HYDRAULICS AND WATER SUPPLY

INTRODUCTION

Hydraulics is the branch of physics which study the mechanical properties of water and other liquids in motion with the application of these properties in engineering.

Hydrodynamics is the study of the motion and action of water and other liquids.

Hydrostatic is the balance of water and other liquids and the pressure exerted by them at rest.

For all intents and purposes hydraulics (Greek: *Hydro* meaning **water;** Aulos meaning **pipe)**, as it relates to the fire service is the study of the behaviour of water in motion or at rest.

GENERAL

Water is the main fire-extinguishing medium used by the fire service because it is relatively cheap and readily available. Even if is not the primary extinguishing agent, it may be found combined with other agents such as foam or may be used extensively for cooling containers in liquid petroleum gas (LPG) fires. It is essential that every fire fighter understand the behaviour of water in difference circumstances.

CHARACTERISTICS OF WATER

Water when pure, is a colourless, odorless liquid with a molecular composition of two atoms of hydrogen and one atom of oxygen (H_2O). A liter of water has a mass of one kilogram (1kg). A cubic meter of water has a mass of 1000 kg (1 tonne) and we find that there are one thousand liters (1,000 1) water in a cubic meter.

Pure water has a freezing point of 0º C (32º F) and a boiling point of 100º C (212º F) at normal atmospheric pressure (approx 1 bar). Between these temperature at atmospheric pressure, water exists as a liquid. It is virtually incompressible and as a fluid, water has volume but is incapable of resisting change of shape ie. when poured into a container, it will adjust itself irrespective of the shape of the container, and come to rest with a level surface. This is because there is very little friction of cohesion between the individual molecules of which water is composed.

Water can be a solid, liquid or gas. No other substance appears in these three forms with the earth's normal range of temperature. This is mainly because the molecules that make up water is constantly moving and the form that water takes depends on how fast they move.

WATER SUPPLIES

Water authorities obtain their water from three main sources:

i. River intakes such as the Rio Cobre scheme or the Yallahs pipelines. Rivers provide the bulk of the water for consumption and distribution.

ii. Impounding reservoirs such as the Hermitage Dam. These reservoirs contain the water collected form high ground, stream and from general rainfall.

iii. Underground sources such as wells, bore holes and spings.

Whatever the source, the water is gathered into a storage reservoir where it is fed after purification to a distribution system.

THE DISTRIBUTION SYSTEM

The function of the distribution system is to convey water from the source to the consumer. **The distribution system consists of pipes, valves, hydrants, meters, storage reservoirs and booster pumps where necessary etc.**

These components are arranged in one of three ways:

i. grid system
ii. tree system
iii. circle or belt system

The most common of the three systems is the **grid system**. However, communities may be found with any combination of the three systems. Grid system is a water supply system which utilizes lateral feeders for improved distributions.

Advantages of the Grid System

i. it is interloped and connected at standard intervals
ii. through proper valving it can still supply the majority of the area if a main breaks

The tree system is a water supply system which utilizes a single central feeder main to supply branches on either side of the main.

The circle or belt system is a water supply system designed in the form of a large loop. Water may be supplied to any part of the system from two directions, resulting in less overall friction loss.

Types of Distribution System

The types of distribution system are:

i. Primary feeders (trunk mains)
ii. Secondary feeders (secondary mains)
iii. Distributors (service mains)

Primary feeders (trunk main) are normally pipes of large internal diameter use to convey large quantities of water from one place to another, from one pumping station to another or to communities where the water is distributed to consumers.

Secondary feeders are the intermediate size between the primary feeders and the distributors. They are sometimes used to supply large consumers (factories or institutions) whose demands are too great for the capacity of the distributors.

Distributors (service mains) are mains of small internal diameter used to supply consumer blocks and individual fire hydrants in the street which they are laid.

