SPECIAL REPORT

THE

PRINCIPLES

OF

TOUCH-FREE

WASHING

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MARK VII
AquaJet®

THE PRINCIPLES OF TOUCH-FREE WASHING

I. Introduction

With the popularity and demand of touch-free washing increasing, it's crucial that you be familiar with the principles of the touch-free wash process. Your knowledge of these principles will help you evaluate your existing touch-free operations, your competitors' touch-free washes and prospective equipment for your future locations. You will be able to make informed choices that will increase the value of your business and attract more customers.

Although this report has been compiled by a major manufacturer of touch-free equipment, every attempt possible has been made to report all variables on an objective basis—therefore you are left to make your own conclusions on the overall effectiveness of any particular touch-free wash process. Whenever possible, third-party sources were used and referenced.

There are four basic elements that combine to provide a touch-free wash:

- Water Hardness
- Temperature
- Chemicals
- Impingement

Each element contributes significantly to the level of performance of a touch-free wash.

II. Water Hardness

Hardness is a term that refers to the content of certain minerals in water—primarily calcium and magnesium. Virtually all water naturally contains some degree of hardness. Hardness is measured in grains per gallon (gpg), parts per million (ppm), or milligrams per liter (mg/l). One grain equals 17.1 ppm or mg/l. Soft water is defined as having less than one grain per gallon. All water with hardness of one grain or more per gallon is considered "hard." The following table defines the degree of water hardness:

TABLE 1†

Grains Per Gallon	Parts per million or milligrams per liter	Description
Less than 1.0	Less than 17.1	Soft
1 to 3.5	17.1 to 60	Slightly hard
3.5 to 7.0	60 to 120	Moderately hard
7.0 to 10.5	120 to 180	Hard
10.5 and higher	180 and higher	Very hard

The hardness of the water impacts the touch-free wash process in several ways:

- Chemicals
- Water Temperature
- Impingement
- Customer Satisfaction
- Equipment Reliability

Chemicals

The calcium and magnesium found in water also affects the washing chemicals. These minerals are relatively soluble and look for other minerals or ingredients to attach themselves to. These other ingredients are commonly found in car washing chemicals†. When a reaction takes place, the active cleaning ingredients in car wash chemicals are neutralized. As hardness increases, more chemical concentrate is required to provide an active cleaning solution. In contrast, soft water allows the operator to use less chemical concentrate to obtain the cleaning power desired. The following table shows the savings:

TABLE 2

CHEMICAL SAVINGS USING SOFT WATER	
ORIGINAL WATER HARDNESS	APPROXIMATE SAVINGS WHEN SOFTENED
2 - 5 grains	15%
5 - 10 grains	25%
10 - 15 grains	35%
15 - 20 grains	45%
20+ grains	50%

Chemical savings alone provide justification for inclusion of a water softener in the touch-free equipment package.

