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Standard Practice for Pressure Water Cleaning and Cutting[1]

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1. Scope

1.1 This practice covers the personnel requirements, operator training, operating procedures, and recommended equipment performance/design for the proper operation of all types of pressure water-jet cleaning and cutting equipment as normally used by industries concerned with construction, maintenance, repair, cleaning, cutting, and demolition work.

1.2 The term high-pressure water jetting covers all water jetting, including the use of additives or abrasives at pressures above 100.5 psig (0.69 MPa).

1.3 Any person required to operate or maintain pressure water-jetting equipment shall have been trained and have demonstrated the ability and knowledge to do so in accordance with the original equipment manufacturer's instructions, specifications, and training programs.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See 3.1.3, 4.4, 5.7.2, 5.11, 5.14, 6.2, 6.7, and Sections 8 and 11 for specific hazards statements.

2. Referenced Documents

2.1 *ANSI/IEEE Standard:*[2]
957-1987 IEEE Guide for Cleaning Insulators

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *dump system, n*—the discharge orifice operator-controlled, manually operated device or system that reduces the pressure to a level that yields a pressure flow at the nozzle that is considerably below the risk threshold.

3.1.2 *guard, n*—should be so designed, constructed and used that it will:
(*a*) provide positive protection;
(*b*) prevent all access to the danger zone during operations;
(*c*) cause the operator no discomfort or inconvenience;
(*d*) not interfere unnecessarily with production;
(*e*) operate automatically or with minimum effort;
(*f*) be suitable for the job and the machine;
(*g*) preferably constitute a design, integral built-in feature;
(*h*) provide for machine oiling, inspection, adjustment and repair;
(*i*) withstand long use with minimum maintenance;
(*j*) be durable, fire- and corrosion-resistant;
(*k*) not constitute a hazard by themselves (without splinters, sharp corners, rough edges, or other sources of accidents); and
(*l*) protect against foreseeable use and foreseeable misuse of operational contingencies, not merely against normally expected hazards as determined from a job safety analysis

3.1.3 *high-pressure water cleaning, v*—the use of high-pressure water, with or without the addition of other liquids or solid particles, to remove unwanted matter from various surfaces, where the pressure of the liquid jet exceeds 100.5 psig (0.69 MPa) at the orifice. (**Warning—**The limit of 100.5 psig (0.69 MPa) does not mean that pressures below 100.5 psig (0.69 MPa) cannot cause injury or require any less attention to the principles of this practice. Adequate precautions, similar to those of this practice, are required at all pressures.)

3.1.4 *high-pressure water cutting, v*—the use of high-pressure water, with or without the addition of other liquids or solid particles, to penetrate into the surface of a material for the purpose of cutting that material, where the pressure of the liquid jet exceeds 100.5 psig (0.69 MPa) at the orifice.

3.1.5 *hose assembly, n*—a hose with safety coupling each indicating pressure capacities and attached in accordance with manufacturer's specifications.

3.1.6 *lance, n*—a rigid metal tube used to extend the nozzle from the end of the hose.

3.1.7 *lancing, v*—an application whereby a lance and nozzle combination is inserted into, and retracted from, the interior of a pipe or tubular product.

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[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.1.8 *moleing, v*—an application whereby a hose fitted either with a nozzle or with a nozzle attached to a lance is inserted into, and retracted from, the interior of a tubular product. It is a system commonly intended for cleaning the internal surfaces of tubes, pipes, or drains. It can be self-propelled by its backward directed jets and is manufactured in various shapes, sizes, and combinations of forward- and backward-directed jets.

3.1.9 *nozzle, n*—a device with one or more openings where the fluid discharges from the system. The nozzle restricts the area of flow of the fluid, accelerating the water to the required velocity and shaping it to the required flow pattern and distribution for a particular application. Combinations of forward and backward nozzles are often used to balance the thrust. Such nozzles are commonly referred to as tips, jets, orifices, etc.

3.1.10 *operator, n*—a person who has been trained in accordance with the original manufacturer's instructional training program and has demonstrated the knowledge, experience, and ability to perform the assigned task.

3.1.11 *operator trainee, n*—a person not fully qualified due to the lack of sufficient knowledge or experience, or both, to perform the assigned task without supervision.

3.1.12 *pressure water jet system, n*—water delivery systems that have nozzles or other openings whose function is to increase the speed of liquids that may cause injury. Solid particles or additional chemicals may also be introduced, but the exit in all cases will be in a free stream. The system shall include the pumps (pressure-producing devices), hoses, lances, nozzles, valves, safety devices, and personal protective equipment, as well as any heating elements or injection systems, attached thereto.

3.1.13 *shotgunning, n*—an application whereby a lance or nozzle combination can be manipulated in virtually all planes of operation.

4. Significance and Use

4.1 This practice is intended to provide guidance on the proper operation of pressure water-jet cleaning and cutting equipment.

4.2 This practice is also applicable at lower pressures where there is foreseeable risk of injury.

4.3 This practice is provided to assist persons unfamiliar with the operation of water-jet cleaning and cutting equipment in learning to correctly use the equipment.