Water mains are normally constructed of any of the following:

i. cast iron
ii. ductile iron
iii. steel
iv. polyninyl chloride (PVC)
v. other plastics and synthetic materials

Cast iron was the earliest type of pipe material used and is still widely used today. It has good corrosion resistance and has a relatively long life. Sometimes cast iron is lined with cement to improve its carrying capabilities.

Ductile iron maintains the properties of cast iron with the added mechanical properties of steel. It is generally used in areas where the mains are subjected to shock and overhead loading.

Steel pipe is used for application requiring large diameter of pipe or in special situations. Steel pipe has good strength to weight characteristics but has low corrosion resistance.

Polyvinyl Chloride (PVC) and other plastic pipes are been increasingly used as water supply piping. It is possible that PVC / plastic will become the standard for water distribution in the future. PVC / plastic pipe is light, has excellent corrosion resistance and very good flow characteristics. One area still unknown to man is the expected life span of plastic pipes since they have only been recently utilized.

Mains however, are subjected to deterioration. These are classified as:

i. Corrosion
ii. Tuberculation

Corrosion is the deterioration of the pipe material internally and externally which has the effect of roughening the internal surface of the main, thus increasing friction loss as well as reducing the effective strength of the main.

Tuberculation is the incrustation of the internal surface of the main due to the formation of a deposit from the water which has the effect of reducing the bore of the main causing a reduction in the flow.

The factors which govern the flow of water from a main are:

i. the size of the main
ii. the friction co-efficient of the internal surface of the main
iii. the pressure at which it is working
iv. the distance from the point of supply to the point of delivery

STORAGE

The storage of municipal water is performed for several reasons. These include:

i. a ready supply of portable water
ii. adequate capacity of normal and emergency use without service interruption
iii. maintain reasonably uniform pressure in the water system during peak demand periods
iv. allow supply pumps sufficient cycle intervals, thus reducing wear and operating cost
v. maintain storage of water for fire fighting purposes
vi. main adequate supply for weak areas within a water system

Storage containers broadly fall under two headings:

i. Ground storage reservoir
ii. Elevated tanks

Ground storage reservoirs are generally found at treatment plants or wells and occasionally at high demand points on the distribution system. Ground storage reservoirs are built of steel or reinforced concrete. Pump is generally used at these locations to maintain the desired pressure in the distribution system. However, ground storage reservoir can also be placed on hills and at high points in a system to utilize gravity flow.

Elevated tanks are usually built of steel but reinforced concrete can also be used. Elevated storage tanks are sometimes used at pumping stations to absorb pressure surges in the distribution system or at weak areas on the system to meet peak demands. At some location, elevated tanks are used solely for storage of water for fire protection systems.

HYDRANTS

Hydrants are usually constructed of cast iron, ductile iron and steel. They are placed at regular intervals along the pipe network (105 – 120 meters) solely to provide water for firefighting purposes. However, areas of high risk and dense population will have the hydrant installed closer (90 – 105 meters).

Hydrants are of two types:

i. Upper ground hydrants
ii. Pillar hydrants

Most hydrants in this country are pillar hydrants but a few under ground hydrants may still be found in old towns or in the older section of large town. **Underground hydrants** will require the use of a standpipe.

Hydrants are operated by the opening of a valve interspersed between it and the main. The direction in which the valve is turned, as well as the styling of the hydrant will depend on the manufacturer's specification. It is therefore important for firefighters to familiarize themselves with the hydrants on their station ground. The valves are located or placed in a valve pit or short distance away from the hydrants themselves and some will have the valve as an integral part (eg. macavity with central control).

Tools For Hydrant Operation

The tools required for hydrant operation are:

i. Hydrant cover key
ii. Hydrant key and bar
iii. Adaptor
iv. Stand pipes (for under ground hydrants).

Blank caps and false spindles are normally left fitted on the hydrants and valves. However, due to vandalism these may be missing and the fire appliances normally equipped with these for such circumstances.

