960

shorthand

Conversion chart

needed for the math

Convert	Multiply by:	Obtain
cubic foot (ft^3)	7.48	gallons
gallon (gal)	3.785	Liters
Million gallons per Day (mgd)	1.55	cfs
Million gallons per Day (mgd)	694	gpm
Pounds per square inch (psi)	2.31	Feet of head
Day	1,440	minutes
Pounds	453.6	grams

The Use of Conversion Factors

Sometimes we have to use "conversion factors" in our calculations

A conversion factor is an arithmetical multiplier that converts a quantity expressed in one set of units into an equivalent set of other units

A conversion chart was provided early on in this presentation and can be accessed by reversing the video to that point

An example of conversion factor use:

A container is holding 1.25 cubic feet of water. How many gallons is this?

1.25 ft^3 X (7.48 gals/ft^3) = 9.35 gallons

7.48 is the conversion factor

Notice the multiplier, the conversion, and the equivalency

Conversion factors are fixed numbers – they don't change

Six Hydraulic Concepts

Some Examples

As described with the help of the 8 hydraulic terms

Volume

Shown as “Volume” or “Vol”

Volume Calculation

- How many gallons will this tank hold if it is 40 feet tall and 50 feet wide? Ignore the pipe section.
  - Volume = Area X height
    - Volume = (0.785 x 50’ x 50’) x 40’
    - Volume = 1,962.5 ft^2 x 40’ = 78,500 ft^3
  - Convert cubic feet to gallons
    - 78,500 ft^3 x (7.48 $gals/ft^3$) = 587, 180 gallons

Volume Calculation

- A new 30-inch main is being installed and you must fill it up for pressure testing. If it is 1,500’ long, how much water will it take to fill it?
  - Vol = 0.785 x $2.5'^2$ x 1,500’ ≈ 7,360 ft^3
  - 7,360 ft^3 x 7.48 ≈ 55,048 gallons

This symbol means “approximately equal to”

Flow Rates

Shown as “Q”, and units are typically gpm or cfs or mgd

Flow Rates

- Flow rates, or "rate of flow", is a term we use in hydraulics that describes the **AMOUNT** of water flowing for a given **UNIT OF TIME**
- In water systems, the math we use in flow rate calculations often assigns the symbol "Q" to denote flow rate
- Flow rate, or Q, must be calculated by determining two things:
  - the area, or "A", of the vessel through which water is flowing, and
  - the speed or velocity, "V", of the water flowing
- The formula for flow rate is $Q = A * V$ (i.e., A multiplied by V)

Flow Rate Calculations

- A flow rate, or the "rate of flow", provides us with information about the **AMOUNT** of water moving through a system per **UNIT OF TIME**.
- The symbol that is typically used to denote flow rate is the letter "Q"
- For distribution system hydraulics, the flow rates most commonly seen are:
  - Million gallons per Day (MGD)
  - Gallons per minute (gpm)
  - Cubic feet per second (cfs, or ft^3/sec)

Flow Rate – things to remember when using the formula Q = A x V

- The **Area** of the vessel will usually need to be calculated
- The vessel through which flow rate is being calculated is typically or pipe or a channel
  - For a pipe, use the formula $\Pi \times R^2$, or $0.785 \times D^2$
  - For a rectangular channel, use Depth x Width
- Area and velocity units must MATCH
  - If area is in square feet, the velocity must be feet per unit time
    - Example: feet per second, fps
- You cannot multiply square inches by feet per second – you must convert one of the other to have them the same
- You may need to convert answers back and forth between gpm and cfs (or other)

Example Flow Rate Calculation

- How many gpm are flowing through a 16-inch water main if the velocity in the pipe is 2.5 fps?
  - Use the formula Q = A x V
  - Since they are asking for an answer in gpm, first convert the diameter of the main to feet
    - 16 inches x (1 ft/12 inches) = 1.33 feet
    - Area of 16 inch main = 0.785 x $1.33'^2$ = 1.389 ft^2
  - And: Q = 1.389 ft^2 x 2.5 feet per second = 3.47 cfs
  - 3.47 cfs x (60 sec/min) x (7.48 gal/ft^3) ≈ 1,560 gpm

Velocity

Shown in formulas as “V” and common units are fps or mps

Velocity

- Velocity is a term we use in hydraulics that describes the **SPEED** of water flowing for a given **UNIT OF TIME**
- In water systems, the math we use in velocity calculations often assigns the symbol "V" to denote speed or velocity
- Velocity, or V, must be calculated by determining two things:
  - the area, or "A", of the vessel through which water is flowing, and
  - the flow rate, "Q", of the water moving through the vessel
- The formula for Velocity is Vel = Q ÷ A (i.e., Q divided by A)
- By its nature, the Velocity formula suggests an average rate of many velocities
  - Important to understand that every drop of water in the flow column is moving at different speed, and they average out to V

Velocity Equation

- You may have noticed that the Velocity equation looks a lot like the equation we use for Flow Rate
  - Q = A * V
  - That's because it is the same equation simply rearranged to calculate V, not Q
  - As such, the same principles apply to the velocity equation that apply the equation for Q:
    - You will need to find the square area of the vessel through which the water is flowing
    - For cylinders, use 0.785 * D^2, and for rectangular channels use the width times the depth

Velocity – things to remember when using the formula V = Q/A

- The **Area** of the vessel will usually need to be calculated
- The vessel through which Velocity is being calculated is typically a pipe or a channel
  - For a pipe, use the formula Π x R^2, or 0.785 x D^2
  - For a rectangular channel, use Depth x Width
- Area and flow units must MATCH
  - If area is in square feet, the flow must be cubic feet per unit time
    - Example: cubic feet per second, cfs
- You cannot divide gpm by square feet– you must convert the gpm to cubic feet per unit of time
- You may need to convert answers back and forth between fps and centimeter/min (or other)

