Fire Service Hydraulics and Water Supply Analysis

FPST2483 Unit 02
Water at Rest: Hydrostatics

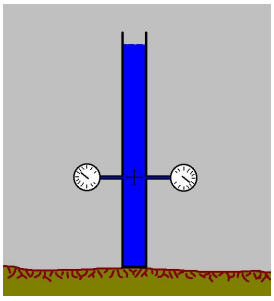
Hydrostatics

- The study of water at rest and the science behind it.

Chapter TWO

Five Basic Principles of Hydrostatics

PRINCIPLE 1



THE PRESSURE AT ANY POINT IN A LIQUID IS CONSTANT IN EVERY DIRECTION.

PRINCIPLE 2

PRESSURE APPLIED FROM EXTERNAL SOURCES ON A CONFINED LIQUID WILL BE TRANSMITTED IN ALL DIRECTIONS THROUGHOUT THE LIQUID WITHOUT REDUCTION IN MAGNITUDE

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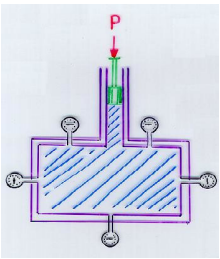
PRINCIPLE 2

DUE TO INCOMPRESSIBLE NATURE



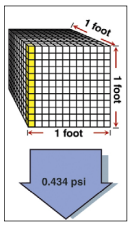
IF P=50 PSI, EACH GAUGE WILL REGISTER A PRESSURE INCREASE OF 50 PSI

PRINCIPLE 3

THE PRESSURE CREATED BY A LIQUID IN AN OPEN CONTAINER IS DIRECTLY PROPORTIONAL TO THE DEPTH OF THE LIQUID.

P = F/A, for 1ft^3 of water:

P = 62.4 lbs / 144 in^2 = 0.433psi



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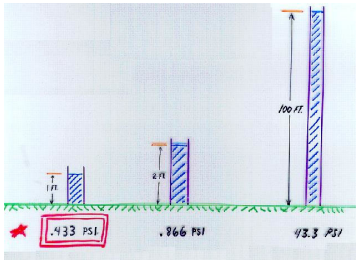
PRINCIPLE 3



PRINCIPLE 4

THE PRESSURE CREATED BY A LIQUID IN AN OPEN CONTAINER IS DIRECTLY PROPORTIONAL TO THE DENSITY OF THE LIQUID.

P = wh
Where:
P = pressure (psi)
w = specific weight of the liquid in lb/ft^3
h = height of liquid column in feet

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PRINCIPLE 4

For 1 ft^3 of Water:

P = wh

$P = \frac{62.4\ lb/ft^3 (1ft)}{144\ in^2/ft^2}$

P = 0.433 psi/ft

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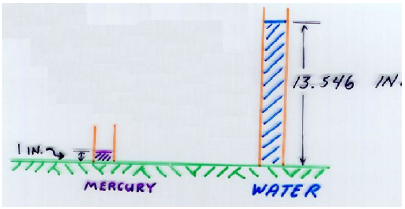
PRINCIPLE 4

SINCE THE DENSITY OF MERCURY (845.27 LB/FT^3) IS 13.546 TIMES GREATER THAN WATER:



EQUAL PRESSURE IS DEVELOPED

PRINCIPLE 5

THE SHAPE OR VOLUME OF A CONTAINER HAS NO EFFECT ON THE PRESSURE CREATED BY THE LIQUID

Only DEPTH and DENSITY effect Pressure!!!

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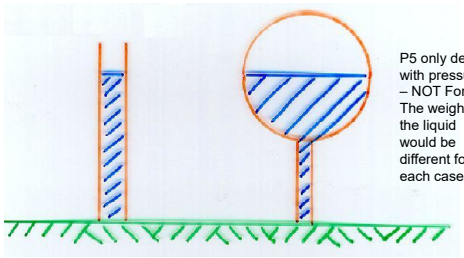
PRINCIPLE 5



P5 only deals with pressure – NOT Force: The weight of the liquid would be different for each case.