Good hydrant practice demands that valve pits (hydrant pit in the case of under ground hydrants) are left clean and free from dirty water which may seep back into the main through faulty valve and contaminate the water supply. Hydrants should be open slowly to prevent to prevent <u>shock</u> to the hose and close slowly to prevent <u>water hammer</u>.

Water hammer is the force created by the rapid acceleration or deceleration of water in a main. It general result from closing of valve or nozzle too quickly, the water flowing in the main has both mass and velocity, if this velocity is instantaneously converted into pressure which must be absorb by the main and could result in the failure of the main (burst the main).

The hydrant valve should be closed sufficiently to prevent leaks, but not to the extent that it is jammed and cause difficulty for other users.

FACTORS THAT GOVERN HYDRAULICS

Hydraulics as it relates to the fire department is governed by five factors and the relationship between these factors in any given circumstances will affect pumping operations and the quality of fire fighting jets. These factors are:

(i) **Volume** is the amount of space occupied in three dimensions. It is the cubic content or the cubic magnitude and is measured in metres cube.(M^3)

(ii) **Velocity** is the rate of change of direction in relation to time and is measured in metres per second (M/S).

(iii) **Pressure** is the force exerted against an opposing body and is measured in Newton per metres square (N/M^2)

(iv) **Head** is the vertical height of the surface of the water above the point at which the pressure is measured and is expressed in metres (M)

(v) **Friction** is the retarding action of one action passing over another.

VOLUME

When working out the area of a figure, two lengths are multiplied. In calculating volumes, three lengths must be multiplied. Basically, this means multiplying the surface area by the depth. The calculation of the volume of water in any tank is done in two stages.

First	-	calculate volume in cubic meters
Second	-	convert the volume from cubic meters to a volume in liters

Rectangular Tanks

The volume of rectangular tank is calculated by multiplying the length (L) by the breadth (B) by the depth (H). It is important to remember that all dimensions must be in the same units such as meters or millimeters.

If the dimensions of a tank are:
Length 7.5m, Breadth 2m and depth 1 m, then the volume (in cubic meters) will be: 7.5 x 2 x 1 = 15 cubic meters (m^3).

As t here are 1 000 liters in a cubic meter, the total capacity of the tank in liters is obtained by multiplying the volume by 1 000, ie. $15m^3$ x 1 000 = 1 5000 liters.

Capacity of a rectangular tank (liters) = l x b x h x 1 000.

The capacity of a rectangular tank with uniformly sloping bases such as swimming pools can be obtained by proceeding as above but multiplying by the average depth which is achieved by adding together the values for the deep and shallow ends and dividing by two. If all the dimensions are in meters, the capacity would be:

$$L \times B \times \frac{H1 + H2}{2} \ (m^3)$$

$$= L \times B \times \frac{H1 + H2}{2} \ (\text{liters})$$

Circular Tanks

The volume or a circular tank is determined by calculating the surface area and multiplying by the depth (h), all measurements being the same unit. This can be expressed as:

$$\Pi r^2 h \text{ or } 0.7854 \times D^2 h$$

The capacity of a circular tank that is 10m in diameter and 4m deep would be

$$3.142 \times 5^2 \times 4 = 314.2 m^3 \ (ap)$$
$$0.7854 \times 10^2 \times 4 = 314.16 \ m^3$$

Multiplying by 1 000 gives the capacity in liters = 314,160 liters. 0.7854 is approximately 0.8, therefore a quick calculation method would be:

Quick formula: capacity of circular tank (m^3) = 0.8 D^2h

D = diameter and H = depth, both in meters. In the above example, this would be $0.8 \times 10^2 \times 4 = 320 \ cm^3$ (which is about 2% too high).

