1) Water puts out fire NOT pressure.

There is general agreement on the fact that the water puts out the fire. There is NOT agreement on what the correct ratio of flow (GPM) and pressure (PSI) should be. Obviously, it is a compromise of both. A hose pressurized to 10,000 PSI and closed off will do no more than millions of gallons of water in a moat surrounding a burning building. The real controversy lies in what compromise of these two factors is appropriate.

A 1000 gallon per minute stream that does not have enough pressure to reach the fire will do no more to combat the fire than will a high pressure fog stream that reaches the fire, yet evaporates before cooling the burning material below its flash point. The answer lies in making informed choices about the correct compromise of both factors.

The flow needed is determined by the size of the room, the contents of the room, the amount of ventilation that has taken place, and the stage to which the fire has progressed. All of these things are beyond the control of the fire department. Fire does not care if you have a three man crew or a five man crew, a 2000 GPM pumper or a 250 GPM mini pumper. If the critical flow rate is not surpassed, the fire will continue to burn until the critical flow rate is equal to the flow being applied. Then it will go out.

Many departments have spent the whole night on a house fire "stretching" their water with small lines waiting for the fire to burn down to a size that could be controlled.

The book "Rural Firefighting Operations" authored by Larry Davis contains an exceptionally well written section on the results achieved when the water supply is stretched instead of being applied efficiently. Mr. Davis explains the history of high pressure fog and its failure to perform as advertised. Many a structure has been lost to high pressure fog while water remained in the tank.

The pressure required at the pump depends on numerous factors some of which are:

1. Flow rate required to achieve control
2. Elevation losses
3. Size of the hose that is to be used to deliver that flow
4. Number of personnel available
5. Type of stream that will be needed (fog or straight stream or a combination of both)
6. Amount of "action" (Nozzle Pressure) that is desired from the stream
7. Distance from the fire from which the attack will be begin

It has been observed by many experts in the fire industry that there is a tremendous OVER ESTIMATION of the flows that are being delivered in everyday fire fighting in the US. Many departments have purchased new nozzles along with inch and three quarter hose and instantly assumed that they are delivering 200+ GPM. This is simply not the case. **(E**ngine **P**ressure **= F**riction **L**oss **+ N**ozzle **P**ressure **or EP=FL+NP)** Unless the proper pump pressure is supplied to cover the friction losses involved, the flows will be less than expected. We have all heard the saying "You don't get something for nothing" and it certainly applies to pump operation. We tend to focus on the nozzle, when the fact of the matter is that the water is what puts out the fire, not the NOZZLE. If a sufficient amount of water is delivered to the fire to absorb the heat being produced, it doesn't matter if its a SYRINGE that delivered it. This is the case whether the nozzle is a smooth bore, a manually adjustable combination nozzle, an automatic nozzle or a BUCKET.

2) It's easier to determine flow with a smooth bore or a manual nozzle than an automatic.