4.4 Correct operation and use of the pressure water-jet cleaning and cutting equipment requires that the operator has familiarized himself with the identification of pressure metal fittings, hoses, guns, and accessories in accordance with the original equipment manufacturers specifications, instructions, and programmed instructional material only then shall hydrojetting begin. Modification of water-jetting equipment shall not be done without prior written approval by the manufacturer of the equipment. Employees shall be instructed in the recognition and avoidance of unsafe conditions as identified/required in 5.18. (**Warning—**Serious harm or injury may result from the misuse of water-jetting equipment and the use of improper fittings, hoses, or attachments.)

4.5 The use of pressure water-jet equipment for cutting and cleaning is a rapidly evolving technology. This practice will be periodically reviewed for any required changes at least every five years.

5. Apparatus

5.1 *Pressurizing Pump*—A unit designed to deliver pressure water or other fluid with or without chemicals or particle material. This is usually based on positive displacement pistons or rubber diaphragm/hydraulic systems and discharges water into a common manifold in which either flexible hoses or rigid tubing connect to lances and nozzles. These pumps can be either mobile or permanently mounted.

5.1.1 The pump shall have permanently mounted identification plates or tags which provide the following information:

5.1.1.1 Product and supplier,

5.1.1.2 Production model and serial number, or year of production,

5.1.1.3 Maximum performance, in terms of gallons per minute and pressure in pound-force per square inch, and

5.1.1.4 An outline of recommended safety procedures and warnings.

5.2 *Relief System*—The system shall be equipped with an automatic relief device on the discharge side of the pump and an auxiliary relief dump device as part of the pump.

5.3 *Relief System-Types*—These may take the form of the following:

5.3.1 *Pressure Relief Valve or Bursting Disk in Holder*—Usually mounted on the pump discharge chamber to prevent the pressure exceeding the rated maximum pressure of the whole system.

5.3.2 *Automatic Pressure Regulating Valve (Unloading Valve)*—Limits the pressure at which the pump operates by releasing a preset proportion of the generated flow back to the pump suction chamber or to waste. It may be used to regulate the water pressure from the pump and is individually set for each operation. This device may be integral with the pump hydraulic assembly. Where there is no demand for pumpage, the pressure is brought down to zero.

5.3.3 *Bypass Valve*—Limits the pressure at which the pump operates by releasing a preset proportion of the generated flow back to the pump suction chamber or to waste. It may be used to regulate the water pressure from the pump and is individually set for each operation. This device may be integral with the pump hydraulic assembly.

5.4 *Pressure Gage*—The system shall be equipped with a gage indicating the pressure being developed. Gages shall have a scale range of at least 50 % above the maximum working pressure of the system.

5.5 *Filter or Strainer*—The water system shall be equipped with a filter or strainer to prevent particles from restricting the orifices in the nozzle. The strainer or filter shall be capable of removing particles smaller in size than the smallest orifice in the nozzle and usually smaller to protect pumps and other components.

5.6 *Dry Shut-Off Control Valve*—This operator-controlled valve, normally hand-controlled, automatically shuts off flow to the lance or nozzle assembly, or both, when released by the operator but retains the operating pressure within the supply line when so shut off. This valve shall be used in systems with an automatic pressure regulating valve.

5.6.1 Release the pressure in the dry shut-off valve and line when the pump is shut down; otherwise, the valve operating lever may remain alive. This valve may alternatively be actuated by solenoid or pilot pressure mechanism.

5.7 *Dump System*—The system should be equipped with a device that will either shut down the unit, idle it to low revolutions per minute, bypass the flow, or reduce the discharge pressure to a low level. The dump system shall be manually controlled only by the nozzle orifice operator. The dump system actuator device should be shielded to preclude inadvertent operation. This device shall immediately shut off the pressure water stream if the operator loses control.

5.7.1 *Dump Control Valve*—An operator-controlled valve, normally hand-operated, that automatically terminates significant flow to the lance or nozzle assembly, or both, when released by the nozzle operator, thus relieving the operating pressure within the whole system by diverting the flow produced by the pump to atmosphere. A valve size should be selected that will not cause generation of significant back pressure at the maximum possible pumping rate of the pump. This valve may alternatively be actuated by a solenoid or a pilot pressure mechanism.

5.7.2 *Solenoid and Electrically Operated Control Dump Systems*—All electrically controlled dump systems should be of fail-safe design. (**Warning—**Voltage of an alternatingcurrent (ac) or directcurrent (dc) dump system handled by personnel shall not exceed 24 V.)

5.8 *High-Pressure Hose and Couplings*—A flexible hose and coupling that connects two components and delivers the high-pressure fluid to the gun or nozzle components. The hose and fittings shall have a burst rating of a minimum of 2.5 times the maximum working pressure. Operating levels below this ratio should require a protective shielding around that hose and coupling. The hose and coupling shall be marked with the manufacturer's symbol, serial number, the maximum permissible operating pressure, and the test pressure. High-pressure hose shall be tested at 2.5 times working pressure in accordance with the original equipment operators' specifications, test methods instructions, and training programs.

5.9 *End Fittings and Couplings*—Pressure hose end fittings and safety couplings shall be manufactured to be compatible with the hose and tested as a unit.