Capacity of Hose and Pipelines

Since firefighting hose when under pressure is circular in shape, its capacity can be obtained in the same way as that of a circular tank, ie. by multiplying the cross-sectional area by the length. Owing to the small size of the hose, however, the diameter is expressed in millimeters and great care must be taken to convert this to meters to obtain the volume in cubic meters, which is then converted to liters. The formula presented has all the conversions done, and is an approximation that gives an over estimation of about 2%.

$$\text{Capacity of 1 meter of hose (liter)} = \frac{8d^2 \text{ x length}}{10,000}$$

Therefore for a 70 mm hose, the capacity per meter would be approximately:

$$\frac{70 \text{ x } 70 \text{ x } 8}{10,000} = 3.92 \text{ liters}$$

This is slightly more than the true value of 3.58 liters per meter. Using the same figures as above the capacity of 25m length of hose becomes:

$$\frac{8d^2 \text{ x } 25}{10,000} = \frac{2^2 \text{ liters}}{50}$$

Capacity of a 25m length of hose (liter) $\frac{d^2}{50}$

PRESSURE

The characteristics of pressure in liquids

There are six basic rules which govern the principal characteristics of pressure in liquids:

i. Pressure is perpendicular to any surface on which it acts

If a vessel with flat sides contains water at rest, then the pressure on all sides of the vessel due to the mass of water acts perpendicular to the sides. This is illustrated in figure i.

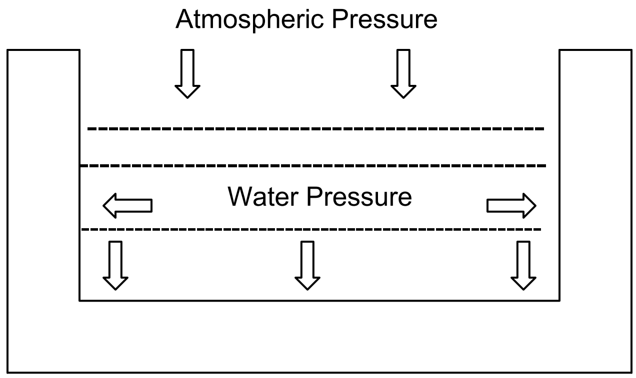


Figure i.

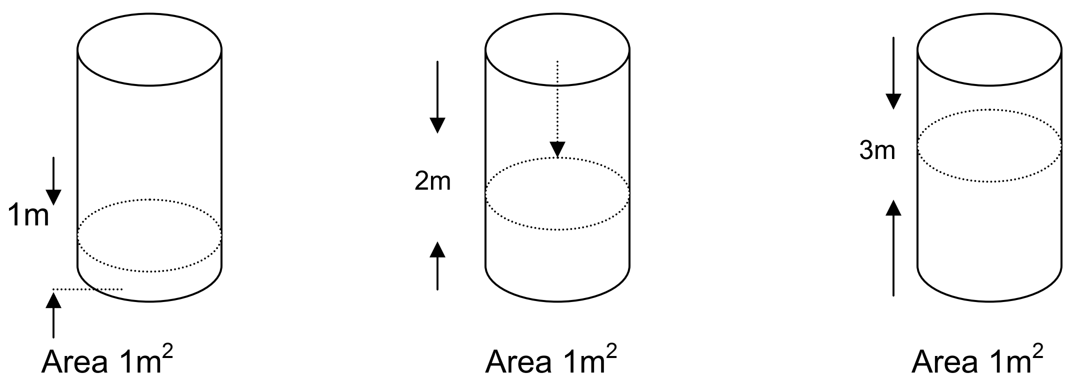
ii. Pressure at a point in a liquid at rest acts with the same intensity in all directions. Therefore, it can be said that fluid pressure at a point in a liquid at rest has not direction. This is illustrated in figure ii.

Figure ii.

iii. Pressure applied from outside a vessel containing liquid is transmitted equally in all directions within the vessel. This is illustrated in figure iii.

Figure iii.

iv. Downward pressure of a liquid in an open vessel is proportional to its depth. (Pressure in a liquid increases with depth). This is illustrated in figure iv.