If this statement were TRUE, then the automatic nozzle would NEVER have been invented. If manual transmissions were easier to drive, then the automatic transmission never would have been invented. Fuel injection, relief valves, pressure governors are all examples where automation has improved our effectiveness. There are hundreds of other examples where automation has made life easier and simpler. How many of your attack lines have pressure gages right behind the nozzle? How many of your fire officers carry Pitot gages in their bunker gear ? Without KNOWING the base pressure of a fixed gallonage nozzle, it is IMPOSSIBLE to know the flow. you wouldn't believe how many firefighters think that a nozzle is flowing 95 GPM when it's set to 95 GPM, just because there is water coming out the end. Without confirming that the nozzle pressure is at the RATED pressure, the flow is nothing but a guess. A manually adjustable nozzle does not flow the amount set on the dial just because the valve is turned on anymore than a car is going a given speed because it was put into a particular gear. For a car to go 55 miles per hour requires a given amount of power. The exact same thing is true of a fixed gallonage nozzle. For a given setting it will deliver a given flow ONLY if the proper amount of power/water pressure is being delivered for the hose length and size being used. When the pump pressure is to be calculated for some "target" flow, the manual nozzle and the automatic nozzle are treated equally. The flow is selected, the length and size of the hose is selected, and the friction loss calculated. This friction loss is then added to 100 PSI (the rated nozzle pressure) and the result is the required pump pressure. This calculation will work out just fine for both nozzles as long as there are no kinks in the line, no elevation losses, no confusion over the ACTUAL hose size, no confusion over the length of the line, no problem with 18 feet of small pipe and 14 elbows going to the rear discharge etc. etc. etc. If any of these things should occur, then the manual nozzle will either be over pressured or under pressured, and the flow will not be at the selected rate (95 GPM). The automatic's flow will also not be known, but it will be perfectly pressured, and because it is perfectly pressured, the reaction feel will give a reliable indication of flow to the firefighter. **(AUTOMATIC NOZZLES DO NOT CHANGE HYDRAULICS CALCULATIONS)** The most important point here is that when things go RIGHT, the calculations for a manual nozzle are IDENTICAL to that of an automatic nozzle. When things do not go right, the automatic makes the best of the situation.

A very important thing to realize is that the REACTION force of an automatic nozzle is ALWAYS a direct indication of FLOW. Let's state that again. For a given FLOW, the reaction force of an automatic nozzle will always be the SAME. The nozzle pressure is constant at 100 PSI. A look at the nozzle reaction calculation shows that if the pressure is held constant, then the force is in direct proportion to the flow. This is NOT the case for a non-automatic nozzle. Let's look at a 95 GPM fixed gallonage nozzle. When flowing 95 GPM with a nozzle pressure of 100 PSI, the reaction force for this nozzle is 48 lb.

If we cut the flow to 65 GPM, the nozzle pressure falls to 45 PSI, and the reaction falls to 22 lb. Conversely, if we increase the flow to 125 GPM, the nozzle pressure increases to 175 PSI, and the reaction increases to 84 lb. Reducing the flow by less than one third has cut the reaction in half. Similarly, increasing the flow by one third has almost doubled the reaction. This can be very confusing when the nozzle becomes one with multiple flow settings.

It is very easy for a firefighter to set the nozzle at too low a setting for the pump pressure being delivered. This causes the nozzle to be grossly over pressured causing a high reaction force, making the firefighter believe that he is delivering much more flow than he actually is, based on the reaction force of the line. This table shows that it is possible to have 50 lb. of reaction force at three separate flows from 76 to 140 GPM all depending on the nozzle pressure. Since we don't have a means for the firefighter to measure nozzle pressure, how is he supposed to know whether the reaction he is feeling is due to pressure or flow? Which puts out the fire? Isn't it important that he know?

Nozzle Pressure	Actual Flow	Reaction Force
50 PSI	140 GPM	50 lb
108 PSI	95 GPM	50 lb
170 PSI	76 GPM	50 lb

Now lets look at those same flows from an automatic nozzle to see that reaction force is always in direct proportion to flow.

Nozzle Pressure	Actual Flow	Reaction Force
100 PSI	140 GPM	71 lb
100 PSI	95 GPM	48 lb
100 PSI	76 GPM	38 lb

The nozzle setting is not applicable because the nozzle is automatic. The nozzle pressure stays at 100 PSI, because the nozzle is controlling the pressure. The important point to note is that reaction force of an automatic nozzle is ALWAYS in direct proportion to the flow. This allows fire personnel to "feel" flows fairly accurately once they have practiced holding the nozzle with a known flow and resulting reaction force.

3) Low pressure streams are easier to handle.