Velocity calculations

- Example of a velocity calculation:
  - What is the water velocity in feet per second in a 0.19625 square foot pipe if the water is moving through it with a flow rate of 0.589 cubic feet per second?
  - Velocity, V = Q/A
  - Area of pipe given = 0.19625 square feet
  - Flow rate was given as 0.589 ft^3/sec
  - Vel = 0.589 ft^3/sec ÷ 0.19625 ft^2 = about 3 ft/sec

Notice that the square feet in the denominator cancel out square feet in the numerator, leaving you only

with feet per second $\frac{ft \; X \; ft \; X \; ft/sec}{ft \; X \; ft} = ft \; per \; second, or \; fps$

Velocity calculation and conversion

- What is the velocity in fps in a 24-inch water main when the water is flowing at 6,060 gpm?
- V = Q/A
  - Area of a 24-inch main is A = 0.785 x 2’ x 2’ = 3.14 ft^2
  - Flow rate, Q is given as 6,060 gpm
- V = Q/A = 6,060 gpm ÷ 3.14 ft^2 - this won’t work – you must convert gpm to cfs
- 6,060 gpm x (1 min/60 sec) x (1 ft^3/7.48 gal) = 13.5 cfs
- V = Q/A = 13.5 ft^3/sec ÷ 3.14 ft^2 = 4.3 fps

Detention Time

Seen as "Dt" and typical units are sec or min or hr or D

Detention Time Calculations

- Detention Time calculations tell us the TIME it takes for a VOLUME of water to FLOW from or into a vessel such as a pipe or tank
- The symbol used to denote detention time is D_t
- The formula for detention time is:

$$\mathbf{D_t = Volume\ /\ flow\ rate,\ or\ Vol/Q}$$

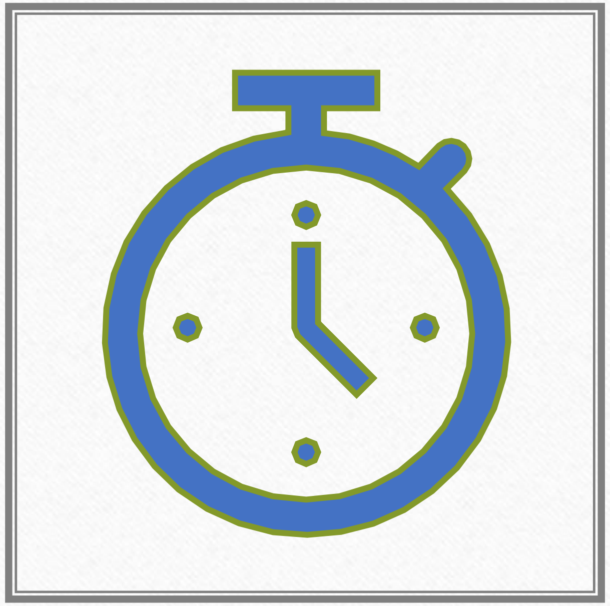
- Where Dt is time in standard units (e.g. sec, mins, hours, days), Vol is the amount of water contained in the vessel, and Q is the rate of flow entering or leaving the vessel

Detention time – things to remember when using the formula $Dt = \frac{Volume}{Flow\ rate}$

- The volume of the tank or pipe is always in the numerator, or top of the fraction
- The flow rate of the water moving into the tank, or through the pipe, is always the denominator, the bottom of the formula
- Time and volume units must MATCH
  - If detention time is in minutes, then the flow rate used in the calculation must have the same time frame (such as cfm, or gpm)
- Volume and flow units must MATCH
  - You cannot divide gallons by cubic feet per sec, nor can you divide cubic feet by gpm - you need to **convert** one to the other

Example Detention Time Calculation

- How long will it take to fill an empty cylindrical storage tank that is 28.5 feet in diameter and 34 feet in height if it is filling at a rate of 475 gpm? Give your answer in hours and minutes.
- Use the formula Det Time = Vol/Q
  - We will have to make a conversion between gallons and cubic feet, and change hours to minutes
  - 475 gpm x (1 ft^3 / 7.48 gals) = 63.5 cfm
- Dt = $(0.785\ x\ 28.5'x\ 28.5'x\ 34')/_{63.5\ cfm}$
- Dt = 341.4 minutes, or 5.69 hours, which is 5 hours and (0.69 x 60 mins)
  - 5 hours and 41 minutes



Head and Pressure

Is seen as psi or feet or ft or H’