Water Temperature

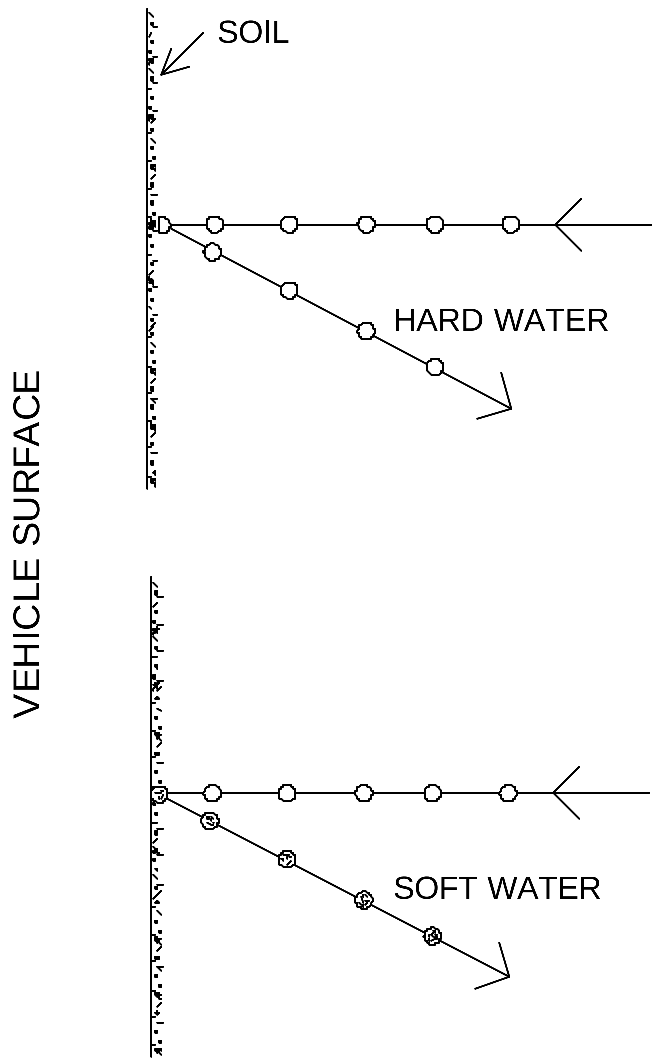
Water heating efficiency decreases when the calcium (scale) builds-up on the heat exchanger surfaces due to hard water†. The scale forms insulation between the heating source and the water. Therefore, more energy (B.T.U) is required to raise the water temperature to the desired level. The general rule of thumb is for each 1/8 inch of scale, fuel costs increase 16%†. As the scaling builds-up, a point is reached when the maximum B.T.U. exchange capacity of the heater cannot raise the water temperature to sufficient levels for desired chemical reaction and wash quality suffers. Water heaters can be de-scaled. This costly procedure can be avoided if soft water is consistently used.

Impingement

Impingement is also enhanced when soft water is used. Hard water has the property of "surface tension." You may recall the high school physics experiment where a water glass was filled with water to the rim. Then, drop-by-drop, additional water was added. You could actually see the water above the rim. Yet, the water didn't overflow. The reason it didn't was surface tension. In fact, the experiment would not work with soft water because soft water doesn't have surface tension. Soft water allows the surfactants in the soap to operate at their full potential, reducing the surface tension of the water.

Surface tension will affect the wash process. In high-pressure touch free applications, the water stream emitted by the nozzles consists of tiny droplets of water. The water droplets must break through the existing water and soap on the surface of the car to agitate the soil and flush it away. The forces holding the water close to the surface of the vehicle are very strong. Greater surface tension causes the force of the water droplets to dissipate on the water surface without imparting significant work on the dirt, oil or road film (see Figure 1).

FIGURE 1



Customer Satisfaction

Hard water also leaves a residue or film on the vehicle's surface†. The film consists of calcium residue that has dropped out of the water in reaction to the active cleaning compounds in the car wash chemicals. On the other hand, soft water leaves no such residue because the calcium has been removed—leaving the customer with a higher quality wash.

Equipment Reliability

The calcium fallout, described above, also affects the performance of the equipment and the water heater †. The calcium (scale) builds-up inside the pipe components, valves, hoses and even the nozzles. Such build-up causes the flow of water to be restricted. As a result, water pressure and water volume is reduced, adversely affecting wash quality.

The scaling on internal valve surfaces causes valves to not seat properly. Scaling will cause erratic pressure and, ultimately, premature pump failure inside the high-pressure pumps†. Pumps operating with hard water require more frequent service to maintain their desired output. Scaling inside the pressure regulator valve also causes erratic operation of this critical component of the high pressure pumping plant.

In summary, hard water is one of the touch-free wash's worst enemies. It affects all other aspects of the touch-free wash process. Virtually all touch-free equipment manufacturers recommend the inclusion of water softeners in their equipment packages and soft water throughout all the wash cycles. At least one manufacturer even requires softeners and its warranty is void if a water softener is not used. Only one manufacturer is believed not to recommend or mandate soft water for all aspects of their touch-free wash process.