Lowering the nozzle pressure lowers the nozzle reaction. That is an indisputable fact. The question is, how low can we take nozzle pressures and still obtain an effective fire fighting stream? If we move from 100 to 75 then why not 50, why not 25, why not take the nozzle off, lay the open butt in the window, and let the building fill up? The answer to this is not a simple one. Why was one hundred PSI chosen? Is it a "magic" number"? Is it absolutely sacred? No one that I know of KNOWS with certainty where it came from, and I don't think that anybody will ever know. It seems to be a good round number that causes a combination nozzle to have good fog and straight stream properties. Unfortunately, a lot of comparison testing is done while using the "Parking Lot Fire Fighting Stance". Enough of this is being done, in fact, that I think a manual could be written on the subject. In actual fire combat, we commonly measure time of application in seconds not minutes. We are crouching, kneeling, laying flat. We are NOT STANDING UP IN A PARKING LOT. The reaction felt while down in a crouch position is a far cry from that felt while standing up. The question that we have to answer (And I will agree that there is no RIGHT answer) is this, "How much pressure is enough?" We need to arrive at this number based upon the hitting power of the stream, the reach of the stream, the breakup of the fog pattern, the supply pressure available and other such criteria. It should not be whether it has 14 or 15 percent less reaction and is easier to handle standing in the parking lot flowing water for 5 minutes at a clip. Currently, there is a lot of interest in lower pressure nozzles. One reason for this would be to lower the reaction forces of the nozzle while maintaining the flow constant. Another reason might be to obtain higher flow rates when supply pressures are limited. There is NO EASY answer. What really matters is that SUFFICIENT WATER be delivered to the area of fire involvement as quickly and as safely as possible.

4) To reach the seat of the fire you have to use a smooth bore.

Many people have come to believe that a stream from a combination nozzle "evaporates" before it reaches the seat of the fire whereas the "solid rope" of water from a smooth bore does not. Let’s consider for a moment the fire walker. He walks across hot burning coals in his bare feet-not standing still even for a moment. We all have experimented with this on a smaller, but less hazardous scale. Do you recall moving your finger through the flame of a candle? Did you get burned? Of course not, there was insufficient time for the heat to be absorbed by your skin. The water exiting a nozzle at 100 PSI is moving at the rate of 98 feet per second. Therefore, a stream aimed at the back of a room in a typical house from the front door (at most 25 feet) arrives at the back of the house in 3 tenths of a second.

Testing was conducted in the summer of 1991 by Task Force Tips to prove that this is, in fact, the case. In these tests, two streams of equal gallonage, one from a smooth bore, and one from a combination nozzle were directed through a 14 foot long tunnel heated to 2000 degrees F with propane burners. All of the water exiting the tunnel was collected. The test was run for 5 minutes at various flow rates. In no test was there a difference in the amount of water collected that was measurable within the limitations of the test. The data collected from many of the tests mentioned in this presentation could in themselves be the subject of a complete program. Complete details of this testing are available upon request.

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5) A combination nozzle has a HOLLOW STREAM.

Let's explore how smooth bores and combination nozzles form streams. The smooth bore forces the water into an ever smaller space which causes the water to accelerate or speed up. At the point it leaves the nozzle, the velocity/speed across the water stream is not uniform. The velocity/speed at the center is much higher than that at the edge. The velocity/speed at the edge is slowed by the friction with the walls of the tip, and the velocity/speed in the center is at its highest. The instant that the water leaves the nozzle, the higher velocity water at the center "tears" away from the lower velocity water at the outside, and this occurs at the same time as the air bites at the outside of the stream. Picture yourself trying hold an open pan of water out of the window of your car at 70 miles per hour and keeping the water in the pan. The main point to note is that once the water leaves the nozzle, it only has one way to go, outward. It must spread apart — there is no force available to hold it together. The smooth bore delivers a stream that can be compared to the beams of light from a filament type bulb.