Pressure 9.81 kn Pressure 19.62 kn Pressure 29.43kn

Figure iv.

v. Downward pressure of a liquid in an open vessel is proportional to the density of the liquid.

vi. Downward pressure of a liquid acting on the base of a container is independent of the shape of the container. This is illustrated in figure v.

The pressure exerted on the base of each container will be exactly the same if each vessel is fill to the same level.

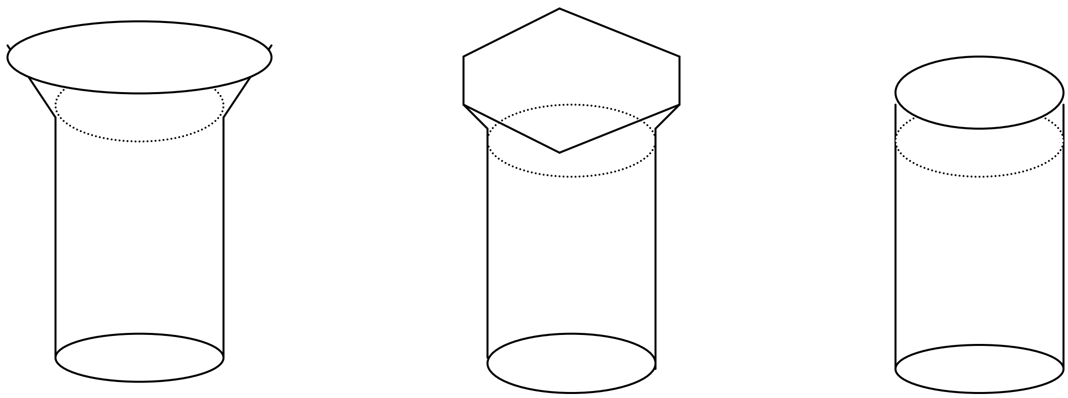


Figure v.
The pressure of a liquid acting on the bottom of a
Container is independent of the shape of the container

PRESSURE AND HEAD

Rule four of the six rules governing the principal characteristics of pressure in liquids states that **downward pressure of a liquid is proportional to its depth or the height of the surface above the point at which the pressure is measured.** Another name for depth is 'height' or 'head' and this term 'head' is commonly used in hydraulics calculations.

If a cubical container having side lengths 1m each is filled with water (neglecting the weight of the container), the mass of the water will be 1 000 kg. The force due to gravity on this mass of water is 1 000 kg x 9.81 Newton and this force is carried by the base of the cube of area, $1m^2$. Therefore, the pressure exerted by the water on the base of the container is:

$$\frac{1000 \times 9.81}{1} = 9810 \text{ Newton per square meter } (N/m^2).$$

Let us now say that the depth of water in a container is not 1m but H meters high. The total mass of the water will be H x 1000 x 9.81 Newton. The pressure exerted on the base of container in this case is.

$$\text{Pressure} = 9810 \times H \text{ Newton per square meter}$$

$$H = \frac{\text{pressure}}{9810}$$

P = pressure and H = head

The SI unit for pressure is Newton per meter square, which is equal to one (Pascal). This is very small unit. In that, even small pressure such as atmospheric pressure will result in large numbers. Eg. atmospheric pressure is equal to $101,325 n/m^2$. Hence, this unit is fall to small to be of much practical use in fire service calculations because it would rise to very large resulting numbers.

A larger and more convenient unit of pressure is the 'Bar' which is equal to $100,000\ n/m^2$. If we use the Bar as the unit of pressure for fire service calculations, the above equation becomes:

P = 9810 / 100,000 x h Bar or P = 0.0981 x H Bar

$$H = \frac{P \times 100,00}{9810} \quad \text{or } H = 10.19 \times P$$

As a closer approximation we can say $P = \frac{H}{10}$:- H = 10 P

Examples

A gauge registers 4 bars. What is the relative pressure in head in meters?