Head and Pressure Calculations

Head and Pressure are two interchangeable terms we use to help us with math

Head

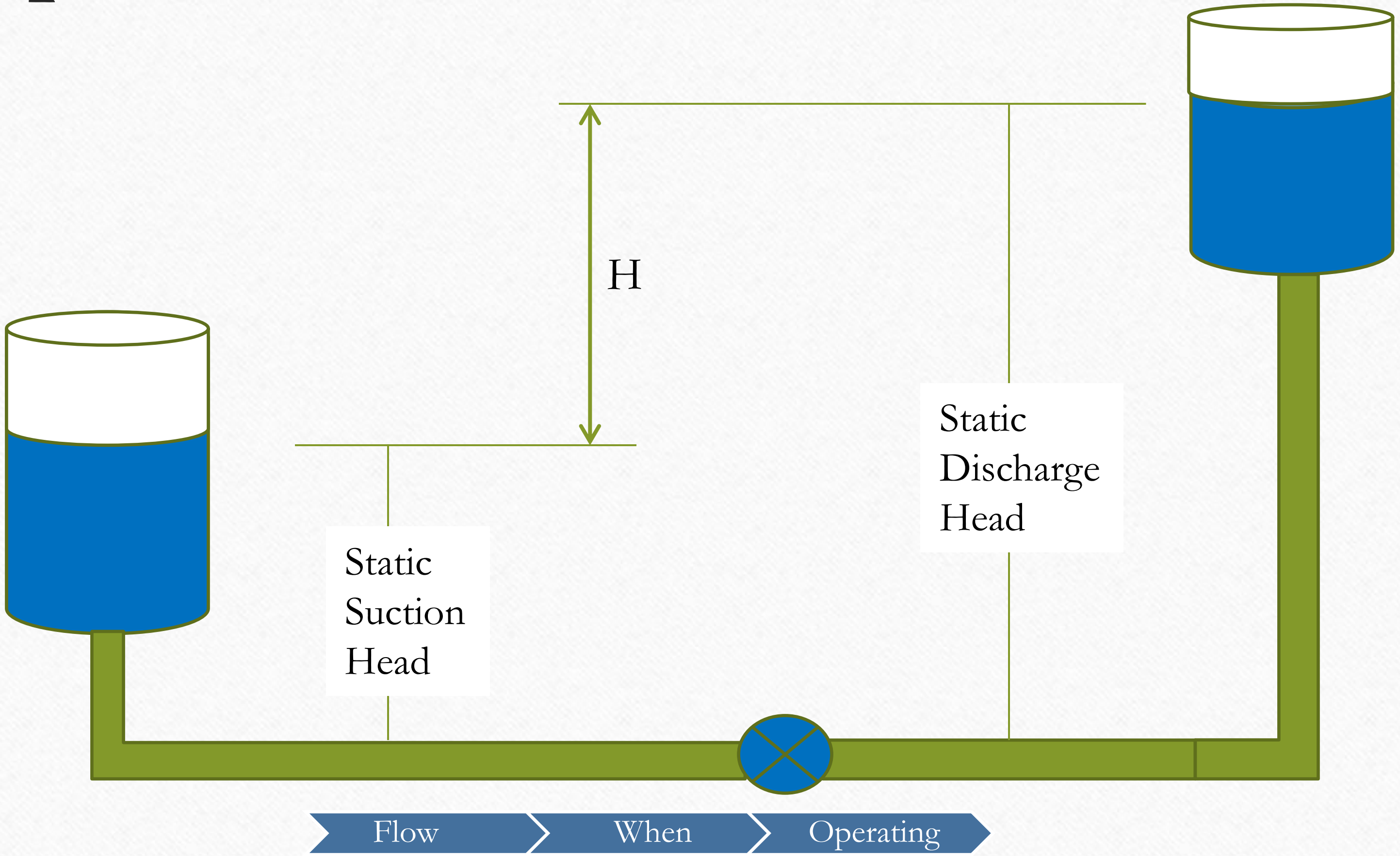
- For practical purposes, head is the **PRESSURE** at any given point in the water system
- It is calculated as the pressure exerted by a hypothetical column of water with its free surface rising in the column above the hydraulic system
- Head is usually expressed as feet, but also as meters

Pressure

- Pressure is described as the **FORCE** pushing on a **UNIT AREA**
- Pressure is normally expressed as psi
- Pressure can be measured as:
  1. Psi
  2. Feet of head
  3. Meters of head

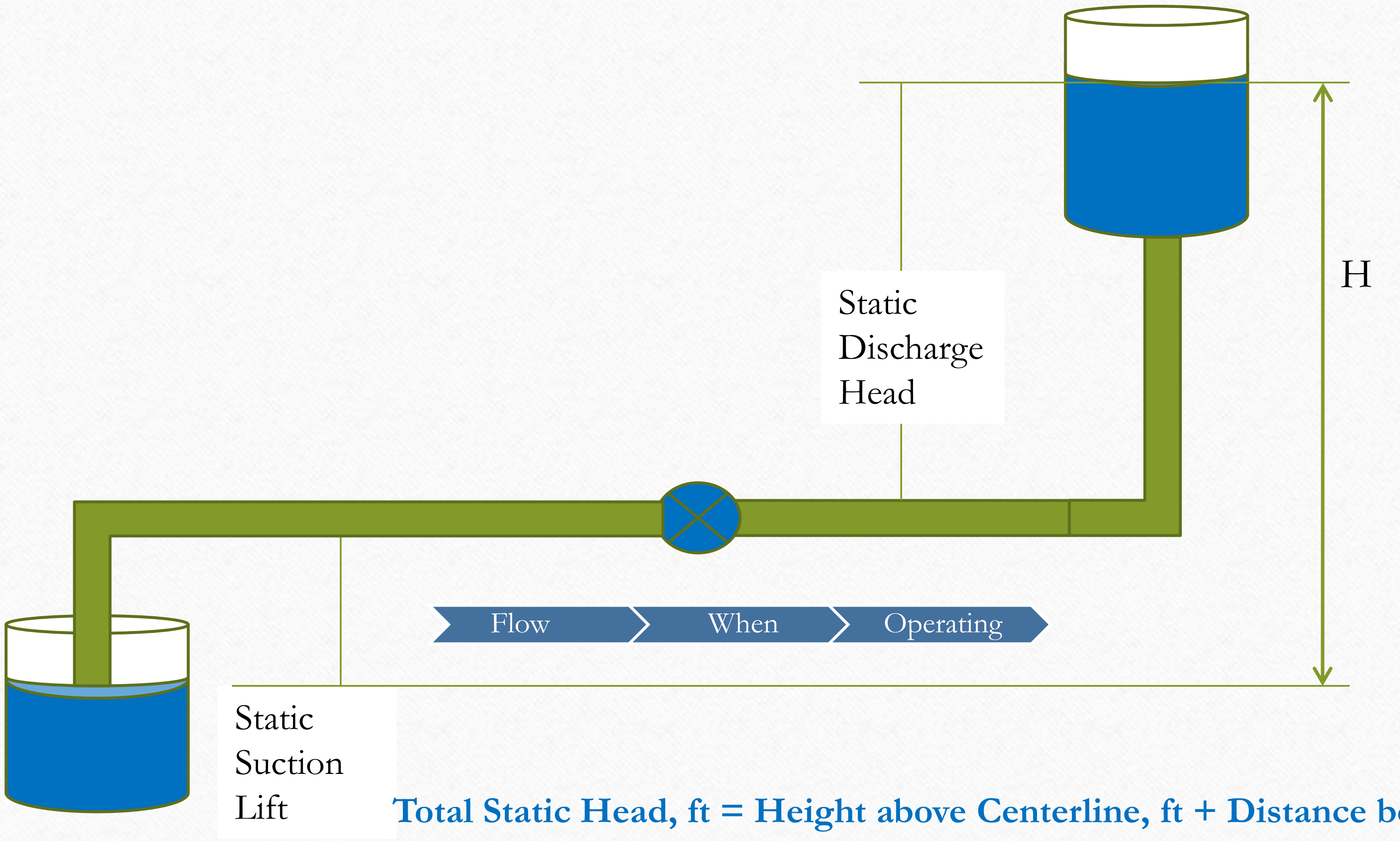
Conversions: 1 psi = 2.31 feet of head 1 foot of head = 0.433 psi

