Firefighting Handline Nozzles
Jetting through the Fog!

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1.0 Introduction

In a battle, knowledge is the key weapon. Knowledge of the enemy, his strengths and weaknesses, his weapons, as well as your own! Fire fighting situations are quite literally, battlefields, and knowledge of the fire situation is as important as knowledge of the equipment and systems which you possess, and their firepower (or, rather their firefighting power)! Whenever firefighters enter dangerous situations, their lives and others' will depend greatly upon their training, and the performance and reliability of the equipment and systems which they use. The same is also true for firefighting handline nozzles.

For a long time, the Fire services in the country have been using solid jet nozzles for firefighting. In fact, even today, for most municipal fire services, it is still the main line nozzle. However, due to its limitations, and the large variety of fires that are encountered, it is clear that it does not present the best solution for firefighting. Other nozzles such as the Universal nozzle (also called the Triple purpose nozzle), Fog nozzle and the London Pattern Hand Control Branch were thus introduced into the Fire services. The past 2 decades have seen a variety of nozzles make an appearance on the scene. This large variety of firefighting nozzles available today can confuse a layman, unfamiliar with fire service operations. In fact, even fire service personnel, who are not familiar with the different designs and operational/ performance parameters of such branches are baffled and not confident about using them. It is therefore, necessary to provide the basic information and knowledge regarding such nozzles to all concerned personnel so that they can make a proper, informed choice regarding the nozzle they wish to use and deploy.

2.0 Basic nozzle concepts

Nozzles form an important of fire service operations. To combat fires, it is important to throw water over the required distance so that it falls on the area, affected by the fire. Pressurised water is normally available at most places adjacent to the fire situations, in the form of fire water system outlets or from pumps of firefighting vehicles. What is required however, is to direct this water to the affected area. For this, it is required to convert the pressure energy of the water into velocity energy. At the same time, it is necessary to project the water in the desired form i.e. jet, spray or fog, to ensure maximum effectiveness depending upon the situation. This means that the nozzle design is based on these main factors –

- Controlling the quantity of water flowing from the nozzle.
- Adjusting the flow and pressure to ensure that water is projected the required distance.
- Giving the desired pattern and shape to the water discharge.
- Being handline nozzles, they should also comply with operational and ergonomic considerations i.e they should be comfortable and easy for firefighters to handle during firefighting situations, without which the best designs are futile.

3.0 Handline Nozzles – Basic Types

Considering the history and development of handline nozzles, we shall take a look at some of the basic types of nozzles being used by Fire services around the world, and in the country. The first firefighting operations using water involved throwing the water using containers such as buckets on the fire. This had some inherent drawbacks – the water could be projected only a limited distance, thus limiting its effectiveness, and continuity of operations was difficult. It led to the concept of having water lines at all suitable locations, where fire risks existed. Thus the concept of firewater mains was born, and fixed piping carrying water was made available at all required locations, with hydrant valves provided, for drawing water from these lines. The other problem still remained i.e. getting the water effectively on the fire affected area. Flexible fire hoses were used to transport the water from the pipelines to the fire, but to project the water effectively, it was required to convert the pressure energy of the water to velocity energy. The development of the handline nozzle began with this.

3.1 Solid Bore Nozzles

The first nozzles (and still commonly used in the country) used a restriction in the outlet of the nozzle to convert the pressure developed into velocity. Such nozzles are commonly called the solid jet or solid bore nozzles (in the country, popularly called the short branch pipe with nozzle). The nozzles of such branches come in different sizes, and these bore sizes will give different performances at different pressures, and for a given pressure, a specific size will give the best performance. For eg. if the pressure is 3.5 kg/cm2 at the inlet of the nozzle, a 25mm nozzle will give a very poor quality jet; a 10mm or 8 mm nozzle is likely to give a good jet. Similarly if the pressure increases to 7 kg/cm2, the performance of a 10mm size solid bore nozzle will not significantly improve as the jet will begin to break after leaving the nozzle, thus affecting its range. The optimum performance of a nozzle with a specified flow can be obtained at a specific pressure. Solid Jet nozzles provide good reach and penetration, and have been in use for a long time, hence most fire service personnel have been exposed to them at some time or the other in their careers. These nozzles are still quite popular in the country, and are found commonly in most fire services.

Solid bore nozzles give a fairly effective jet even at low pressures, and most fire services will operate these nozzles at 50 psi. Though the back thrust from nozzles flowing the same amount of water and at the same pressure, it is experienced that the back thrust from solid bore nozzles is slightly lesser as compared to other types of nozzles. Due to a simple design, it requires practically no maintenance, and chances of malfunction are practically nil. The jets from solid bore nozzles are able to withstand the effects of wind slightly better than those from combination nozzles. Hence, due to these advantages, these nozzles are still preferred by many fire services.