H = 10.19 x P
= 10.19 x 4
= 40.76m

Water level of a tank in a sprinkler installation system is 50 metes above a pressure gauge. What is the pressure in Bar recorded on the gauge?

P = 0.0981 x H
= 0.0981 x 50
= 4.905

ATMOSPHERIC PRESSURE

Atmospheric pressure is the pressure exerted by the atmosphere at the surface of the earth due to the weight of air. Atmospheric pressure at seal level exerts a pressure of 14.70 psi. ($101,325 n/m^2$). It increases as elevation decreases below sea level and decreases as elevation increases above sea level. The atmosphere surrounding the earth has depth and density and exerts pressure upon everything on earth. Atmospheric pressure is greatest at low altitude. Consequently, its pressure at sea level is used as standard (14.70 psi).

Atmospheric pressure acts uniformly on the surface of any open body of water just as on the other parts of the earth's surface. If this atmospheric pressure is removed from above, a portion of the water, (in other words – of a vacuum is formed) then the surface of the water is subject to unequal pressure and the water being resistant to compression but no to change of shape. That part of the surface which is relatively free from pressure is called a **vacuum**. Absolute zero pressure is called a **perfect vacuum.**

The formation of a vacuum in this way is of fundamental importance in firefighting since it is the basis for the process of priming a pump from open water.

Look at the diagram (fig vi.). AB is the surface of a sheet of open water over part of which CD is inverted a long tube which is sealed at the upper end, except for a connection to a pump. If this tube contains air at normal atmospheric pressure, the set up is similar to a set of scales carrying the same weight, 1.013 bar. If the pressure in the vertical tube is reduced, the pressure bearing down on the portion CD is reduced. The atmospheric pressure outside the tube does not change. Therefore, the system becomes unbalanced. Water will flow up the tube until the pressure exerted at the base of the column of water in the tube is equal to the pressure of the surrounding atmosphere.

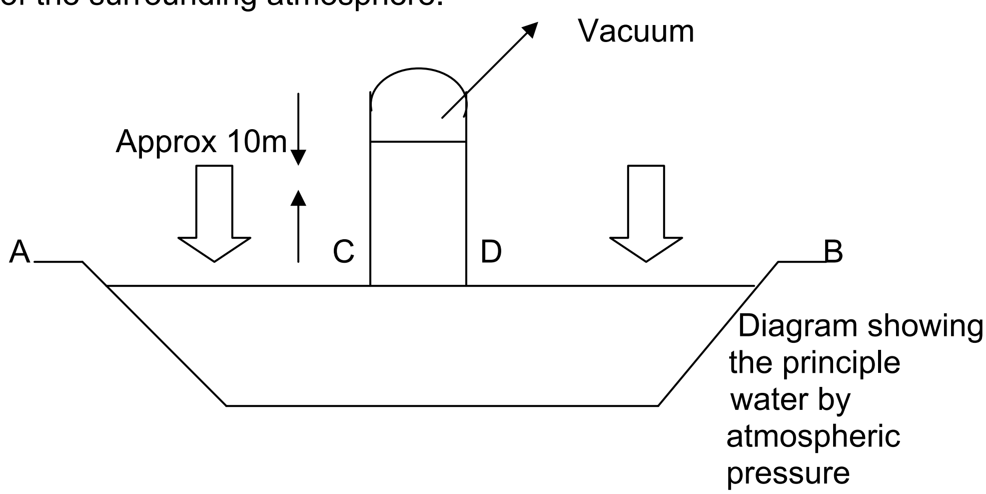


Fig. Vi.

SUCTION LIFT

Theoretically, if an absolute vacuum could be form in the tube, ie. if the air could be completely exhausted, it would be found that the water would rise a vertical distance of approximately 10.3 m because a column of water 10.3 m high is equivalent to a pressure of 1.013 bar acting on each square meter of the exposed surface of the water, ie. 0.0981 x H = 10.33 = 1.01325. No amount of further effort whether by trying to increase the vacuum (which is impossible) or by lengthening the tube, will induce the water to rise higher than 10.3m.