III. Temperature

All physical and chemical reactions are temperature-dependent †. A rule of thumb is that for each 10 degrees Celsius (C)—18 degrees Fahrenheit (F)—rise in temperature, the rate of reaction doubles. In other words, the higher the temperature, the faster and better the cleaning. Naturally, there are limits. Those limits would be temperatures at which the surface being cleaned or the wash equipment itself could be damaged. Temperatures should be limited to 140 - 150 degrees F to avoid such potential damage.

Most chemical suppliers recommend surface reaction temperatures of 80 to 100 degrees F. Some recommend higher surface temperatures up to 130 degrees F. Virtually all suppliers agree that temperatures less than 80 degrees lower the reaction to unacceptable levels. Only one supplier is known to be advocating cold presoak.

A representative of a major chemical company lists the following factors in cleaning that are dependent on temperature†:

1. Soils and soil deposits are more soluble at elevated temperatures—80 to 100 degrees F.
2. The surface active agents in chemicals are more efficient at a higher water temperature.
3. Emulsification of dirt, oil, and combinations of these types of soils is much faster at a temperature of 100 degrees F than at lower temperatures.
4. The alkaline builders in chemicals saponify the oils in soils much faster at 100 degrees F than they would at 50 degrees F.
5. Solvents present in liquid chemicals, such as the glycol ethers, solubilize soils much faster at elevated temperatures.
6. Chelation of minerals in various soils takes place much faster at elevated temperatures.

To summarize, the higher the temperature, the faster the various water, soil and chemical molecules move in a solution (as long as temperatures do not exceed safe levels). The result is better cleaning power. Just like washing your dishes at home, using a higher water temperature produces a more effective cleaning result.

IV. Chemical

Car wash chemical is the element of the touch-free wash process that loosens the soil on the vehicle's surface so that it can be rinsed-off. Chemical is one of the most variable elements of the touch-free wash equation. Hundreds of chemical suppliers are selling products that they claim are safe, effective and cost-efficient.

Chemicals can be liquid or powder. Either type can have fillers—ingredients that add weight but no cleaning enhancement. Liquids are more convenient to use and can be automatically dispensed very easily. Powders do require premixing, however they usually cost less than liquids. Chemical prices vary depending on the following:

- Freight
- Packaging (generally, larger quantities cost less per unit)
- Ingredients
- Distribution (layers of mark-up)

Higher prices do not necessarily translate to higher quality. Some chemicals are built very inexpensively by using only two or three ingredients. Others contain numerous ingredients, including some designed as buffers to inhibit oxidation of aluminum. Chemical costs are also affected by dilution ratios.

Most chemicals contain ingredients that clean by both chemical and physical reactions. Chemical reactions include saponification and chelation. Physical reactions include dispersion, solubilization, and wetting.

Chelation is a chemical reaction where some minerals on the soiled surface are latched-on to by a chelating agent in the chemical, making these minerals more soluble.

Saponification is the chemical reaction between alkali, oils and grease on the vehicle surface. The alkali in the chemical reacts with and loosens the oils and grease making them easier to rinse-off.

Dispersion is a physical reaction in which chemical ingredients break-up the soil on the surface so they will disperse when rinsed and not redeposit themselves on the newly-cleaned surface.

Solubilization is the dissolving of soils into the water-chemical liquid solution. This reaction is the same as dissolving salt in water. The salt is still present—however the mineral is in a liquid suspension.

Wetting is the action of penetrating and softening heavier soils[†].

Some chemicals contain all of the above characteristics, some do not. The best way to determine any chemical's effectiveness is to observe the results. Most touch-free equipment suppliers offer start-up chemical with their equipment. It is logical to assume that the chemical they supply is, in their opinion, the best available. After all, they want their equipment to clean as well as it possibly can. Therefore, the operator should use the chemical that the equipment supplier recommends. If the cleaning results are not as good as the operator desires, the equipment supplier should be given the opportunity to offer a more effective solution. If the equipment supplier is unable to do so, then the operator should look for an alternative chemical.