Pump with Static Suction Head



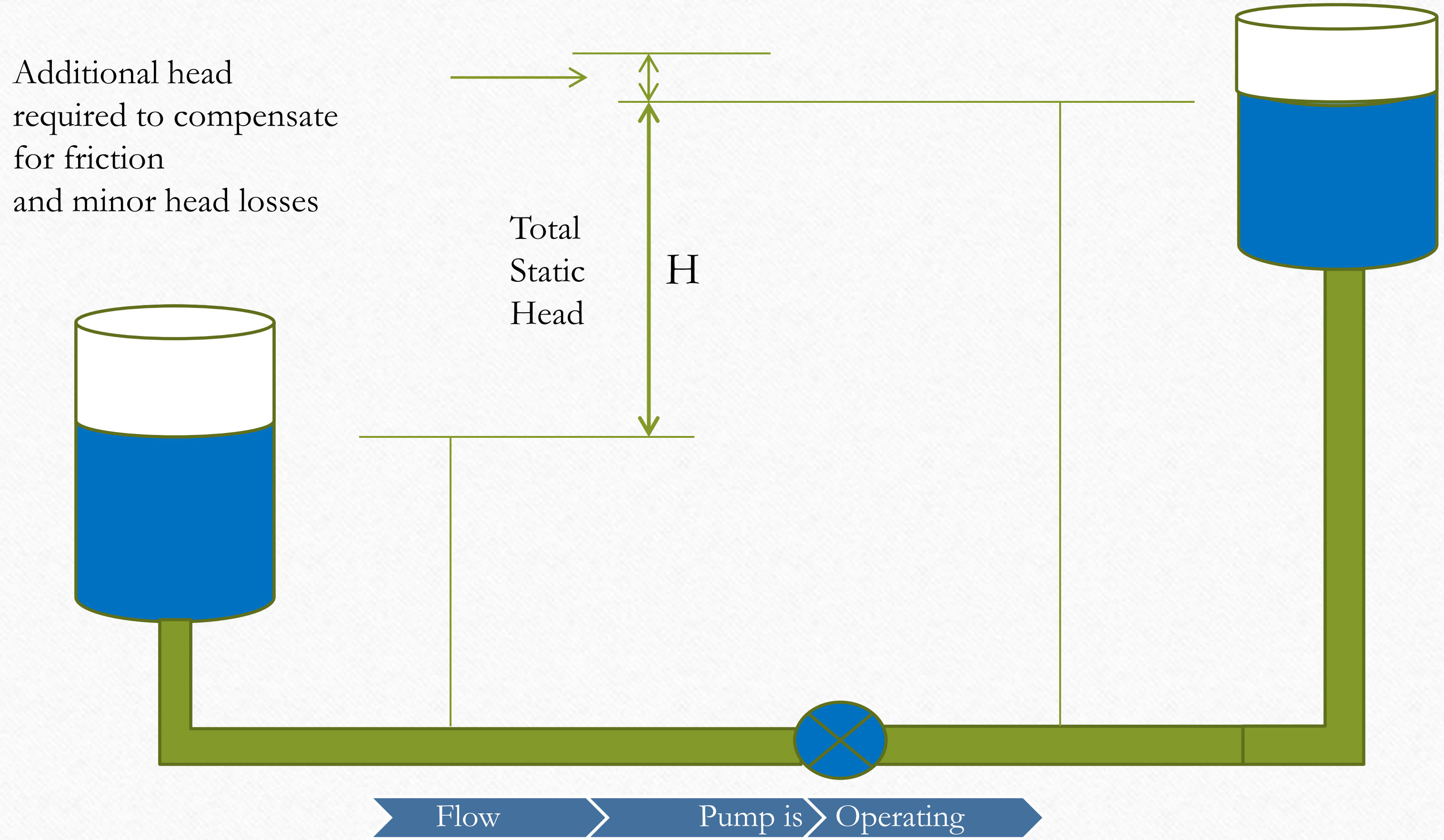
Total Static Head, ft = Higher elevation, ft - Lower Elevation, ft

Pump with Static Suction Lift



Total Static Head, ft = Height above Centerline, ft + Distance below Centerline, ft

Pump operating with Head Loss



Total Dynamic Head, ft = Total Static Head, ft + Head losses, ft

Horsepower and Pumping

Seen as HP

Pumping water

- We tend to think of a pump as a machine that moves a certain VOLUME of water per UNIT OF TIME, and we are right to do so
- But in order to talk about the amount of WORK DONE when a pump moves water, we have to focus on the WEIGHT of water being moved over a specific elevation distance, or HEAD, in an interval of TIME
- In fact, the formula for work done by a pump – which we call HORSEPOWER – does just that: it calculates the POWER needed to move WEIGHT of water up hill (HEAD) in that TIME interval