However, if the air is not completely exhausted from the tube, then the water will only rise to a height to balance the pressure difference existing between the inside and the outside of the tube. Therefore, if these remain in the tube, air equivalent to a column of water 3.3m high, then the water will only rise 7m. It will be seen therefore that, when a vacuum is formed in a long tube, the water is not sucked up by the formation of the vacuum, but is driven up by the external pressure of the air acting on the exposed surface of the water.

This is precisely what happens when a pump is primed. The suction hose takes the place of the vertical tube and the primer is the device for exhausting or removing the air from the suction. As the pressure inside the suction is reduced, the excess pressure of the air on the exposed surface of the water forces the water up the suction until it reaches the inlet of the pump. It follows therefore, that even theoretically, when under perfect working conditions, a pump cannot under any circumstances lift water from a greater depth than 10.3m from the surface of the water to the center of the pump inlet.

A pump is said to lift water when the water is taken from the open source below the inlet of the pump. Water has no intensible strength and cannot therefore be plugged upward and it is the atmospheric pressure only which raises the water.

The work performed by a pump when water is being lifted on the suction side is to create a partial vacuum within the pump chamber. As the impeller revolves while pumping with a centrifugal pump, a partial vacuum is created at the impeller inlet and in the suction hose. The atmospheric pressure exerts pressure on the surface of the water and so forces the water through the suction hose and into the pump.

PRACTICAL LIFT AND THEORETICAL LIFT

It has been shown that water cannot rise to a vertical height greater than approximately 10 m in a completely evacuated tube and that water rises because it is forced up by the atmospheric pressure outside. When a fire pump is put to work from open water, the factors to content with are:

i. Raising the water from its existing level to the level of the intake

ii. Overcoming frictional resistance to the water both on entering and on passing through strainers and suction hose.

iii. Turbulence as the water enters the pump impeller (this is known as **entry loss**)

iv. Creating flow – a certain portion of the available atmospheric pressure is used in creating a flow in the water. This varies according to the velocity in the suction hose, but in all cases, represents a relatively small portion of the available pressure.

Because of the factors (ii) and (iii), it is obvious that a static suction lift of 10 m cannot be obtained in practice and whilst suction lifts of 8.5 m are sometimes obtained under very good conditions, 8.5 m can be considered the maximum **practical lift.**

VELOCITY AND DISCHARGE RATE

The amount of water a hose or pipe will transmit or convey in a given time depends on:

- its size (cross-sectional area)
- the speed at which water is passing through it, ie. it's velocity. The velocity or rate of flow is invariably expressed in meters per second.

The formula for calculating the quantity of water passing through a hose or pie is: $Q = V \times A$

Where Q is the quantity in cubic meters per second, V is the velocity in meters per second and A is the cross-sectional area of the pipe in square meters.

Firefighters however, prefer to deal with discharges from open pipes or hoses in liters per minute, and to refer to the diameter of such hose or pipes in millimeters.

Thus Velocity (V) = $\frac{2.2L}{D_2}$ (where L is liters per minute) (where D is diameter in millimeters)

This is simplified (5½ per cent low) approximately $\mathbf{V = \frac{20L}{D^2}}$

Example:

What is the velocity of water in a 70m diameter hose if the discharge is 100 liters per minute?

$$V = 20 \times \frac{1000}{70_2}$$

$$= \frac{20,000}{5,000}$$

$$= 4 \text{m/s}$$

Conversely, if the velocity is known, the discharge can be found by: $\mathbf{L = \frac{vd^2}{20}}$

VELOCITY ENERGY AND PRESSURE ENERGY

When water leaves the pumps and enters the hose, it does sp at a certain pressure, which depends on a number of factors. It also travels at a certain velocity.