5.10 *Jetting Gun Extension*—A length or lengths of tube carrying pressure fluid to the nozzle. Each shall be manufactured from material suitable to the application. End connections shall be suitable for the application. The extension is used in conjunction with a control valve. The extension shall have a minimum burst strength of at least 2.5 times the highest actual operating pressure used.

5.11 *Nozzle*—The nozzle creates the water jet or jets at the required velocity, flow rate, pressure, shape, and distribution for a particular application. Combinations of forward and backward direct water jets are often used to balance the thrust. Such nozzles may be referred to as tips, jets, or orifices. (**Warning—**Personal protective equipment and nozzle guard shall be provided.)

5.12 *Water Jet*—A jet stream of water produced from the individual outlet orifice of a nozzle. The shape of the jet is determined by the form of the orifice, while the speed at which it travels is determined by the orifice design, orifice area, and flow. The pressure drop at the orifice is a result of an increase in velocity. The two most commonly used jet shapes are the straight-jet and fan-shaped jet.

5.12.1 *Straight Jet*—Concentrates the stream of water over a small area of the workpiece by minimizing the spread. A typical application is for cutting, or for general cleaning of matter with higher shear or bond strength, or both.

5.12.2 *Fan Jet*—Spreads the stream of water in one plane, thus giving a wide band coverage of the workpiece. A typical application is for cleaning larger areas requiring less energy to remove unwanted matter.

5.13 *Jetting Hand Manifold and Spray Bars*—These are pieces of equipment which individual nozzles are fitted for protection of the workmen.

5.14 *Foot Control Valve*—The orifice operator's control valve may be arranged for actuation by the operator's foot if desired, either in place of, or in addition to, hand-control. (**Warning—**An adequate guard shall be fitted to prevent accidental operation, and the base plate should be sufficient to ensure stability in use. If of the dump type, the layout should ensure that the dump line used is restrained from whipping when the valve is released.)

5.15 *Jetting Gun*—A portable combination of operator's control valve, lance, and nozzle resembling a gun in layout and assembly. The control valve is hand-operated by a squeeze-action dead-man-type trigger for the hand of the operator who should always have control of this device and may be of the dry shut-off or dump type, the gun being named accordingly. The hand-control normally takes the form of a trigger or lever that is provided with a guard adequate to prevent accidental operation and that shall have the means of being immobilized in the "off" position by means of a safety catch. The gun shall be fitted with a shoulder pad or hand grips to facilitate back-thrust control.

5.16 *Retro Gun*—A retro safety gun is fitted with forward- and backward-facing jets. This reduces the thrust experienced by the operator. This type of gun is used mainly for underwater jetting operations. The retro balance jet protection tube shall be sufficiently long or constructed so as to prevent the operator from directing a retro balance jet at himself.

5.17 *Changeover Valve*—An operator-controlled valve designed to properly direct pressure water flow from the pump to one or other items of equipment at the operator's choice. It shall be designed to withstand 2.5 times the maximum system pressure, and may be power-operated.

5.18 *Original Equipment Manufacturer (OEM)*—The original equipment manufacturer shall design the equipment based

upon the foreseeable uses and misuses and design recognized hazards out of the equipment. Hazards that cannot be designed out shall be guarded and warned to protect and alert the operator. Warnings and instructions shall never be used as a substitute for the elimination of hazards or guarding. Failure Mode and Effects Analysis (SAE J-1739) and Job Safety analysis shall be provided by the OEM in there programmed instructional material.

6. Care and Maintenance of Equipment

6.1 *Pump Unit*—Maintain the pump unit in accordance with the manufacturer's instructions, specifications, and programmed instructional material. Where applicable, this should include daily checks on the following items:

6.1.1 *Drive Unit*—Lubricating oil, water, hydraulic fluid, and fuel levels,

6.1.2 *Pump Unit*—Lubricating oil and gear box oil levels,

6.1.3 *Hydraulic Hose Reel*—Lubricating oil and fluid levels, and

6.1.4 *Condition of Guards and Shields.*

6.2 *Filters and Strainers*—Check all water filers at regular intervals, dependent upon the supply water conditions, and in accordance with the pump manufacturer's recommendations. (**Warning—**Take extreme care to filter the water source through a proper micron filtration device, to prevent foreign particles from cutting changeover valves and seating surfaces, and to prevent clogging the changeover valve operating mechanism. Such clogging can cause a loss of control, which can be dangerous to the operator.)

6.3 *Hose Assemblies*—Inspect all hose assemblies prior to use with respect to the following:

6.3.1 Correct pressure rating and size,

6.3.2 Free from external damage, that is, broken wires, and

6.3.3 All end fittings and couplings are in good order and of the correct pressure rating for the unit operating pressure.

6.4 *Nozzles*—Keep all jetting nozzles clean and check the orifice to ensure that it is not obstructed or damaged before installation. Do not use defective nozzles; replace or repair before installation. During the startup prior to operation, move the nozzle from the lance and flush the system thoroughly to remove air and foreign particles.

6.5 *Jetting Guns and Lances*—Check jetting guns and lances daily and examine the trigger mechanism and guard thoroughly to ensure correct operation. Observe all pressure connections during operation of the equipment. If a leak is observed, shut down the pump and repair or replace the connection before further operation.