The HORSEPOWER Formula

- The formula most often shown to us on exams for calculating Horsepower (HP) is this:

$$HP = \frac{gpm\ X\ Head'}{3{,}960}$$

- But that is a shortened form of the original formula which came about at a time when we hadn't yet developed steam power or electrical power, but draft horses, and it is:

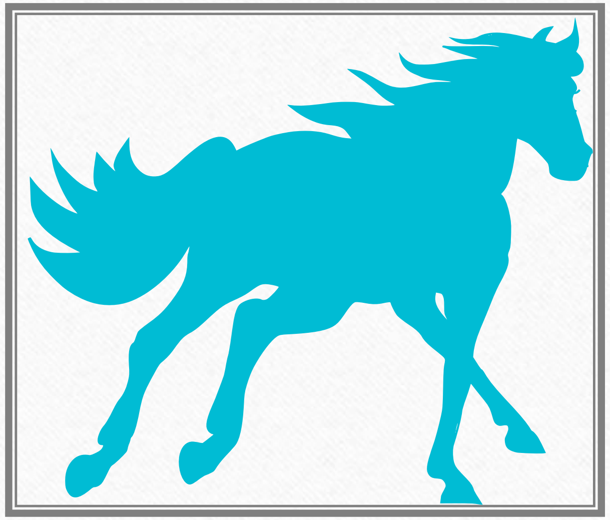
- $$HP = \frac{(gal/min) \times 8.34\ lbs/gal) \times (H^{feet})}{(33{,}000\ ft\text{-}lbs/min)\ /\ HP}$$

A good draft horse could pull 550 lbs a distance of 1' in 1 sec

In 1 minute, that is 33,000 ft-lbs

And 33,000 divided by 8.34 lbs/gal – about 3,960

Horsepower Calculations



- So when we do HP calculations, we typically must find the information we need:
  1. We need to find out the amount of water being pumped or flowing into or out of a vessel – and it needs to be changed into gpm if necessary
  2. We need to find out how much distance the water is going to move against or which level it moves up to – the Head in feet
     a) Friction can play a role, and it needs to be added to the head
     b) The elevation of the water on either side of the pump must be known
  3. If the math questions asks for efficiencies to be factored in, they must be put into the bottom of the HP fraction – which causes the calculated answer to increase. In other words, friction causes us to put in more power to get the job done

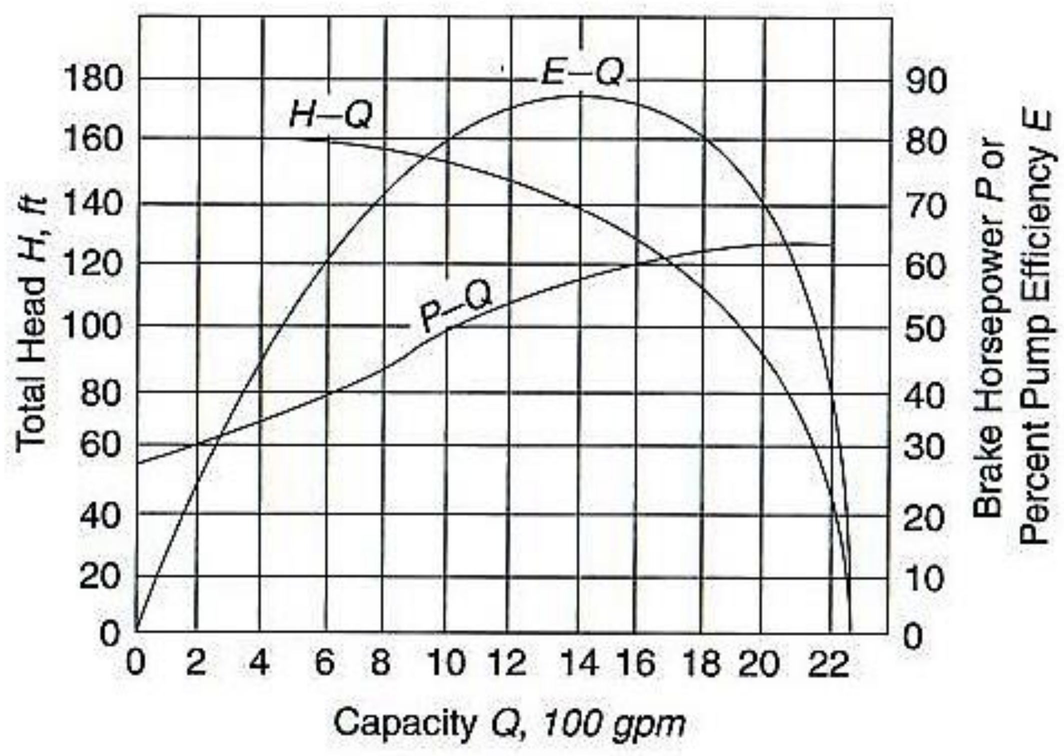
Example HP Calculation

Theoretical

- Calculate the theoretical HP needed to pump 585 gpm to an elevation of 56’

- $\text{HP} = \frac{gpm\ X\ Head'}{3{,}960}$

- $\text{HP} = \frac{585\ gpm\ X\ 56'}{3{,}960} = 8.27$



Pump curves

- H-Q is Head curve
  - Shows the relationship between total head (H) against which the pump must operate and pump capacity (Q)
- P-Q is Power curve
  - Shows the relationship between power (P) and capacity (Q)
- E-Q is Efficiency curve
  - Shows the relationship between pump efficiency (E) and capacity (Q) – the more efficient the pump system is, the less costly it is to operate