In looking for an alternative chemical, it is recommended that the operator observe the prospective product in use elsewhere. If the operator's evaluation is positive, then the alternative chemical should be tested in their own wash. It is not recommended that the operator test several different chemicals, one after the other. Such testing causes inconsistency to the consumer product.

In summary, good chemical is mandatory for a quality touch-free wash. The operator should trust their equipment supplier for the best chemical possible. The equipment and chemical work together as a system, and <u>the equipment supplier should be accountable for the entire process</u>.

V. Impingement (Impact)

Impinge: "to come into sharp contrast (with)" *Webster's Encyclopedic Dictionary*; "to collide, to push against" *American Heritage Dictionary*; "to strike or dash with a sharp collision" *Webster's New Collegiate Dictionary*.

Impingement in a touch-free wash is the force of the water striking against the surface being cleaned. An adequate balance of force must be reached so that the force is sufficient enough to remove the soil, but not too severe as to inflict damage to the vehicle's surface. The amount of impingement or impact force is determined by a combination of several factors:

- Water Flow
- Water Pressure
- Strike Pattern
- Speed/Time

Water Flow

Water flow is determined by the output of the pump, the amount of friction that reduces flow between the pump and nozzles and the size of the nozzle orifice. The pumps most commonly have outputs of 30 to 40 U.S. gallons per minute. Depending on the distance between the pumping plant and the nozzles, flow can be reduced significantly. The closer the nozzles are to the pump, the less the flow is affected by friction. Friction loss of flow rate can be reduced by driving the pump at higher revolutions per minute (rpm) with more motor horsepower.

Water Pressure

The operating water pressure is determined by the flow and the nozzle size combined. All high-pressure pumps used in touch-free wash applications are positive displacement-type pumps. These pumps positively force the water flow from the intake valves into the cylinders and through the exhaust valves. The water can flow only one-way, so no internal bypassing can occur. The fluid is then forced through the nozzles. The size of the nozzle orifice or restriction determines the amount of pressure—the smaller the orifice, the higher the pressure.

To regulate the pressure, a pressure regulating bypass valve is located between the exhaust side of the pump and the nozzles. Pressure is normally measured at or near the pump. The pressure reading is actually the back-pressure created by the nozzle restriction. Because water flow is reduced due to friction, the pressure at the nozzle is also reduced. That reduction can be substantial. In equipment with remote pumping plants, the nozzle pressure can be as much as 35% less than the pump head pressure. Equipment with the pumping plant on-board the wash gantry will have a nozzle pressure approximately 5% less than at the pump. Most touch-free systems operate with pump pressures of 1,000 to 1,200 pounds per square inch (psi).