The function of the branch and nozzle at the end of a line of hose is to provide an efficient striking jet. To accomplish this, the pressure energy at the branch must be converted to velocity energy. It is shown in the previous example that 1 000 liters/min were passing through a line on 70mm diameter hose, the velocity of the water is approximately 4m/s. If the cross-sectional area through which that quantity of water is passing is reduced, then obviously the velocity must be increased.

If therefore a 25mm diameter nozzle is being used, the same quantity of water which was passing through an area of 3850 mm^2 (70^2 x 0.7854) must pass through an area 491 mm^2 (25 mm^2 x 0.7854). In this case, the velocity of the water is increased about 7.8 times (3850 ÷ 491) and will emerge from the nozzle with a speed of 31.2 m/s (4 x 7.8) approximately.

JET REACTION

When water is projected from a nozzle, a reaction equal and opposite to the force of the jet takes place at the nozzle and it tends to recoil in the opposite direction to the flow. The man or men holding the branch muse exert sufficient effort towards the jet to overcome this reaction.
The whole of the jet reaction takes place as the water leaves the nozzle and whether or not the jet strikes a near object has no effect on the reaction. Thus, whether or not a firefighter holding a jet on a ladder is able to maintain stability is governed solely by the reaction of the nozzle.

While it is often possible for one person to hold a small jet, several persons are required for a large jet, even though the velocity in both jets may be the same. The reason for this is that in the case of the small jet, reaction takes place on a small mass of water per second and one person can counteract the reaction, but in the case of a large jet, the reaction takes place on a large mass of water per second, with the result of either a number of persons are needed to hold the branch or the reaction must be taken by some type of support, such as a branch holder.

The approximate amount of the reaction of a jet in Newton can be calculated from the formula:

$$R = \frac{1.57 \times P \times d^2}{10}$$

Where R = reactions in Newton, P = pressure is bars and D = diameter in millimeters.

Example:

What is the difference between the reactions of the water leaving a 25mm nozzle as compared with a 12.5 nozzle if the pressure in both cases is 7 bars?

$$R = \frac{1.57 \times p \times d^2}{10}$$

(a) with a 25 mm nozzle

approx. $\frac{1.57 \times 7 \times 25^2}{687 \text{ Newton}}$

(b) with 12.5 mm nozzle

$$R = \frac{1.57 \times 7 \times 25^2}{10}$$

approx. 172 Newton

It can be seen that the reaction of the water leaving a nozzle varies as the square of the diameter of the nozzle and it is obvious that whilst one man could easily handle a 12.5mm jet, if the size of the nozzle is doubled, the reaction increases to four times making it more difficult if not impossible, for one person to control.

HYDRAULICS & WATER SUPPLIES

QUESTIONS

1. What is Hydraulics?
2. Why is water the main fire-extinguishing medium?
3. What is the formula for water?
4. Describe the composition of water?
5. What is the freezing point of water?
6. What is the boiling point of water?
7. What is the weight of a litre of water?
8. Name two main sources where water authorities obtain water?
9. The function of a distribution system is to convey water to the consumer. Name two?
10. Explain the term trunk mains and give an example?
11. What are Service mains?
12. What is corrosion?
13. What is Tuberculation?
14. What are the factors, which governs the flow of water from a main?
15. What is an Hydrant?
16. What is the usual spacing of hydrants?
17. Name the two types of hydrants?
18. Name the tools required to operate a hydrant?
19. What tools are normally fitted on hydrant?
20. Why should hydrants be opened slowly?

21. Why should a hydrant be closed slowly?

22. What is Volume?

23. What is Velocity?

24. What is Pressure?

25. What is Head

26. What is Friction?

27. Name three factors, which governs Hydraulics?

28. How is the volume of a rectangular tank calculated?

29. What is the formula for finding the capacity of a rectangular tank?

30. How is the volume of a circular tank determined?

31. What is the formula for finding the capacity of a circular tank?

32. What is the approximate vertical height at which water can be raised in a completely evacuated tube?

33. Name two factors to contend with when a fire service pump is put to work from open water?