Four Keys to Quality Jetting

Basic knowledge of water jetting mechanics can help you get better results for your customers in multiple applications

By Mark House

When water jetting, it's important to use a tool well designed for the job - but that by itself is not enough. Factors outside the realm of tool design are also important.

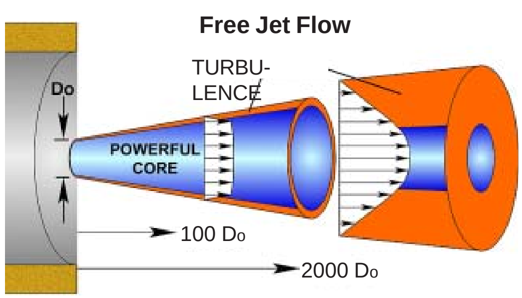
In the simplest terms, the goal of a water jetting system is to deliver as much of the pump's power as possible to the surface being cleaned. Use of the wrong tools or mismatched equipment can forfeit as much as 80% of the jetting pump's power.

Four factors are critical to productive, profitable water jetting.

1. Preserve jet quality

The first prerequisite for a successful job is excellent quality jets. The jet is nothing more than a shaped restriction in the flow channel that forces the water to accelerate, converting potential energy (pressure) into kinetic energy (velocity).

The jet shape, materials, and upstream flow turbulence are all important to delivering maximum energy to the work. The powerful, cohesive, high-velocity jet is established in the first 8 to 25 orifice diameters downstream from the orifice. Farther away, the outside surface of the jet is slowed by drag through the air.

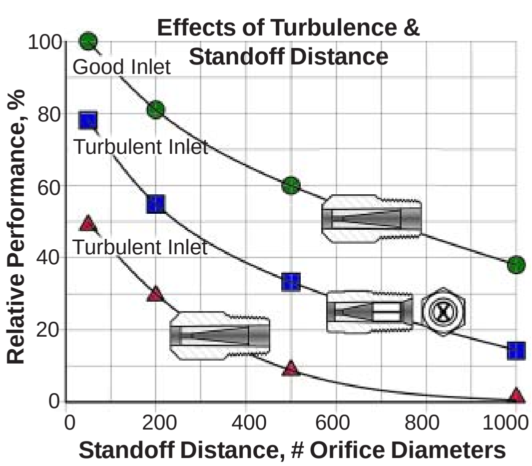


Droplets of water appear in the air surrounding the jet, and bubbles of air are entrained into the jet's outer surface. This turbulent zone grows at the expense of the powerful cohesive core of the jet until there is no power left at all. Only the cohesive core of the water stream cleans effectively, not the turbulent zone.

Even the best jet deteriorates with air drag. It is possible, though, to lose as much as half the jet's power at the start due to excessively turbulent flow upstream of the jet. Turbulence can be increased by abrupt diameter changes in the flow channel, or by direction changes.

Of course we can't avoid turbulence completely, so we need ways to repair its effects. Fortunately, that can be done with a straight section of pipe, or with a flow straightener inlet the orifice.

Eventually every jet wears out from erosion caused by microscopic cavitation from the high-velocity water. Seen through a microscope, the eroded surface looks like a rough canyon. That rough flow channel causes rapid growth in the turbulent zone, which can be seen as a fanned-out shape to the water jet.



Greater turbulence and greater distances from the work surface reduce jet performance.

In severe cases, the original diameter grows to the point that pump discharge pressure falls. Even before it's worn so badly that pressure falls, the jet's impact power is severely reduced. When cleaning performance deteriorates, with no obvious reason, then it's time to replace jets.

Erosion-resistant materials are important in jet design. Ceramics are probably the most erosion-resistant materials. Tungsten carbide nozzles are also popular, and hardened, plated, polished stainless steel can last even longer. Whatever the material, the important point is to select nozzles that start with a visibly tight, cohesive jet shape, and retain it for a long time.

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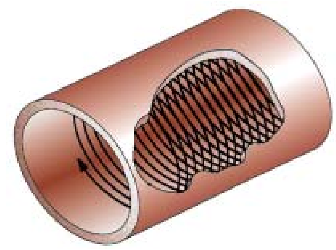
2. Manage the numbers

The second important principle is to use the fewest and most powerful jets possible. If one good jet doesn't cut the surface of the deposits to be cleaned, then more of them will not do better.