Strike Pattern

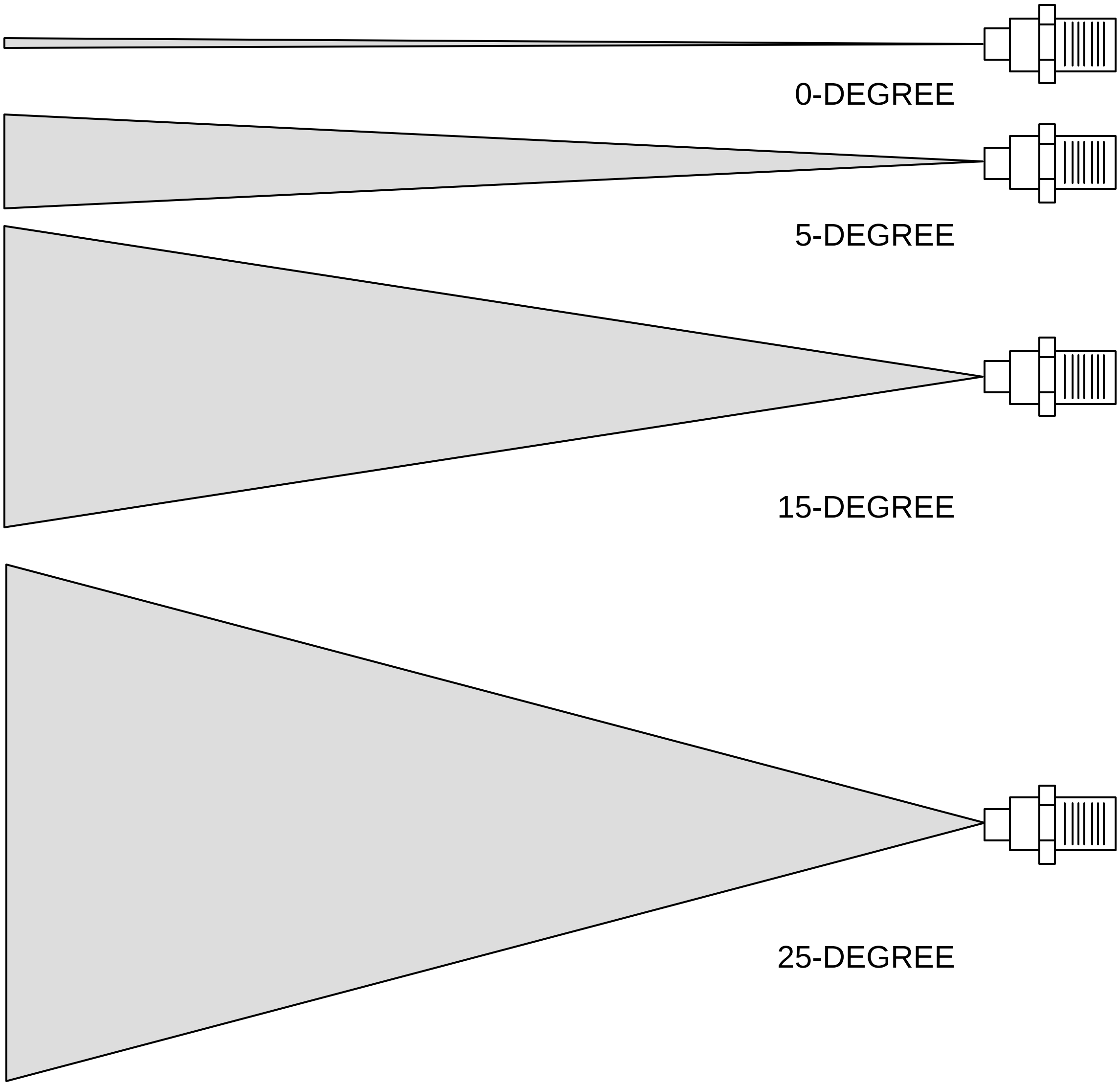
The nozzles on the wash gantry are the first element of the strike pattern equation. The most common nozzle orifice sizes used in touch-free wash systems are 02 and 03. There are three types of high-pressure nozzles used:

- V-Jet Nozzle
- Zero-Degree Nozzle
- Turbo Nozzle

V-Jet Nozzle

V-jet nozzles project a V-shaped spray pattern. The shape of the "V" is determined by the angle of the spray. Typical angles are 5 degrees, 15 degrees and 25 degrees. A V-jet nozzle with a 02 orifice and a 15 degree angle is numbered 1502. V-jet nozzles can be mounted on fixed spray bars or moving spray bars† (see Figure 2).