The combination nozzle works on a very different principle. The water is divided and spread outward by a baffle. The water is then forced to turn a corner by the stream shaper. The wall of water leaving the stream shaper is thinner than the smooth bore, but it is of uniform velocity/speed and moving parallel to the direction of throw. There is, in fact, a measurable vacuum on the inside of the stream immediately in front of the nozzle. Because the water has been forced to leave the nozzle in a parallel manner, there is no inherent tendency to spread apart like the smooth bore. The effects of the air are similar to that of the smooth bore, in that, both when properly pressured, will peel off a layer of "fuzz". In most cases, the number of gallons contained in this fuzz are an insignificant percentage of the total stream flow. In summary, the stream of a combination nozzle resembles a laser. A very dramatic way to demonstrate that the stream is NOT hollow is to use a Pitot gage to "measure" the pressure at a distance of 3 to 5 feet from the exit point. Both the combination nozzle and the smooth bore can have their pressure measured at this point. Testing has shown that for equal FLOWS and BASE PRESSURES, the combination nozzle will have a higher Pitot pressure than the smooth bore. This proves that the combination nozzle MUST have a tighter stream. If the flows are equal, and the base pressures are equal, then the stream with the higher Pitot pressure is the stream with the highest water density. In all cases where a smooth bore and a combination nozzle are compared at equal flow and pressure, the combination nozzle will have the BETTER stream. I realize that this flies in the face of tradition, but you will find it to be true. The typical "parking lot" demonstration compares a smooth bore at 50 PSI to a combination nozzle at 100 PSI. It should be fully expected that the lower pressure stream will have less "fuzz". But is the stream with the least amount of "fuzz" the best stream for fire-fighting? Either bring the combination nozzle's pressure back to 50 or increase the smooth bore to 100 PSI. Whichever way you choose to compare, the combination nozzle will make the better stream. This is in addition to its ability to deliver a fog pattern and to change the flow rate without the water being shut down. It will be clear after performing this test that a combination nozzle does not have a hollow stream if examined past the first few feet of the stream. The focal point of a combination nozzle is that point at which the stream ceases to be hollow.

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6) Low pump pressures should be used to go "easy" on equipment.

Many of those that promote the use of lower pressures claim that one of the benefits of this practice is reduced work load on the equipment. Is this a goal that we are trying to achieve? In the past 5 years, NFPA has adopted new standards for test and working pressure of fire hose. The fire hose currently being used by most departments has a service test pressure of at LEAST 300 PSI and in some cases 400 PSI. Recent developments in the weave of fire hose jackets has increased the flexibility, while at the same time significantly reducing the tendency to kink.

We are paying huge amounts for our fire apparatus to increase the volume that they can pump and to increase the pressures that they are capable of delivering. Yet we have fire departments with pump pressure standard operating procedures that are no higher than those used by the steamers in the late 1800's, a time when the hose was made of LEATHER. Are we trying to reduce the load on our personnel or on our equipment? Surely we all agree emphatically that we need to reduce the work load and stress on the firefighter. One of the reasons that people believe that equipment is under undue strain is that we stand in the street next to a stationary engine, and listen to it scream. This fools us into believing that we are overworking it. Compare the tachometer reading of an over the road tractor trailer at 60 MPH to that of a typical fire pumper delivering 200 PSI, and you will find that they are almost identical. The over the road truck is expected to travel 250,000 miles between overhauls, whereas the typical fire pump is retired with one tenth of that. What are we worried about? Let's use the pressure capability of our modern pumpers and hose to deliver higher volumes through smaller, lightweight, and more maneuverable attack lines.

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7) Smooth Bore nozzles "Hit Hardest".