Consider the conventional assortment of jetting nozzles used - non-rotating sleds, bullets, torpedoes - needing 6 to 12 jets to clean without leaving dirty streaks. These are good designs because they have no moving parts and are inexpensive. The drawback is that they divide the pump horsepower into 6 to 12 relatively low-powered jets. Greater power is delivered to the surface with fewer, more powerful jets, rotated to cover the surface in a helical jet path. In a nozzle using, for example, three or five jets, each jet is 2 to 2.5 times as powerful as the non-rotating alternative.



A rotating water jet cleans the pipe surface in a helical pattern.

3. Control rotation speed

The third important factor is to control rotation rate to avoid unnecessary jet quality deterioration, and to provide enough dwell time so that the jet can do its work.

A good rule of thumb is to provide about 15 mph transverse jet velocity along the surface being cleaned. This rule works whether the tool is cleaning a one-inch-diameter heat exchanger tube, a 12-inch sewer pipe, or a 40-fooot-diameter crude oil storage facility.

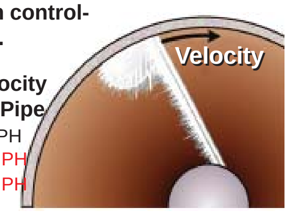
Now consider the dwell time for a typical jet in the case of a quarter-inch-diameter root coming through a crack in the wall of an 18-inch-diameter sewer. At 280 rpm, or 15 mph transverse velocity, the powerful core of the jet contacts the root for only one thousandth of a second. Clearly, rotating too fast impairs results. Besides reducing dwell time, rapid rotation increases turbulence of the jet.

The bigger the diameter, the slower the rotation required. Large pipes or vessels may require air-motor-powered gearboxes to keep rotation rate slow enough to maintain the necessary transverse velocity at the wall.

Unfortunately, rotation speed control adds complexity and expense to a jetting tool. Some nozzles rely on a viscous fluid governor to brake the rotation speed, but other technologies work too. For ex-

Effective pipe cleaning depends on controlling transverse jet velocity.

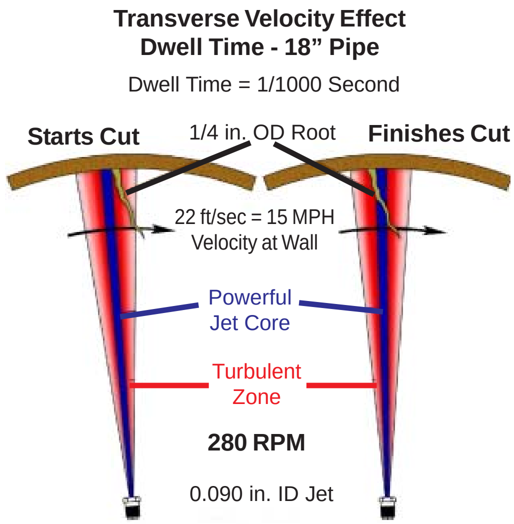
Rotation	Transverse 8" ID Pipe	Jet Velocity 12" ID Pipe
300 rpm	7 MPH	22 MPH
3,000 rpm	71 MPH	224 MPH
10,000 rpm	240 MPH	358 MPH



Max. Transverse Velocity - 15 MPH = 22 ft/sec

Pipe ID	4"	8"	18"	36"	60"	180"
Max. RPM	1240	620	280	140	80	27

ample, centrifugal and magnetic mechanisms are also effective. Users need to recognize when the rotation control system needs repair. The best tool is the human ear. If the rotating nozzle sounds like a jet aircraft engine, it's too fast, and repairs must be done before the seals and bearings burn out.



At 15 mph transverse velocity, the powerful core of the jet contacts the root for just .001 second

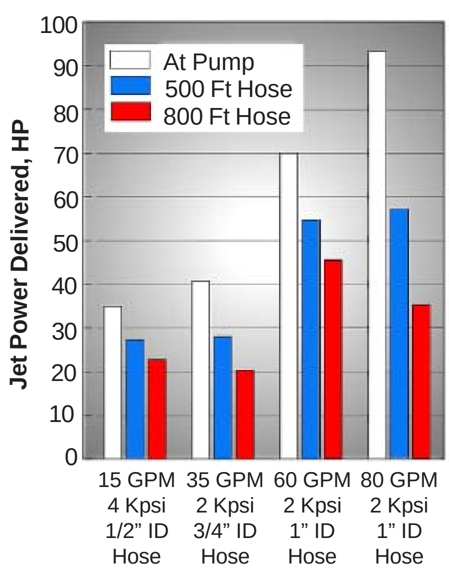
4. Manage hose pressure drop

The fourth important factor is to balance hose pressure drop for the pump being used. Hose pressure drop - a direct, proportional loss in power - is caused by friction as water molecules slide across the wall of the hose and against other water molecules in the hose. The only ways to reduce pressure drop are to use shorter or larger diameter hose.