6.6 *Foot Control Valves*—Check and clean all foot control valves and switches daily and give the foot mechanism and guard a thorough visual and mechanical examination to ensure correct operation and freedom from accidental actuation. When the nozzle operator is not the trigger operator, the nozzle operator shall use a guarded safety foot control valve to de-energize the flow in the event of an emergency.

6.7 *Electrical Equipment*—All electrically operated, pressure water-jet cleaning and cutting equipment units shall be checked daily for external damage, with special emphasis placed on connections, junction boxes, switches, and supply cables, and shall be of the waterproof type. (See National Electric Code Section 430-91.) (**Warning—**Ensure that the electrical system is protected from the ingress of water Only NEMA classified electrical equipment, which is of the waterproof type, shall be used. Check correct direction of rotation of the electric motor on initial installation and after every reconnection.)

6.8 *Trailers*—Check trailer-mounted units daily, examining the tires, braking systems, jacking points, towing hitch, lights, safety chains, structural damage, and for general cleanliness. Tow the units only by vehicles designed for that purpose.

6.9 *Engine Controls*—Check all throttle cables and engine stop devices daily to ensure that they are functioning properly.

6.10 *Maintenance Servicing and Repair*—The following operations should only be carried out by competent personnel:

6.10.1 Manufacturer's servicing requirements.

6.10.2 The following items should be overhauled and checked for correct functioning at the original manufacturer's recommended intervals:

6.10.2.1 Pressure relief valve,

6.10.2.2 Bursting disks, if used,

6.10.2.3 Pressure control valves,

6.10.2.4 Hand- or foot-operated dump control valve or dry shut-off control valve,

6.10.2.5 Dry shut-off valve or dump system,

6.10.2.6 Changeover valve, and

6.10.2.7 Personal protective equipment.

6.11 *Tools*—Use the correct size tools when maintaining or assembling jetting systems. The use of adjustable tools having serrated gripping jaws (for example, pipe wrenches) can damage equipment and is not recommended, particularly on the crimped portion of a hose fitting.

6.12 *Compatibility*—Check all component parts and fittings to ensure they are of the correct size and rating for the unit.

7. Operational and Training Requirements

7.1 *Qualified Operators*—Only personnel who have been trained in accordance with the ORIGINAL EQUIPMENT MANUFACTURERS' programmed instructional material from the original equipment manufacturer shall operate pressure waterjetting equipment and supervise the training of new operators.

7.2 *Operator and Employer Training*—A personnel training program shall be developed utilizing the original equipment manufacturer's programmed instructional material and shall be presented to each operator and employee before assignment to the employee's first pressure water-jet cleaning and cutting equipment task. Such training shall include, as a minimum, coverage of all items listed in this practice that are relevant to safe operation, maintenance, and use of the equipment, and records of employee training shall be kept for five years.

7.3 *Cutting Action*—The cutting action of a pressure water jet and the potential hazard it poses to the human body shall be demonstrated through the use of audiovisual aids or actual use

of equipment (by cutting through a piece of lumber, a concrete block, cleaning painted metal, etc.).

7.4 *Personal Protective Equipment*—The minimum personal protective equipment requirements shall be explained to each operator and employee. Instructions shall be given as to when and how specific clothing and other types of personal protective equipment shall be worn according to the type of work performed as specified in the original equipment manufacturer's programmed instructional materials.

7.5 *System Operation*—The operation of the system shall be explained by pointing out potential problems and proper corrective action, based upon the foreseeable uses and misuses analysis (system safety) as provided by the original equipment manufacturer.

7.6 *Control Devices*—The operation of all control devices shall be explained. The importance of not tampering with any control devices as well as the importance of keeping the control device in proper working order shall be stressed.

7.6.1 *Equipment Maintenance*—Valves and seating surfaces in pressure-regulating devices encounter high wear during pressure water jetting. These items require frequent inspections, maintenance, or replacements, or a combination thereof, in order to provide proper operation as delineated by the instructions provided by the original equipment manufacturer.

7.7 *Hose*—The proper method of connecting hoses, including laying out without kinks, protection from excessive wear, and proper tools to use on couplings and fittings shall be explained to operators and employees as delineated by the instructions provided by the original equipment manufacturer.

7.8 *Stance*—The proper stance for sound footing and how to use the various devices for lancing, shotgunning, and moleing shall be demonstrated. The operator and employee trainees, under close supervision, shall use the various devices while the unit is slowly pressurized, as delineated by the instructions provided by the original equipment manufacturer.

7.9 *Proficiency*—Personnel shall demonstrate knowledge and skill in the proper operation, inspection, and maintenance of equipment through practical application.

7.9.1 The employer of operators and operator trainees is responsible for establishing and validating practices that are in compliance with relevant recommended practices and standards.

7.10 *General Requirements:*

7.10.1 The system shall be depressurized when:

7.10.1.1 It is not in use,

7.10.1.2 An unauthorized or inadequately protected person enters the barricaded area,

7.10.1.3 Replacement or repairs are made to the system, or

7.10.1.4 Any recommended practices are violated.

7.11 *Refresher Training*—Operator retraining shall be on an annual basis, or more frequently if needed.