However, there are some limitations of these nozzles, and these problems led to the development of newer types of nozzles. The pattern of flow in solid jet nozzles could not be controlled, which means that they were unable to project water in form of fog, or spray for protection. At the same time, the nozzle could not be shut off by the nozzle man, which meant that he had no control over the branch. This lead to the development of the next type of nozzle called generally as the combination nozzles or spray type nozzles. These could give both jet as well as spray patterns, and at the same time, incorporated the arrangement for the operator to shut off the nozzle, if required. Such nozzles can further be divided into sub-types, and we shall take a look at these briefly below.

3.2 Basic Spray nozzle

The basic spray nozzle is the simplest form of the combination nozzle, and as explained above gives both hollow jet and spray patterns, with the facility of shutting off the nozzle. In the country, such nozzles are known as the 'Universal branch' or popularly as the 'Triple purpose branch'. These can be found in various flow capacities, right from small capacity hose reel nozzles to monitor nozzles! The pattern changeover mechanism as well as the shut off arrangement can be operated by rotating the outer body of the nozzle. As a general rule, the pattern sequence changes from spray to hollow jet to shut off when the outer body is turned clockwise (when viewed from nozzle inlet side).

However, in these nozzles, the flow varies as the pattern changes from the hollow jet to the spray pattern i.e. the orifice gap changes as the pattern changes. In most cases, the flow in jet pattern is lesser and increases as the pattern changes to fog.

3.3 Constant flow (gallonage) nozzles

Constant flow nozzles, also known as Single gallonage nozzles, provide a constant flow throughout the different range of discharge patterns. For eg. a nozzle with a setting of 400 lpm @ 7 kg/cm2 pressure will give the same discharge whether in jet or spray pattern (unlike the above type of nozzles). However the flow will change proportionately with change in pressure. Such nozzles will normally have a shut-off arrangement in the form of a handle connected to a ball-valve. Many suppliers of these branches also give a pistol grip handle for ease of handling. The discharge pattern can be changed by rotating the nozzle outer body, which is normally provided with a rubber bumper for protection.

Combination (Jet/ Spray) nozzles are capable of giving different patterns (i) hollow jet for long range firefighting (ii) narrow fog for cooling or vapour dispersal & (iii) wide fog for radiant heat protection

The problem with such branches is that in case of low pressures the performance may not satisfactory. At the same time, if higher flows are required in certain firefighting situations, it is not possible to obtain such flows from these nozzles. Many foreign manufacturers, however, claim that there has been a significant improvement in designs and that their nozzles provide good discharge patterns even at low nozzle pressures.

Teeth designs for Fog / Spray patterns

In earlier nozzles, the spray pattern was simply in the form a water curtain. Water curtain has limitations in terms of cooling capacity. The fact is that as water droplet size reduces, its radiant heat absorbing capacity increases. Hence, the need was felt to have good quality fog which would absorb maximum heat in fire situations. With further developments in nozzle design, the nozzle outlet came to be provided with teeth. Providing teeth on the nozzle outlet served two purposes; first, in the narrow fog position, it deflected part of the water to the centre of the spray(which is otherwise hollow). Secondly, in the wide fog position, it caused the water curtain to break up into streams which then impinged on one another to create a better quality fog. A variety of different designs of teeth are used to create this fog.

With further research and trials, a newer spinning ring with angular teeth came to be provided at the nozzle outlet. The spinning teeth would rotate in the fog position, causing the break up of the water curtain into fine droplets. Many manufacturers provide spinning teeth to the nozzles, as it is believed that the fog pattern produced gives a range of fine droplets, and is ideal for fire gas cooling operations, as also for flashover control operations. Spinning teeth rings can be of a variety of material, including polymers, metals, etc.

Development in rubber/ polymer technology resulted in the development of teeth moulded into the rubber bumper provided on the nozzles. Rubber/ polymer teeth have the advantage of being flexible, and their designs are claimed to produce superior fog patterns. There is still a lot of debate on the effectiveness of the different type of teeth designs and different users have their opinions/ preferences.