This is probably one of the most commonly held beliefs in the fire service. Somewhere along the line in a recruit's training, somebody with much more experience will point to a smooth bore and say "We use the combination nozzles all the time, but when we want some 'real punch' we switch to that." To develop some scientific evidence on this matter, Task Force Tips undertook extensive testing. The commonly held belief that a smooth bore "Hits Harder" is primarily based upon the belief that a combination nozzle's stream is a hollow stream. That topic is discussed in another section of this presentation. A test stand was configured where nozzle flow, pressure, and the impact against various size targets could be measured and tracked with a strip chart recorder. Multiple flows were tested as well as multiple distances. In ALL cases, the combination nozzle had equal impact to the smooth bore. The only exception to this was in the 25 foot test where the combination nozzle had a HIGHER force than the smooth bore. When presented with this information, some have stated that the reason they are the same is that we have collected the impact force over too large an area, thereby not taking advantage of the "tight stream" of the smooth bore. To be assured that this was not a factor, all of the tests were done with different size targets. At each distance and flow, the reduction in force with the smaller target was, in each case, the same for the smooth bore and the combination nozzle all the way down to a 3 inch diameter target. A complete report!on these tests is available.

Now, I realize that about now there are many of you saying to yourself that this guy is crazy-granddad couldn't have been that far off. The question is does this "make sense" from what we know of physics? Lets look for a moment at that aspect. We all have heard of Sir Isaac Newton and a fundamental law of nature that he discovered, F=MA which translates to FORCE equals the MASS times ACCELERATION. The MASS is the amount of water flowing, the ACCELERATION in this case actually relates to de-acceleration as the water hits the target and as such relates to the velocity or pressure of the water. So streams of equal MASS (rate of water flow) and equal ACCELERATION (equal speed when striking the target, same as equal pressure) will have equal FORCE. Physics tells us that the streams should be of equal impact at equal flows and pressures. Our testing confirmed this. For those of you that have specific interest in this testing, further details are available upon request.

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8) Manually adjustable nozzles are easier for pump operators.

The origin of this belief is very difficult to understand, as automatic nozzles were invented as a direct result of the difficulties involved with pumping to fixed and or manually adjustable nozzles.

In May of 1968, the automatic nozzle was invented by Clyde McMillan. He drew the first design on a napkin at his kitchen table. He designed the automatic to solve problems that he had experienced at a major fire in Gary, Indiana the night before. The reason it was invented was to SOLVE hydraulics problems, not make them worse, and it has been doing just that for 25 years!

A good comparison can be drawn with automatic transmissions. Why are the vast majority of new apparatus built with automatic transmissions? Hasn't the advent of automatic transmissions dramatically decreased the work load on our drivers. The driver now selects his speed based on conditions that he sees out the front window. Responding with a single control, the throttle, rather than having to adjust throttle, shifter, and clutch in harmony allows more attention to be placed on safe driving. In addition, the engine will always operate at efficient speeds well within its limitations.

Automatic nozzles have been solving the fire ground problems of many departments for years. So many years in fact, that many have forgotten the extent of those problems. An automatic nozzle does not CHANGE the laws of nature! If friction loss calculations are done correctly, an automatic nozzle will perform the same as a properly sized manual nozzle. Automatic nozzles simply make things work when the chips are down, and when, in spite of all the pre-planning, things don't go as planned.

Let's look at the steps to arriving at a pump pressure with a fixed gallonage nozzle. The nozzle and flow rate are selected, the friction loss for that flow is calculated, and then the friction loss is added to the nozzle pressure that was used to determine flow to arrive at the correct pump pressure. (Elevation and device losses are also sometimes considered, but are rarely significant) If the above procedure is done for an automatic nozzle, it will SIZE itself INSTANTLY to be the correct size nozzle for that selected flow. If however the hose is kinked, longer or shorter than thought, a different size than thought, if water supply is less than expected, the pump transfer valve is stuck, or any of a thousand other things that can and do go wrong on the fire ground occurs, the automatic will size itself to deliver an effective stream at that new flow rate.

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9) Fog patterns are not needed for aggressive interior fire attack

While it is true that fog patterns are frequently used when not appropriate, there are times when they are truly advantageous. Any tool that is used incorrectly by an inexperienced user can do more harm than good. Imagine the untrained apprentice carpenter, and that he has NEVER seen a claw hammer. It may be just as likely that he would try to drive a nail with the claw, as it is that he would use the face. Does this mean that we ought to ban all claw hammers? Does this mean that we give him a double faced sledge hammer so that he can't make a mistake? Of course not, we must teach people when to use a tool and how to use it. The fog stream from a combination nozzle is just the same, it is a tool. There are times that it is useful, and there are times when it does much more harm than good.