8. Hazards

8.1 *Personnel Protection and Use of Protective Clothing:*

8.1.1 *Compliance*—All applicable recommended practices and regulations, instructions, and warnings covering personal protective equipment shall be followed as prescribed by the original equipment manufacturer's programmed instructional material.

8.1.2 *Head Protection*—All operators shall wear the suitable head protection capable of withstanding the jet stream. This should include a full face shield, suitable for the type of work or operation being undertaken.

8.1.3 *Eye Protection*—Suitable eye protection (adequate for the purpose and of adequate fit on the person) shall be provided to all operators of pressure water-jetting equipment and must be worn within the working area. Where liquids liable to cause eye damage (see Material Safety Data Sheets) are encountered, it is necessary to use either a combination of visor and goggles or a full hood with shield.

8.1.4 *Body Protection*—All operators should be supplied with suitable jet-resistant waterproof clothing and personal protective equipment (for example, foot, leg guards) having application for the type of work being undertaken. Garments should provide full protective cover to the operator, including arms. Liquid- or chemical-resistant suits shall be worn where there is a reasonable probability of injury (see Material Safety Data Sheets) that can be prevented by such equipment.

8.1.5 *Hand Protection*—Adequate hand protection shall be supplied to all operators and shall be worn when there is a reasonable probability of injury that can be prevented by such equipment. (See original equipment manufacturer specifications.)

8.1.6 *Foot and Leg Protection*—All operators shall be supplied with waterproof boots with steel toecaps and shanks. A metatarsal guard and leg guards shall be used by the jetting gun operators where there is a reasonable probability of injury that will be prevented by such equipment.

8.1.7 *Hearing Protection*—Pressure water-jetting operations may produce noise levels in excess of 90 dB(A). Suitable ear protection issued in accordance with the recommended practices of the original equipment manufacturer must be worn. Provision should be made of regular inspection and maintenance, including daily cleaning of hearing protection devices that are of the reusable type. All personnel and operators shall receive instruction in the correct use of ear protectors such that noise exposure lies within the limits as specified by the original equipment manufacturer's instructions.

8.1.8 *Respiratory Protection*—A respiratory protection program shall be implemented where there is a reasonable probability of injury that can be prevented by such a program.

8.1.9 *Equipment Limitations*—It should be recognized that some protective equipment may not necessarily protect the operator from injury by direct high-pressure water-jet impact. Shields and guards shall be used as provided in the original equipment operator's instructions and training programs to prevent any injury.

8.2 *Precautions:*

8.2.1 *Personal Injuries*—In the event that a person is injured by the impact of a water jet, the injury caused may appear insignificant and give little indication of the extent of the injury

beneath the skin and the damage to deeper tissues. Larger quantities of water may have punctured the skin, flesh, and organs through a very small hole that may not even bleed.

8.2.2 *Operator Identification*—Immediate medical attention is required and medical staff must be informed of the cause of the injury. To ensure that this is not overlooked, all operators engaged in pressure water-jet cleaning and cutting tasks should carry an immediately accessible waterproof card that outlines the possible nature of the injury and bears the following text: "This person may have been involved with pressure water jetting at pressures up to 14 500 lb/in.^{2} (100 MPa, 1000 bar, 1019 kg/cm^2) with a jet velocity of 900 miles (1440 km)/h. This should be taken into account when making a diagnosis. Unusual infections with microaerophilic organisms occurring at lower temperatures have been reported. These may be gram negative pathogens such as those found in sewage. Bacterial swabs and blood cultures may therefore be helpful."

8.2.3 *Immediate First Aid*—Where medical assistance is not immediately possible in remote situations, limit first aid measures to dressing the wound, maintaining an open airway, maintaining body temperature, laying the patient down, and observing the patient closely until appropriate emergency medical care has arrived.

8.2.4 *Medical Recommendations*—If an accident should occur and water penetrates the skin, contact the National Poison Center.

8.2.5 *Reporting*—If any person or equipment is accidentally struck by the jet, this fact must be reported to the appropriate employer's safety engineer, and director, supervisor, and the owner of the equipment.

8.3 *Permanent Cleaning Areas:*

8.3.1 *Enclosure*—Keep areas suitably enclosed and prominently display warning notices at the access points and perimeters.

8.3.2 *Access*—Access by persons other than the jetting team shall be strictly prohibited while work is in progress. If any unauthorized entry is made, cease all work immediately.

8.4 *Freeze Precaution:*

8.4.1 During the periods where there is a risk of freezing, follow the manufacturer's recommendations on shutting down the equipment, and take the following precautions:

8.4.1.1 Remove gun or nozzle from the delivery hose,

8.4.1.2 Pump water from the supply tank until the level of water is just above the filter,

8.4.1.3 Add recommended quantity of antifreeze into water tank,

8.4.1.4 Place delivery hose into water tank and secure,

8.4.1.5 Run the pump until the antifreeze works through the system, and

8.4.1.6 Move selector level to dump or recycle position until the antifreeze shows in the water tank.

8.4.1.7 If no supply tank is fitted, follow the original manufacturer's recommendations. (**Warning—**If a pump or hose appears frozen, the pump must not be engaged or the engine started. If there is a direct drive to the pump and the system has been thawed out, allow low-pressure water to flow through the system to the nozzle end of the lance, the lance having been removed.)