A pump curve is a graph showing the characteristics of a particular pump

More example calculations

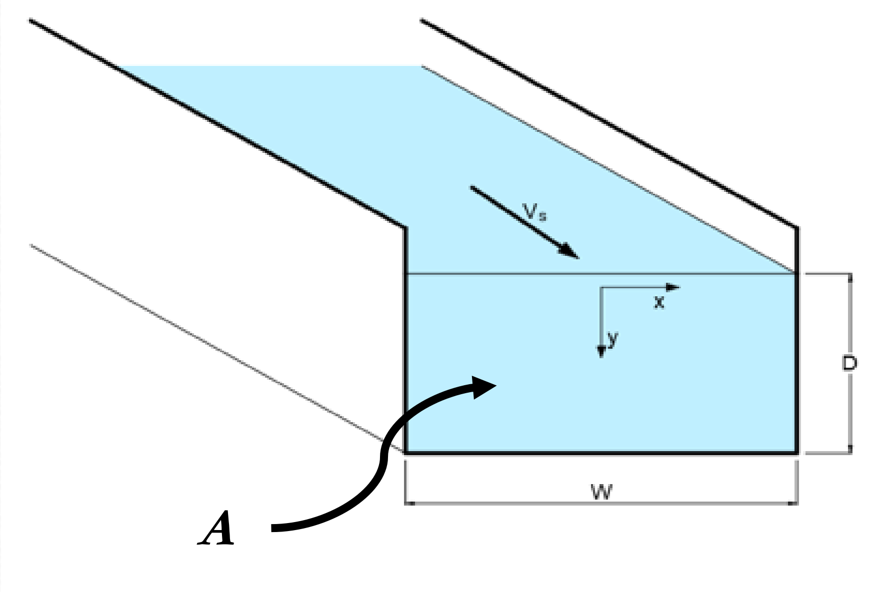
If time permits

Example volume calculation with conversion factor

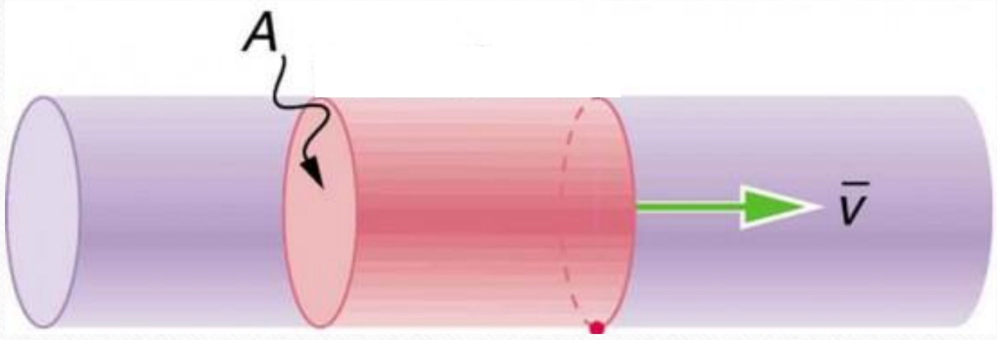
- A day tank is being used to contain a liquid chemical. It measures 4 feet long by 3 feet wide and is filled to a 2-foot level. How much liquid in cubic feet is being held?
  - 4’ X 3’ X 2’ = 24 cubic feet
- How many gallons is the day tank holding?
  - We need to use a conversion factor to find the answer.
  - The conversion factor is that **1 cubic foot = 7.48 gallons**
  - Therefore, 24 cubic feet X 7.48 gallons per cubic foot = 179.52 gallons