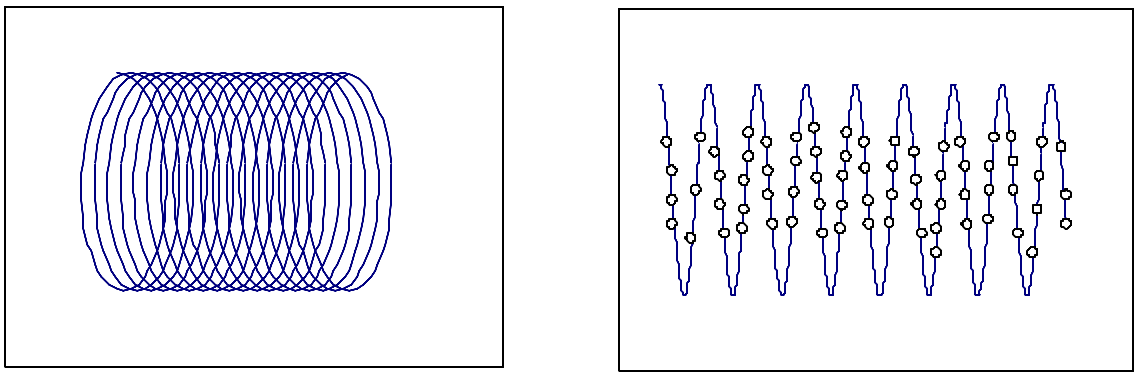
FIGURE 2 NOZZLE SPRAY PATTERNS



The most common spray bar used with V-jet nozzles is the inverted L. A number of nozzles are mounted on the spray bar, close enough to each other to provide coverage of the extended spray pattern on the vehicle's surface. V-jet nozzles are also used in some rotating and oscillating spray bars.

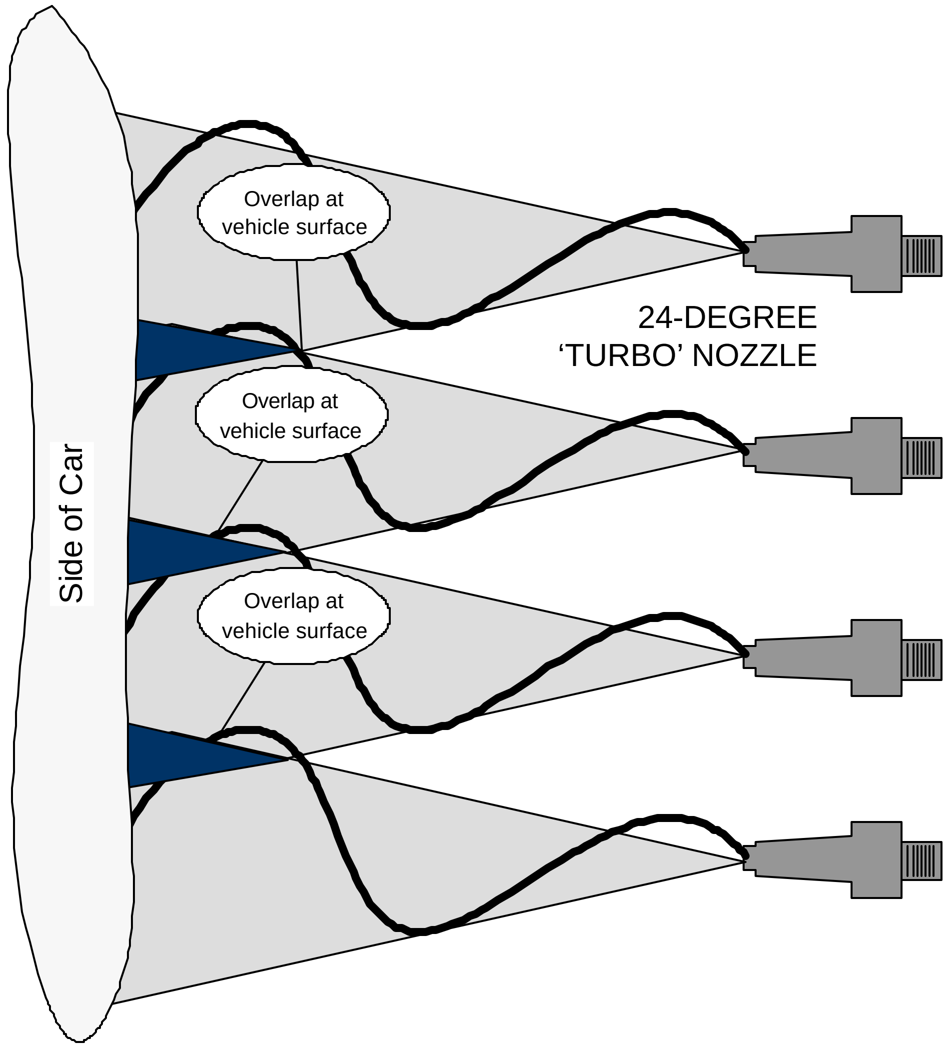
Zero-Degree Nozzle
Zero-degree nozzle orifices are perfectly round and exhaust a very narrow spray pattern. Because of their narrow spray pattern, zero-degree nozzles have no angle of spray and must be moved to provide coverage. Movement is achieved by rotation or oscillation. Rotation provides coverage by timing the revolutions per minute (rpm) to the speed of the gantry moving over the vehicle's surface. Oscillation provides coverage by timing the back-and-forth movement to the gantry speed. (See Figure 3)