Sewer cleaning requires relatively long hoses, and larger diameter hose is heavier and so more difficult to pull through the pipe. So even in the best case, 20 to 25 percent of a jetter's power is lost to hose pressure drop.

Most contractors replace worn-out hose with a long section, cutting it off as the end wears or gets damaged. If you notice more powerful jetting with old hose, that's because it's shorter hose with less pressure drop. It can make sense to buy shorter lengths as replacements.

Higher-pressure, lower-flow pump combinations lose proportionately less power to hose pressure loss. That's because less flow has to go through the hose, and pressure loss is a smaller fraction of initial pressure.



Power delivered decreases with the length of the hose.

The illustration suggests an important way to manage hose pressure loss. Compare the 60 gpm, 2,000 psi and the 80 gpm, 2,000 psi cases.

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More power is delivered by jetting the bigger pump at 60 gpm than at 80 gpm. Engineers call this optimization. Since the jets control the flow, it's easy to accomplish. The pump will operate throttled back a bit from maximum power, but more power will be delivered to the sewer jetting tool.

Getting to work

In summary, a few excellent-quality jets with minimum turbulence, rotated at controlled rates, with enough but not excessive hose length, can dramatically improve jetting results. Now, here's a look at some specific applications for water jetting technology.

Cutting roots. Water jets will cut roots, but real roots are not clamped in exactly the right position in front of the nozzle. Roots bigger than about 3/16 inch diameter require waterblast pressures to cut with confidence. The real challenge is nozzle placement - the jets must hit the roots to have an effect. TV inspection equipment has been used to place the nozzle in perfect position, and amazing root cutting can result. On the other hand it's possible to pass the nozzle through the root mass so quickly that the roots are left very clean, but not cut.

Descaling. Corrosion products and mineral deposits often need to be cleaned to restore sewer capacity, or to allow lining. Mineral scale can be particularly difficult to remove, requiring in some cases up to 10,000 psi. Fortunately that's not always the case, and typical sewer jetting pumps are successful. Best results are delivered by jets that impinge almost directly on the pipe walls (a slight angle helps the deposits flake off). The problem is that jet geometry will not allow the nozzle to pull itself. The most powerful approach is to use conventional pulling jets to pull the hose and nozzle to the next manhole or access point, then plug the pulling jets, and jet the line while retracting the hose with jets installed at the preferred geometry. If there's no access at the end of the run, then power will have to be diminished by what it takes to pull the hose.

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Concrete removal. Water jets are used for concrete demolition, but at 14,000 to 18,000 psi, and 40 gpm or more. That's a 400 hp pump. The feasibility of removing concrete with sewer jetting equipment depends on how well water, sand, silt, and other debris in the sewer have diminished the strength of the concrete mix. Sometimes a fortunate accident occurs, allowing removal at relatively low pressures attainable with sewer jetters. Each case requires a trial-and-error approach, with custom jet geometry and multiple passes to tunnel through the plug, then bore it out to the sewer walls.

Manhole repair. Infiltration of storm water into sewer systems overloads treatment facilities, causing effluents to exceed permitted levels. Manholes are a major cause of infiltration, and manhole repair projects are in progress all over the United States. The typical jet-vac sewer truck is ideal for cleaning manholes, using a properly-selected sewer nozzle with some custom accessories.

Big-diameter lines. Fortunately, most of the sand, silt, and debris that collects in sewers lies in the bottom of the pipe, making it unnecessary to clean the top wall. Roots, scale, and big grease plugs are exceptions. When it is necessary to clean both top and bottom, then centralizing devices are used to place the jetting nozzle near the sewer centerline. In such cases, extension nipples can be used to place the jets close enough to the sewer wall that a high fraction of the jet's initial power is delivered to the surface. In lines larger than about 3 feet diameter, rotation must be slowed below normal sewer jetting ranges.

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