Area relation between circular and rectangular vessels

Rectangular channel flow

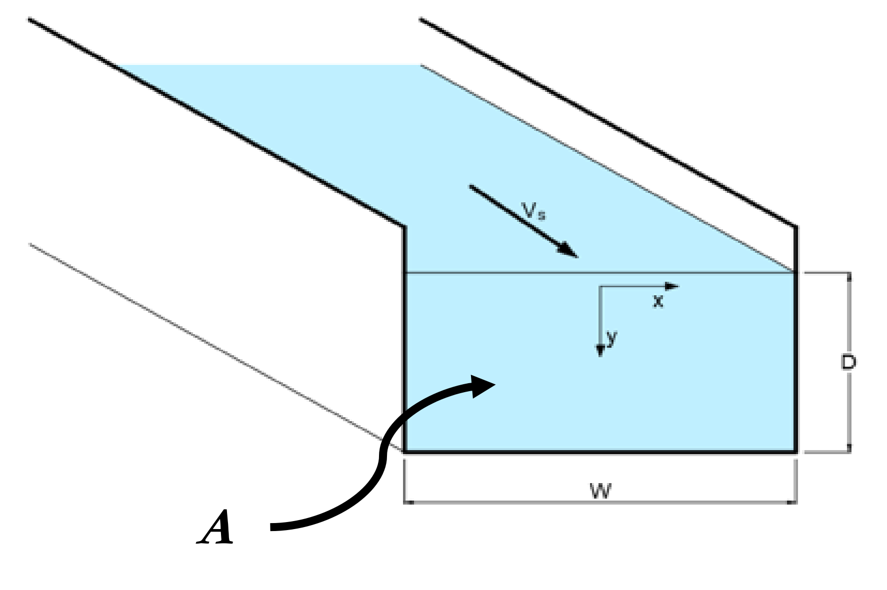


Flow in pipe or cylinder

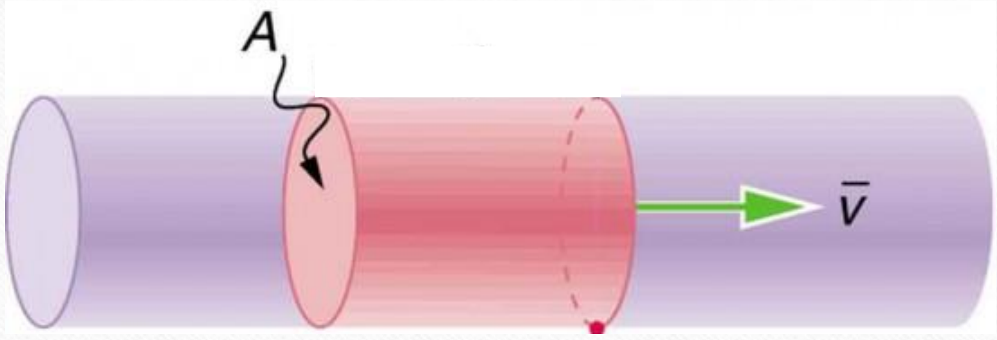


Velocity in circular and rectangular vessels

Rectangular channel velocity



Velocity in pipe or cylinder



Example Velocity Calculation

- Determine the velocity of flow in fps in a 24-inch water main if the flow rate in it is 1,475 gpm
- Use the formula V = Q/A
- Since they are asking for feet per second, we'll have to make a conversions from gallons to cubic feet and from minutes to seconds.
  - 1,475 gal/min x (1 ft^3/7.48 gal) x (1 min/60 sec) = 3.286 cfs
  - A 24-inch main is a 2-foot diameter main.
- V = 3.286 cfs / (0.785 x 2' x 2') = 1.05 fps

Detention time calculations

- Example of a detention time calculation:
  - A 240,000-gallon storage tank is being drained for inspection. It is emptying at a rate of 325 gpm. How long will it take to empty this tank?
  - Detention time = $\frac{Volume}{Flow\ rate}$
  - Volume of tank = 240,000 gallons
  - Emptying rate is stated as 325 gpm
  - Detention time = $\frac{240{,}000\ gallons}{325\ gpm} = about\ 738\ minutes$, or about half of a day

Detention time calculation using conversion

- A flow rate of 0.3 cfs is filling a 75-gallon tank. How long will it take to fill the tank?
- Detention time = $\frac{Volume}{Flow\ rate} = \frac{75\ gallons}{0.3\ cfs} =$ does not work! – first convert
  - Convert gallons to cubic feet
  - 7.48 gallons = 1 cubic foot, so 75 gals/7.48 = about 10 cubic feet
  - So: Detention time = $\frac{Volume}{Flow\ rate} = \frac{10\ cubic\ feet}{0.3\ cfs}$ = about 33 seconds

Detention time calculations using conversion

- Example of a detention time calculation:
  - A 50 gpm pump is used to fill up a new 6-inch water main that is 450 feet long. How long will it take to fill this main?
  - Detention time = $\frac{Volume}{Flow\ rate}$
  - Volume of pipe = 0.785 x 0.5' x 0.5' x 450' x 7.48 gals/ft^3 = 660 gallons
  - Flow rate is stated as 50 gpm
  - Detention time = $\frac{660\ gallons}{50\ gpm} = about\ 13.2\ minutes$

Moving Water Around the System

- We started this module by saying that in order to provide drinking water to our customers, we must move water from one point to another, and sometimes from a lower elevation to a higher elevation
- On its own, water won't move anywhere. It has inertia – it sits still in a container unless we work to move it:
  - It is heavy – it weighs 8.34 pounds per gallon
  - It takes up space – 7.48 gallons of it takes up 1 cubic foot of space
- We had to invent devices to help us with the task of providing water:
  - First came waterwheels and draft animals like the ox and horse
  - Then we invented pumps to move it, and pipes and tanks to contain it

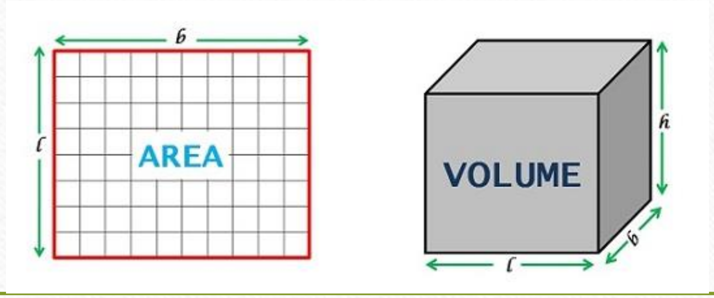
Example HP Calculation

Theoretical

- Calculate the theoretical HP needed to pump at a rate of 3 cfs when the discharge pressure is 105 psi
- Now we have to make some conversions before we can use our formula
  - We have to change psi to feet of head
    - 105 psi x (2.31 ft of head / 1 psi) = 242.55 feet
  - We have to change cfs in to gpm
    - 3 cfs x (1 mgd/1.55 cfs) = 1.935 mgd and 1.935 mgd x (694 gpm / 1 mgd) ≈ 1,340 gpm
  - HP = $\frac{gpm\ X\ Head'}{3{,}960}$
  - HP = $\frac{1{,}340\ gpm\ X\ 242.55'}{3{,}960} = 82\ HP$

The Basics of Distribution Math

- Most of the math problems we face in distribution systems rely on at least 1 of the same 4 recurring components
- If we can learn a few simple points about the 4 components, we can handle most of the math
- The 4 recurring components are:



Horsepower calculation with efficiencies and conversions

- What is the WHP of a system that is pumping 3.5 mgd at 95 psi if the wire to water efficiency is 86%?
  - Convert mgd to gpm = 3.5 x 694 = 2,429 gpm
  - Convert psi to H' = 95 psi x 2.31 = 219.45 feet
- HP = $= \frac{2{,}429\ gpm\ X\ 219.45'}{3{,}960\ x\ 0.86} = 156.5$

Area and Volume Calculations

Area

- Vessels like channels pipes and tanks that store or carry the water in our systems always have a cross-sectional area that we need to calculate
- Area is two-dimensional, and we have to multiply those two dimensions together, and the result will be in square units
- Example: the area of a square that is 5 by 5' is 25 ft^2
- Example: the area of a circle that has a diameter of 5' has an area of 5' by 5' x 0.785, or 19.625 ft^2

By the way – where does this 0.785 come from?