9. Preoperating Procedures

9.1 *Planning*—Preplan each job. Follow the steps outlined in the original manufacturer's instructions and programmed training materials. Personnel familiar with the item to be cleaned, the material to be cut, and the work environment shall meet with the personnel that will be performing the work and outline potential hazards of the work area, environmental problems, safety standards, and emergency aid procedures.

9.2 *Checklist*—Use a checklist to ensure that the proper equipment selection is followed (see Appendix X1).

9.3 *Dump Valve*—All systems shall incorporate at least one fluid shut-off or dump device. The orifice operator must always be able to shut down the water jet by releasing pressure on the trigger, switch, or foot valve pedal.

9.4 *Warning Barriers*—Erect suitable barriers to encompass the hazard area and post signs to warn personnel they are entering a hazardous area. The perimeter should be outside the effective range of the jet wherever possible. Barriers may be of rope, safety tape, barrels, etc., as long as they give an effective warning and are highly visible.

9.5 *Hookup:*

9.5.1 Hose shall be arranged so that a tripping hazard does not occur. Support hoses, pipes, and fittings to prevent excessive sway or wear, or both, created by vibration or stress on the end connections when laid on the ground, over sharp objects or on vertical runs, shall be used. Check all hoses for evidence of damage, wear, or imperfections. The check shall be made periodically during the operation.

9.5.2 *Fittings*—Clean and lubricate all fittings before installing in the system. Be sure all fittings, hoses, and nozzles are fit for the purpose.

9.5.3 *Preflushing*—Flush the system completely with sufficient water to remove any contaminants before installing the nozzle.

9.5.4 *Nozzles*—Check all orifices in all nozzles for any stoppage or damage, or both, or for imperfections.

9.5.5 *Electrical Equipment*—Any electrical equipment in the immediate area of the operation that presents a hazard to the operator shall be de-energized, shielded, or otherwise made safe (see ANSI/IEEE Standard 957-1987).

9.5.6 If hydrojetting is done under water, containments shall not be siphoned back to the pump.

10. Operational Procedures

10.1 *Work Area*—Isolate the workpieces/items to be jetted from any unprotected areas to a protected pressure water-jetting area. Cutting or cleaning in place or adjacent to the installed position can be done with the necessary clearance and permission of the occupier and equipment/facility owner.

10.2 *Area Limits*—Area limits applicable to the cutting or cleaning operations shall be defined, and the employer/owner/operator shall mark these limits by barriers and notices to warn against access to other personnel. Suitable barriers shall be an approved form of hazard warning, rope, or tape, as a minimum. Alternatively, a suitable barrier shield is acceptable at any reasonable distance. Notices should read "Danger—Keep

Clear, Pressure Water Jetting in Operation, Severe Injury May Result." or other suitable wording.

10.3 *Corrosive Materials*—Where there is a possibility of encountering corrosive or toxic material, the general contractor or employer or owner shall be requested to inform the person in charge of pressure water jetting of any precautions that may be necessary, including the collection and disposal of waste materials.

10.4 *Work Surface*—Operators should have good access to the workpiece, safe walking and working surfaces, and secure footing. The work area should be kept clear of loose items and debris to prevent tripping and slipping hazards.

10.5 *Unauthorized Access*—Prevent access by unauthorized persons into the area where pressure water-jet cleaning or cutting, or both, is taking place. The area shall be cordoned off and warning notices displayed in prominent positions. The perimeter should be outside the effective range of the jet wherever possible.

10.6 *Approaching the Operator*—The general contractor or employer or owner shall be requested to inform all personnel likely to require access to the area that pressure water-jet cleaning and cutting equipment is in operation. Personnel having reason to enter the pressure water-jet cleaning and cutting area must wait until the jet is stopped and their presence known. Personnel wishing to have the jet stopped shall approach a team member other than the jet operator. The jet operator shall not be distracted until the jet has been stopped.

10.7 *Side Protection*—Suitably placed side shields shall be provided to safeguard personnel and equipment against contact with grit or solids removed by the jet.

10.8 *Pressurizing the System*—Increase pressure slowly on the system while it is being inspected for leaks or faulty components, or both. Repair or replace components only when the equipment is properly locked out and tagged. The system shall be depressurized and shut down for repairs.

10.9 *Team Operations*—In jetting operations a minimum of two persons, one at the pump and one at the orifice or gun, shall be employed at all times.

10.9.1 *Supervision*—All pressure water-jetting operations shall be controlled by a supervisor who has been trained in accordance with the original equipment manufacturers programmed instructional material in all aspects of the jetting operation.

10.9.2 *Number of Operators*—The operators of the pressure water-jetting equipment should consist of two or more operators according to the equipment being used and the nature of the job. These operators shall work as a team, with one member designated in charge. The operator of the gun or lance, as described in 9.10.3, shall take the lead role while jetting is in progress.

10.9.3 *Gun Operator*—One operator from the team shall hold the lance, gun, or delivery hose with the nozzle mounted on it. That operator's primary duty is to direct the jet.