FIGURE 3



Turbo Nozzle
Another type of nozzle that combines the impingement of zero-degree and the coverage of a V-jet is a turbo nozzle. A turbo nozzle produces a zero-degree water stream that is rotated at a high speed (typically greater than 1400 rpm) from a central point radially out in a cone shape of 20-25 degrees. (See Figure 4) These produce a circular pattern of zero-degree impingement. The diameter will vary based on the distance of the nozzle from the surface of the car. This action produces a high surface impingement with a high speed circular pattern similar to a zero-degree nozzle on a rotating wand. Various applications of this type of nozzle include a static array affixed to both sides of the car wash that effectively scrub the side of the car as the gantry moves down the length of the car. Similar types of static or dynamic mechanisms utilize turbo nozzles in the cleaning of the front, top and back-sides of the car.

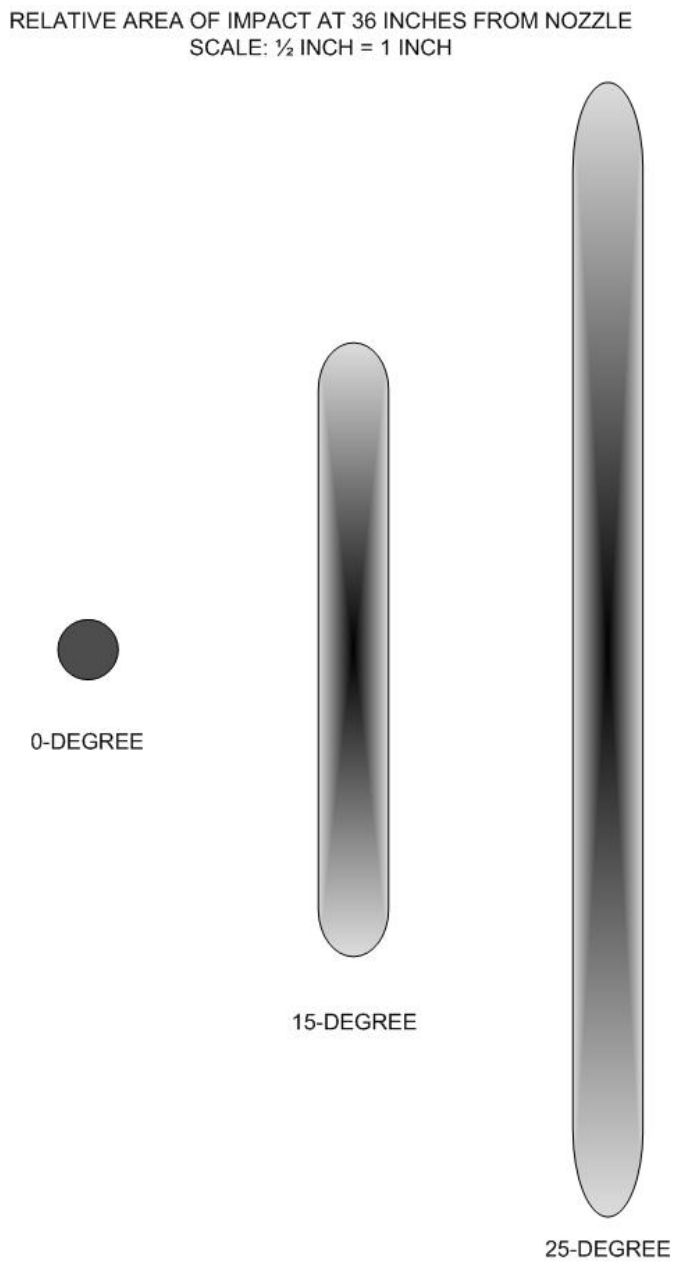
FIGURE 4



For the purpose of this discussion, let's assume that all pressures are equal at the nozzle (which they are not). The type of nozzle pattern and the speed at which the spray passes over the surface determine the amount of impingement at any given point on the vehicles surface—the slower the spray moves, the better or larger the impingement. Likewise, the more concentrated the spray pattern, the better the impingement.