3.4 Selectable flow (gallonage) nozzles

The Selectable flow nozzle was developed to overcome the problems of the constant flow nozzles. In these nozzles, the flow can be varied by the operator as per his requirement. These nozzles incorporate an arrangement to vary the outlet orifice size, hence the flow can be varied by changing this orifice size. Normally, the design will have some locking mechanism to ‘lock’ the flow at certain predetermined settings. Earlier, the operator would be required to shut down the line if the pressure got reduced, and change to a smaller bore nozzle to obtain an effective jet. The advantage of selectable flow nozzles is that the operator can set the flow without shutting down the line, depending upon the pressure available, and other operational considerations. This means that the nozzle can be used effectively even in varying pressure conditions by the operator himself, without any dependence on the pump operator. Also, if enough personnel are not available, the nozzle can be kept on a lower flow setting, resulting in lower back thrust, and hence the line can then be handled by fewer people.

It must be noted that selectable flow nozzles are actually categorized as constant flow nozzles in many documents/ standards. The reason is that for a specific flow setting, the nozzle behaves like a constant flow nozzle i.e. the flow is constant throughout a range of discharge patterns, for a given setting.

These nozzles are extremely versatile and can be very effective, when being used by experienced firefighters. In many firefighting situations, where long lines have to be laid, and pressure drops in the hoses are likely, the nozzle can be effectively used by setting it to the appropriate flow depending upon the pressure available. At the same time, the flow can also be adjusted to suit the requirement of different situations. It can be used for foam operation, both unaspirated or aspirated, using Inline Inductors of suitable capacity, by setting the appropriate flow setting on the nozzle (for aspirated foam operation, suitable attachments should be used on the nozzle).

Some nozzles can be used with foam attachments for foam operation. Foam compound can be inducted using Inline Inductors or directly from Foam Tenders.

3.5 Automatic (Constant Pressure) nozzle

An automatic nozzle maintains a relatively constant pressure over a wide range of flows. Such nozzles have an arrangement in the nozzle which controls the flow by restricting the orifice outlet to maintain pressure. In most nozzles, a spring loaded deflector is used which moves back and forth depending upon the pressure at the inlet of the nozzle. This means that if the pressure is relatively low, the nozzle orifice will automatically restrict the flow, causing pressure buildup at the outlet, and consequently resulting in a good quality discharge pattern. Similarly, if the pressure increases, the orifice opens to allow more flow, again adjusting to a constant pressure at the outlet of the nozzle. However, the fact is that such nozzles sacrifice flow to give reach.

The other important fact is that automatic nozzles should be checked for their rated flows and pressure. If the nozzle is flowing less than the rated flow, it can result in reduced effectiveness. If however, the nozzle is flowing more than the rated flow, it results in excessive backthrust and hose handling problems. Also if the fire water line pressure is in excess of the rated pressure of the nozzle, (as is the case today with many sites in the hydrocarbon/ chemical sector, which have high hydrant line pressures), the flow and backthrust will be much higher, than what is claimed under test conditions (i.e. at its rated pressure). The other disadvantage of such nozzles is that over a period of time, variations may occur in the rated flow due to a number of reasons, and many fire brigades go in for periodical re-calibration of such nozzles.

Automatic nozzles can be used for foam operation. However, if they are to be used with Inline inductors, much higher pressures (as compared to Constant flow or Selectable flow nozzles) have to be used. The reason is that as there is a restriction at the nozzle, it creates a backpressure on the inductors, which can even stop inducting at low pressures. While many foreign manufacturers do claim that their automatic nozzles can be used with Inline Inductors, it must be noted that they commonly use pump pressures as high as 150 to 200 psi, which are uncommon in our country.

Dual Pressure Automatic nozzles

As mentioned above, the problem with automatic nozzles is that if long lines are being used between the pump and nozzle (as during interior firefighting, and also, if the nozzle is being used at a level much higher than the pump), the pressure drop can be substantial. Automatic nozzles set at a certain pressure (normally 100 psi) would give very little flow at these low pressures or in worst cases, no flow at all. To overcome these problems, dual pressure nozzles were developed. Such nozzles are like normal automatic nozzles, in which the stream deflector is connected to a loaded spring. However, the nozzle incorporates an arrangement to change the loading of the spring. Due to this, the pressure setting of the nozzle changes to a lower setting, for e.g. 50 psi, when required. At this lower setting, higher flows are possible even at low pressures, which otherwise would not have been possible at the normal setting.

The setting of automatic nozzles requires careful calibration and machining. For dual pressure nozzles, this is even more important. Hence it is necessary to verify the correctness of these settings, and whether such nozzles can be effectively deployed for the existing fire risks. It is also advisable that these nozzles should be used only after complete training and familiarization of personnel. The other important factor that should be considered are the local factors such as the normal pressure in the hydrant lines, likely fire scenarios, etc, before selecting the nozzle.