THE PRESSURE DEVELOPED IN THESE TWO SITUATIONS WOULD BE THE SAME

Head

Head – pressure expressed in units of feet of water (instead of psi)

h = P/w

Where:

h = head in feet

P = pressure in psi

w = the specific weight in lb./ft^3

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IMPORTANT CONCEPTS

1. P = wh

w is weight density
h is height
P is pressure in psi

2. FOR WATER

P= .433 h

3. IN HEAD:
h = (P) / .433 = 2.31 P

POTENTIAL ENERGY

Potential Energy is stored energy.
It has the ability to perform work once released.

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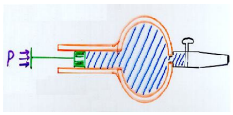
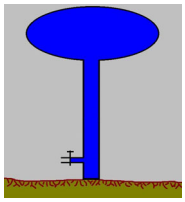
HYDRAULIC POTENTIAL ENERGY

IT IS A RESULT OF :

1. **WATER BEING ELEVATED** (Pe_h)
2. **WATER BEING PRESSURIZED** (PE_p)





AND:
TOTAL PE = PE DUE TO ELEVATION + PE DUE TO PRESSURE

$$PE_t = PE_h + PE_p$$

HYDRAULIC POTENTIAL ENERGY

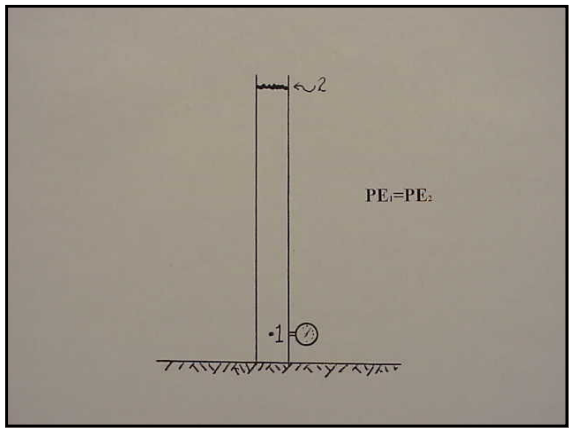
$$PE_t = PE_h + PE_p$$

$$PE_t = (W)(h) + (W)(P/w)$$

REMEMBERING THAT $P = w\,h$ **AND**
STATIC HEAD RELATED TO PRESSURE IS $h = P/w$

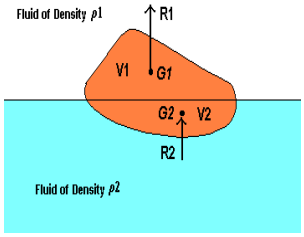
EQUATING TOTAL POTENTIAL ENERGY WITH TOTAL STATIC HEAD GIVES:

TOTAL POTENTIAL ENERGY = TOTAL STATIC HEAD = (P) /w + h

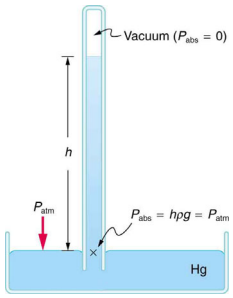


BUOYANCY

- For an object to float, the force downward, must equal a force in the upward direction.



Barometers



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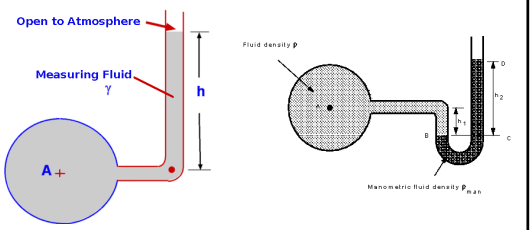
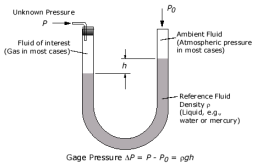
Piezometer Tubes



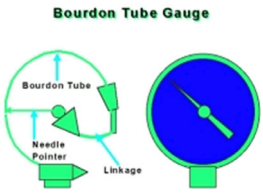
Manometers (U Tubes)

- **Measures very low pressures, 5 psi or less**



Bourdon Tube Gauges

- Pressure gauge that uses a bent tube to measure pressure
- As pressure rises, the bent tube moves, which moves the needle on the face of the gauge



Electronic Pressure Gauges

- Pressure transformed into digital gauge
- Very delicate

Summary

- We must understand the 5 principles of water at rest before we can study water in motion.
- The concepts of head pressure and potential energy are important in preventing unexpected accidents.
- Pressure measurement tools are based on these principles.