At 36 inches (a typical distance between the top or horizontal spray bar and the windshield of a car) the area of spray coverage for a zero-degree nozzle is approximately 1 inch or the surface area of a U.S. quarter. At the same distance, the spray coverage of a 15-degree nozzle is approximately 9 times greater than zero-degree, and the spray coverage of a 25-degree nozzle is approximately 15 times greater than zero-degree. (See Figure 6.) If all nozzles have the same output pressure, the impact force or impingement per square inch of the 15-degree and 25-degree spray are respectively decreased by 89% and 94% relative to zero-degree patterns.

FIGURE 6



Speed/Time

The speed of the spray movement over the vehicle's surface also impacts impingement. The most concentrated spray patterns, zero-degree, are compromised if their movement over the surface is too fast to allow the impingement to occur. Speed is also critical with V-jet spray patterns. Because the V-jet spray has less impact than the zero-degree, the length of time at any given point on the surface should be longer than with zero-degree.

Some touch-free manufacturers speed-up their equipment in order to lower operating costs, while others rotate or oscillate their nozzles at faster speed to facilitate better coverage in zero-degree applications. These types of speed increases will decrease impingement.

You can test the impact of speed at a coin-operated, self-service car wash. Using a fairly-soiled vehicle, wash a side surface (the easiest to do) by holding the wash wand perpendicular to and approximately twelve-inches from the vehicle's surface. Then, walk-along the side of the vehicle from end-to-end. You can repeat this procedure at different walking paces. As you walk faster, less impingement will occur and you can easily see the difference on the vehicle's surface.

To summarize, impingement (the element that actually removes the soil from the vehicle's surface) is affected by water volume, water pressure, spray pattern and the amount of time cleaning on the surface. Within safety limits, higher pressure, a concentrated spray pattern and more time translate to better impingement and better impingement means a better wash—resulting in satisfied customers.

VI. Summary

Many variables are involved in researching or purchasing a touch-free washing system. Touch-free wash operators need to carefully select their equipment configuration and chemical to assure themselves of the highest quality touch-free wash. Many believe that touch-free is the future of the car wash industry. If so, in a few years, most of the commercial washes will be touch-free and consumers will have their choice of touch-free washes—choosing the best wash available.

VII. Glossary

Chelation: A chemical reaction where some minerals on the soiled surface are latched-on to by a chelating agent in the chemical, making these minerals more soluble.

Chemical Fillers: Ingredients that add weight but no cleaning enhancement.

Dispersion: A physical reaction in which chemical ingredients break-up the soil on the surface so that they will disperse when rinsed and not redeposit themselves on the newly-cleaned surface.

Emulsification: The continuous dispersion of two incompletely mixable liquids, one of which is the form of fine droplets.

Impingement: The force of the water striking against the surface being cleaned.

Saponification: The chemical reaction between alkali, oils, and grease on the vehicle surface. The alkali in the washing chemical reacts with and loosens the oils and grease making them easier to rinse-off.

Solubilization: The dissolving of soils into the water-chemical liquid solution.

Surfactant: A substance that facilitates the spreading of another substance; a surface-active agent.

Wetting: The action of penetrating and softening heavier soils.

†Reference sources available upon request. To obtain additional copies of this report, contact Mark VII Equipment, Inc.:

Mark VII Equipment, Inc.
5981 Tennyson Street
Arvada, CO 80003
(303) 423-4910 • Fax (303) 430-0139 • Toll Free U.S. and Canada: 800-525-8248
www.mark7inc.com