10.9.4 *Second Operator*—The second operator of the team shall attend the pump unit, keep close watch on the first operator for signs of difficulty or fatigue, and watch the surrounding area for intrusion by other persons or unsafe situations. If required, the operator will shut off the pressure until any unsafe acts or conditions have been corrected and it is safe to continue.

NOTE 1—**Warning:** Exercise caution in shutting off the pressure rapidly as this can cause the loss of footing by the gun operator.

10.9.5 *Additional Operators*—Additional operators are required in the following circumstances:

10.9.5.1 To assist the first operator with the handling of the lance if it is too long or too heavy for one person.

10.9.5.2 To provide communication if the lance operator is out of sight of the pump unit operator.

10.9.6 *Job Rotation*—The team members should rotate their duties during any job to minimize fatigue to the operator holding the lance or gun.

10.9.7 *Team Leader*—The team leader is responsible for basic equipment checks, the preparation of the working area for safe operation, and for obtaining a permit to work.

10.9.8 *Code of Signals*—Before starting a jetting operation, the team members, one of whom must be in charge, shall agree on a code of signals to be used during the operation of the equipment.

10.9.9 *Fitness*—The operator and other team members shall be capable of performing the required operations safely. All shall be capable of speaking and reading the instructions and warnings in the language of their place of work.

10.10 *Single Person Operation*—Single person operation is allowed where the pressure does not constitute a hazard to personnel.

10.10.1 *Single Operator Guidelines*—All other recommendations pertaining to team operations shall apply.

10.11 *Shotgunning:*

10.11.1 *Controls*—The person operating the nozzle shall have direct control of the dump system.

10.11.2 *Attendance*—The pressurized system should never be left unattended.

10.11.3 *Multiple Operation*—When more than one shotgunning operation is being performed within the same area, install a physical barrier or maintain adequate spacing between operators to prevent the possibility of injury from the pressure water.

10.11.4 *Target Holding*—Never manually hold objects to be cleaned.

10.11.5 *Connection Protection*—The point where the hose connects to the gun shall be shrouded by a protective device such as a heavy duty hose, shoulder guard, and the like, to prevent injury to the operator should the hose, pipe, or fitting rupture.

10.11.6 *Minimum Length*—When used, the minimum length of the shotgun lance extension should be 4 ft (1.2 m) from the triggering device to the nozzle.

10.11.7 *Hose Protection*—Use steel-braided hoses on air-operated, fail-safe systems to keep the system from being activated by someone stepping on the hose or running over it.

10.12 *Moleing or Flex Lancing:*

10.12.1 *Control*—The operator shall have direct control of the dump system.

10.12.2 *Reversing*—A positive method shall be used to prevent the nozzle from reversing direction inside the item being cleaned. Safety guards for this purpose should be used.

10.12.3 *Retrojets*—During manual operations, the entrance to a line or pipe shall not be cleaned with a nozzle containing back jets without adequate shielding.

10.12.4 *Clearance*—The clearance between the outside diameter of the hose, lance, and nozzle assembly and the inside wall of the item being cleaned shall be sufficient to allow adequate washout of water and debris.

10.12.5 *Pressurization*—During manual operation, insert the nozzle into the tube prior to pressurizing. Conversely, depressurize the system before removing of the nozzle from the tube.

10.12.6 *End Identification*—Hoses shall be conspicuously marked no closer than 24 in. (600 mm) from the nozzle to warn the operator of the nozzle location.

10.12.7 *Nozzle Support*—Where the length of the nozzle and rigid coupling is less than the inside diameter of the pipe, a length of rigid pipe of not less than the diameter of the pipe being cleaned shall be fitted directly behind the nozzle, or a suitable safety shield should be provided to protect the operator. This is to prevent the nozzle from turning around 180° and doubling back towards the operator. Specific safety guards shall be used for this purpose.

10.13 *Ridge Lancing:*

10.13.1 *Control*—The operator inserting the nozzle shall have direct control of the dump system.

10.13.2 *Clearance*—The clearance between the outside diameter of the lance and nozzle and the inside wall of the item being cleaned shall be sufficient to allow adequate washout of water and debris.

10.13.3 *Pressurization*—When under manual operation the nozzle shall be inserted into the tube prior to pressurizing. Conversely, the system shall be depressurized before removal of the nozzle from the tube, unless proper shielding is provided.

10.13.4 *Shields*—When lancing tubes with a rigid lance, a guard shall be installed around the lance to prevent a lance nozzle from being inadvertently withdrawn and causing injury.

10.14 *Additives*—Any water additive (chemical, detergent, or solid particle) shall be used in accordance with the manufacturer's recommendations.

10.15 *Proper Operation:*

10.15.1 *Startup*—Do not start the pump unit and bring it up to pressure unless each team member is in his designated position, the nozzle is held in or directed at the workpiece, and the lance or gun is securely held.

10.15.2 *Adjustments*—Apart from operational procedures, no attempt shall be made to perform maintenance or adjust any nut, hose connection, fitting, etc., while the system is under pressure. Stop the pumps and discharge any pressure in the line prior to making any such adjustment. Take care to release the pressure in the dry shut-off gun and the line when the unit is switched off.