3.6 Multipurpose nozzles

These nozzles were developed to combine the advantages of both the solid bore as well as the combination nozzle. Hence, the design incorporates a solid bore jet at the centre of the nozzle, and an arrangement to have spray/ fog like other combination nozzles. Thus, the operator can obtain maximum reach and penetration using the solid jet, and at the same time can operate the fog pattern when required. These operations can be done either independently or together. Such nozzles are not new to the Fire services, and were used earlier in the form of the London Pattern Hand Control branch. However, due to its weight factor, and not being very easy to use, it did not gain popularity. However, due to its utility, it began to be re-introduced, and smaller capacity Multipurpose nozzles, constructed of aluminium and polymer materials are commonly being used by most foreign Fire services, especially in Europe, for the past two decades. Now larger capacity multipurpose nozzles, in Aluminium alloy construction, are being re-introduced.

The other important reason for the popularity of such nozzles today is that the solid bore arrangement can also be used with CAFS (Compressed Air Foam Systems), which are commonly being used in most developed countries. Hence, these nozzles can be used in different situations, such as CAFS applications, foam applications, direct and indirect attacks, cooling, protection, and ventilation.

 

Multipurpose nozzles can discharge both jet and protective spray simultaneously.
Seen here is a newer design (left) and the older London pattern branch (right).

4.0 Nozzle facts and factors

Discussed below are some of the important facts and factors which need to be considered when selecting handline nozzles. A specific nozzle may be ideal, given certain circumstances and factors, however, the same nozzle that effective in others. Simply put, there is no universal nozzle which can be effectively used for all firefighting situations, and hence a careful evaluation of the fire risks and other factors should be done before selecting a nozzle. Other factors which influence nozzle selection are the controls provided on the nozzle, its maintenance, durability, type of operators who will handle the nozzle, and finally, the financial implications.

4.1 Suitability to risk

A casual visit to any of the firefighting discussion forums on the internet will reveal that the suitability of different nozzles for firefighting situations continues to be a hotly debated topic. The fact that fire situations can be vastly different from one another indicates that different nozzles will have varying effectiveness in these situations. Hence, the type of fire risk is the foremost consideration for selecting the nozzle. For eg. oil/ chemical fires require the application of water in the form of a gentle spray/ fog rather than in form of a jet. Areas where electrical equipment are located require the use of a fog rather than a jet. If fires giving out large amount of heats are to be tackled, it will need a nozzle which gives a quality fog for cooling and radiant heat protection will be required. Also if flammable liquids are present, foam application may be required. Can the nozzle be used for foam application, alongwith foam inline inductors?

Important facts to be considered are that Jet/ Spray type (combination)nozzles produce good quality straight streams but require higher inlet pressures, at the same time they can produce good quality fog pattern. Solid bore nozzles on the other hand, are of not much use when protection from radiant heat is required, but they can be effectively used for exterior attack, from a safe distance.

4.2 Patterns and flow range

Depending upon the risks, firefighting strategies and tactics are evolved. Depending upon the resources available, and the training of the people who are going to be involved in the firefighting operations, suitable branches should be selected. For eg. if the objective is to do defensive firefighting from a distance, simple jet nozzles may be sufficient. However, if firefighting teams are required to go closer to the fire area, nozzles with more complex patterns will be required. For eg. as teams approach closer to the fire area, cooling using narrow fog would be required. Or in situations where it is required to approach close to the fire to close valves, etc, nozzles with wide protective fog patterns will be required, to protect the teams from the heat of the fire. The other important factor is that when in a fire situation, it is always better to have a nozzle which is simple to operate. Having too many controls/ patterns on the nozzle may cause confusion, especially under stress.

Depending upon the heat that is given out during fires, the required quantity of water should be applied onto the fire area. If insufficient water is being applied, it will have little or no effect on the fire! It is not possible to theoretically calculate the water required for each fire situation, but experienced firefighters have a fair idea of the quantity of water that would be required for a certain type of fire, based on their experience. For instance, water has a theoretical cooling capability of 2.26 MegaWatts per litre per second, though in real fire situations, this may be scaled down to approximately 0.8 MW per litre per second. Hence rough estimates can be arrived at for different fire situations, for e.g., 50 lpm for 0.70MW, 100 lpm for 1.40MW, 200 lpm for 2.80MW, etc. Knowing the exact energy release rates for different fires is not possible, but based on experience, one can have a rough estimate of the water quantity, and hence the flow required to control and extinguish a specific type and size of fire. Once again, it should be checked if the flow can be controlled by the operators. Normally, it is not possible for untrained operators to handle flows in excess of 400 lpm @ 7 kg/cm2 (i.e. solid bore nozzles of 16 mm or equivalent). For trained operators, normally 2 operators can handle upto 700 lpm flow (19 mm nozzle), while at least 3 operators would be required to handle 1100 lpm flow (25 mm nozzle). If the nozzles are of lower flow capacity, and it is not possible to get the required quantity of water to the fire, it may be required to operate more number of lines to control the fire, and these factors should be considered while selecting nozzles.