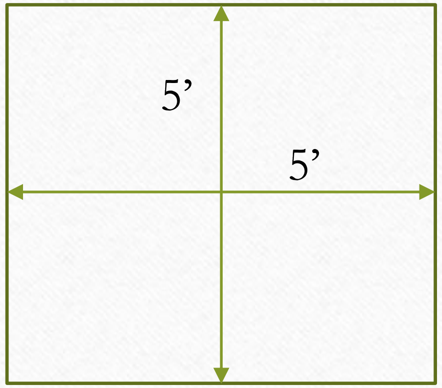
Volume

- When you add a third dimension to an area, it becomes a volume. Pipes and tanks and reservoirs hold a volume of water
- The terms we used for types of area – like "rectangle" and 'circle", now becomes "rectangular" and "circular" when we describe the vessels that are constructed by layers or stacks of these areas.
- Imagine a bunch circular identical areas. Now stack a bunch of them on top of each other until they are one foot high. You now have a volume that equals one of those areas times the 1-foot height.

Area

Square Area

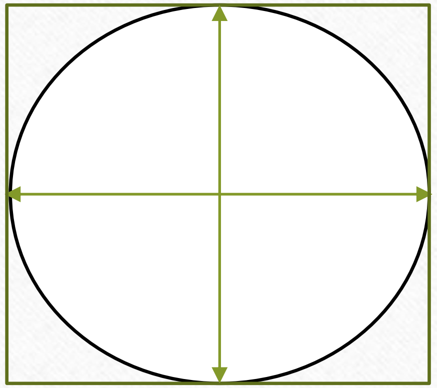
- A square has an area that equals the length times the width



Area = L x W = 5’ x 5’ = 25 ft^2

Circular Area

- The circle with the same length and width as that square, i.e., one that fits perfectly within the square will have an area that is 78.5% of the square



Area = L x W x 0.785 = 5’ x 5’ x 0.785 = 19.625 ft^2

Of course you can use Pi multiplied by the radius squared. Since the radius is ½ of D, when we square ½ we get ¼ so Pi has to be 4 times 0.785, or 3.14

$\Pi \times R^2$ = Area

Time and Distance

Time

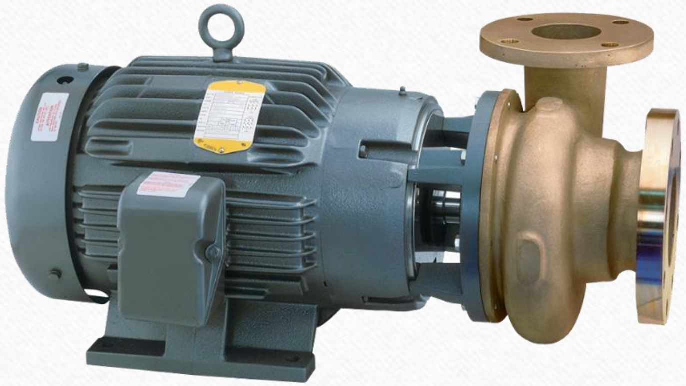
- Time is universal at least from our daily perspective
- We need to know these:
  - 60 sec in 1 minute
  - 60 minutes in 1 hour
  - 24 hours in 1 Day
  - 30 or 31 Days in most months except for February

Distance

- Distance can be tricky – sometimes we have to go back and forth between the English and Metric system

12 inches = 1 foot 3 feet = 1 yard 5,280 feet = 1 mile

1 inch = 2.54 centimeters 1 Meter = 39.37 inches



- A pump is a machine that moves water from a lower elevation to a higher elevation
- Pumps help us overcome gravity
- In doing so, the produce heat which is lost energy
- We have to supply more energy to the pump than the theoretical amount
- Motors that drive pumps are energy inefficient also, so even more energy input is needed

From Theoretical to the Real-World pumping calculations

When pumps do work, they are rated on the amount of horsepower, or HP, they develop.

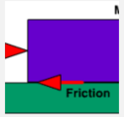
Horsepower is a function of the pressure that the pump puts out and the amount, or flow rate, of water they put out.

HP calculations also require us to know the amounts of energy lost due to friction and other inefficiencies. And we need to know the elevations that effect head

Pump system efficiencies

A pumping system consists of the pump itself and the motor that drives it

Each of these experiences some loss of power as they operate



Loss is due to friction, slippage, heat transfer, etc.

You can feel heat coming from the motor and pump

Each efficiency is expressed as a percent – and is always less than 100% - and is usually shown as a decimal

example 0.85 used for 85%

When multiplied together, they are sometimes expressed as "wire to water efficiency"

Multiply the two efficiencies together

Example: the motor horsepower is 85%, and the pump efficiency is 92%, the water to wire efficiency is (0.85 x 0.92) = 0.782, or 78.2%

Pumping terms - head

- Head terminology – terms used to describe which side of the pump you are on, and whether the pump is operating
  - Suction and discharge head – these are the head terms that describe which side of the pump you are discussing
  - Static Head – head measurements taken on either side of the pump when the pump is not operating – added together they are 'total static head"
  - Total dynamic head (TDH) – this is the total head being developed when the pump operates, and is the sum of the static head plus the friction head and inefficiencies the pump must overcome
    - You may see the term "bowl head" used for TDH

Pumping terms - horsepower

- Horsepower terminology - terms used to describe the types of work being done by the various components of a pumping system
  - Horsepower, or HP, is the amount of work being done
  - There are three components to HP: (note decrease in value)
    - Motor horsepower, or MHP – is the horsepower supplied to the motor in the from of electrical current
    - Brake horsepower, or BHP – is the horsepower supplied to the pump from the motor (they may use the term "bowl" here also)
    - Water horsepower, or WHP – is the actual horsepower available to pump the water

Decreasing

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