In the early stages of a fire when the thermal balance is still intact, a straight stream is the ONLY way to go. A fog pattern can be used to obtain maximum heat absorption by the water available when a fire is in the flashover stage. It can also be used to ventilate a room very quickly, and it can offer protection to a hose crew when the unexpected happens. The fog pattern from a combination nozzle can be a very powerful ventilation tool. There is approximately 30 horse power being delivered in a typical handline stream flowing 150 GPM at 100 PSI. If the fog stream is only 20% effective in delivering that horsepower as air movement, then you are holding a 3 horsepower fan in your hands. True enough that using a fog pattern when your "in bed" with the fire can have negative effects on the hose crew, as well as make the job of finding the fire and extinguishing it very difficult . Please think back a moment to the young apprentice carpenter... Don't we have a responsibility to train our people to use all of the tools available to them correctly and at the proper time? Or do we take the easy way out and just take the tool away?

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10) The pump operator should control the flow.

Think for a moment of the last time that you were involved in towing a vehicle, and you had the unfortunate luck to be in the TOWED vehicle. Do you remember how out of control you felt? There you are, many feet away from and out of communication with the one person that has the real control of the situation, the driver of the vehicle doing the towing. He is going to decide how fast you go and where you go. Imagine trying to merge into a four lane highway. You need just a little more speed to safely merge, but alas, you have NO CONTROL. All you can do is hit the brakes to get his attention (gently, now gently, you don't want to break the rope) but that sends the wrong message to the guy up front, and then he slows further. Isn't this what we are doing to our nozzlemen? We send them in with some half baked SOP FLOW available, whatever happened to work the last time, perhaps...and if it isn't enough what can they do? Why do we insist on taking the control away from the firefighter? He is the only one that knows how much he can handle, how much he needs, isn't he? Traditionally, we leave that decision with the pump operator who is out in the street!

In my opinion, the pump operator's job is to assure that water supplies are adequate, that the truck is operating normally and that sufficient pressure is being supplied to assure the fire fighter of the maximum flow that he might possibly have need for. It is the fire fighters job to evaluate what is the needed flow, then "throttle" the nozzle to a flow that fits the need. Examples of where the fire service does things "backwards" in this regard are plentiful.

LETS consider for a moment the recent past experience in the Persian Gulf war...Did the United States send a small battalion into the fray in Iraq with the admonishment of "Go see what you can do with a squad of men, see what you have, and if you get pinned down, call back, and we'll see if we can scrape up some more help". No of course not. Every effort was made to have the maximum number of troops and equipment humanly possible, ready and waiting for instant deployment. The officers that were on the front made decisions on when to use, how much, and of what resource. Similarly, the military outfits a "Squad" of infantry with a marksman, a bazooka, a machine gun, etc. and sends them all into the fight at ONE TIME. The officer in the fight decides the level of firepower needed to meet the threat, and he employs that level of fire power. If he was forced to call back for what he needed, the remaining troops would lose the battle in the intervening time period, much as our buildings burn while heavier streams are brought to bear. We must make our initial attack with everything that we can muster. Do you increase the flow only when a burning helmet comes flying out the window?

Frequently, we are sending in our "troops" armed with a flow that is too small for the job at hand. By the time they call for reinforcements, it is frequently too late. It is my opinion that we should have standard operating procedures that maximize the capability of the attack team. If it is determined that maximum flows are not needed, then the nozzleman can throttle that flow back to what is needed while still keeping flow capability in reserve should the unexpected happen. Let’s go on the offensive.

So what does all this add up to? Hit it hard, hit it fast, hit it with all you’ve got!

For question and/or comments about these Facts & Fantasies
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