Ball Valves and Slide Valves

For controlling flow through a nozzle (and shutting it off), a valve has to be incorporated in the nozzle design. For a long time, manufacturers have been using the ball valve for this purpose, as it is a proven design, operates well at the pressures used, and is relatively maintenance free. The ball can be of metal, or polymer based materials, depending on requirement.

A new development has been the slide valve, in which a hollow cylinder moves back and forth along the central axis, and seals against a polymer seat. Due to the movement of the cylinder, it causes a variation in the orifice gap between the cylinder and the seat and hence controls the flow. Its biggest advantage over the ball valve is that the flow is always in the same direction regardless of the flow (in case of ball valve, if the valve is half closed, the direction of the water is different than what would have been if the valve had been fully open). This helps in reducing turbulence. However, the design of the Slide valve requires careful design and assembly. In some cases, the nozzle has been known to shut down abruptly as the slide valve is set to lower flows, which is a very dangerous situation. They are also expensive as compared to ball valves, and hence actual performance of the branches should be evaluated to check for tangible advantages.

4.3 Maintenance and durability

Unfortunately, firefighting equipment, unlike most plant machinery and equipment, are not online equipment i.e. they are not operational in the normal course of operations. They are used only in the event of a fire, hence their operational effectiveness cannot be guaranteed unless they have been regularly tested and maintained. Like all other firefighting equipment, periodic maintenance schedules play a very important role in the effective operation of nozzles. The design of the nozzle is therefore, important. Certain types of nozzles, such as solid bore nozzles, require little or no maintenance. However, as the design of the nozzle becomes more complex, its maintenance also involves more time and skill. It is therefore, important to choose a nozzle which can be easily and properly maintained using the available resources.

Similarly, the nozzle design should be such that it withstands long and rough use. Once again, nozzles with simpler designs are more robust and will withstand rough handling over the years. Durability will also depend upon the material used in the manufacture of the nozzle. The selection of the material should be suitable to its application i.e. corrosion resistant, rugged and reliable. Materials like lighter and stronger aluminium alloys (anodized for corrosion resistance), superior quality rubbers and polymers, etc, are being used extensively to ensure long and trouble free operation of nozzles.

4.4 Type of Operators and ergonomics

Another very important factor when considering nozzles is the type of operators available at site, and who will use the nozzle in the event of an accident. The effectiveness of the nozzle is directly related to the ability and skill of the person handling it. Handling pressurized hoses is not easy, and hence the type of personnel in the industry are an important consideration. For eg. hospitals or industries where female employees are more, nozzles with high flows are of little use, as they would be difficult to handle. The training of personnel should also be considered – personnel who are trained and who regularly practice will be able to handle nozzles effectively during an accident. However, certain industries have higher percentage of contractors' personnel, and are not likely to be familiar with the various firefighting equipment, including nozzles. In such cases, it is advisable to have simple nozzles, which can be operated without much training.

Ergonomics plays an important role in operation of any handheld equipment, and handline nozzles are no exception. Firefighting operations are physically demanding, and it requires correct technique and training to handle nozzles during long operations. Proper design of the nozzles therefore, plays an important role in its effectiveness. Recognising this, nozzle manufacturers now are taking efforts to ensure that nozzle is such that it can be handled properly and safely by operators. Nozzles which cannot be easily and safely handled are unlikely to survive in the market.

4.0 Conclusion

Besides the various factors given above, another important factor in the country is the price of the nozzle. In developing countries, where resources are scarce, it is important to have nozzles which are not prohibitively expensive. Hence, good quality, competitively priced products are more likely to be popular, and so there is a trend to develop nozzles which use newer, lighter materials, and are easier to handle. At the same time, they should meet operational requirements, and should be financially viable. A good quality, reliable nozzle, when properly used can play a very important role in controlling fires, and consequently, losses.

References (and useful Links):

A Firefighter's guide to Nozzles, Task Force Tips, U.S.A.
Fire fighting Unit 2, 1973, Resources Protection International, U.S.A.
NFPA 1964, Standards for Spray Nozzles, 2003 edition.
http://www.wfrfire.com/website/articles/firefact.htm
http://www.firetactics.com/FIREENGINEERING-1.htm