10.15.3 *Equipment Malfunction*—If for any reason the water flow does not shut off when the trigger or foot pedal is released, cease work until the item has been serviced, repaired, or changed by properly trained personnel.

10.15.4 *Reaction Force*—The operators should be allowed to experience the reaction force of the jet progressively until the required operating pressure is reached. Use the lowest pressure compatible with the work to be done. Do not adjust the pressure without the operator being aware of this operation.

10.15.5 *Effect of Line Pulses*—Operators should be made aware of the reactive effect of pressure in the line that can transmit a severe jolt to the operator when the dump valve or dry shut-off valve is operated. To minimize this effect, keep total hose lengths as short as possible. Damping devices shall be introduced into the system in accordance with the original equipment manufacturer's designs or instructions.

10.15.6 *Thermoplastic Hoses*—Thermoplastic hose shall not be used for water jetting unless specifically designed for this purpose.

10.15.7 *Operator Positioning*—While operating, the team members shall be safely positioned. Stop the jetting if any person encroaches into the working area.

10.15.8 *Work Stoppage*—Stop work in the following cases:

10.15.8.1 In the event that leaks or damage become apparent,

10.15.8.2 If any person becomes aware of any change in conditions or of any hazards being introduced or existing,

10.15.8.3 If plant or work alarms are sounded, or

10.15.8.4 If any of the procedures in this practice are not being followed.

10.15.9 *Hose Protection*—Protect all hoses from being run over and crushed by vehicles, fork lift trucks, and the like.

10.15.10 *Back Thrust*—The back thrust from a linearly directed jet can be calculated from the equation:

$$B = 0.052\,Q(P)0.5 \quad (1)$$

where:

B = back thrust, lb(kg),
Q = flow rate, gal/min (or metric equivalents), and
P = jet pressure, psi.

It is not recommended that one person be required to withstand a back thrust of more than one third of his or her body weight for any extended period of time.

11. Use of Lances and Nozzles

11.1 *Lances*—Lances that are rigid or semirigid, having nozzles fitted to them with any combination of forward, backward, or 90° angle jets, shall be used with either a dump system or dry shut-off control valve. When a flexible lance or nozzle mounted on a hose is in use, do not operate the jet at pressure unless the nozzle is properly positioned inside the workpiece or the operator is protected by screens or proper shielding from the rear-facing jets. If necessary, clean the lead-in to the workpiece by other methods.

11.2 *Flexible Lances*—Flexible lances, used to clean pipes where the inside diameter of the pipe is not small enough to prevent the lance from turning back on itself, shall have a piece of rigid straight tube, slightly longer than the diameter of the pipe, fitted immediately behind the nozzle to prevent this from happening.

11.3 *Distance Indicator*—When using an assembly that allows the nozzle to enter the workpiece with restricted visibility, clearly mark the lance, hose, or floor in a manner that enables the operator to judge how far the nozzle is in the workpiece before pressure is applied and, conversely, so that pressure is released before the apparatus is completely withdrawn from the workpiece.

11.4 *Lance Length*—The length of a rigid lance or combination of lances shall be such that the operator can maintain control at all times.

11.5 *Jet Pressure*—Operators shall select the nozzle and minimum operating pressure to allow effective and efficient jetting.

11.6 *Improper Use*—Should an operator enter a manhole or access port for any purpose (with the jetting machine turned off) the hose shall not be used to support his weight when climbing up or down.

11.7 *"T" Pieces*—A "T" piece or nozzle carrier "T" (devices for producing two equal and opposite jets at the end of the lance and at right angles to the normal flow) shall be inserted into a tube or vessel, or between two surfaces, before the system is pressurized. This is necessary to ensure that should one jet be larger than the other, or one jet become blocked or partially blocked, the operator of the lance will not be spun out of control. When a "T" piece is used to provide a balancing jet on a long lance to clean a single surface, it is not always possible to check for equal thrust from both jets in the above described manner; therefore, check these lances by progressive pressure increases.

NOTE 2—**Caution:** This shall also apply to any form of multijet nozzle having a radial component.

11.8 *Working in Confined Spaces*—Before entry into a confined space for jetting, obtain a certificate of clearance (a permit signed by the owner or facility representative) to ensure that access is safe. A confined space means a volume that is not intended for continuous occupancy, that may have unacceptable air quality or present the risk of engulfment by loose particles or bulk materials present (solid or liquid), and further may contain physical hazards, atmospheric contaminants, or be oxygen deficient. Before entry into a confined space an entry permit shall be obtained and atmospheric testing shall be performed if atmospheric contaminants or oxygen deficiency are possible. Consider contaminants that may be generated or released by the pressure water-jetting operation when assessing the need for additional precautions such as additional atmospheric testing, ventilation, attendants, rescue equipment, and personal protection equipment.

12. Safety Hazards

12.1 The pressures used in pressure pumping systems can cause injuries unless all original manufacturer's/assembler's operating instructions and maintenance procedures are followed. Keep original manufacturer's/assembler's Installation, Operating and Maintenance Manuals with the pressure waterjet cleaning and cutting equipment at all times for employee and operator reference. All manuals shall be kept in a waterproof compartment of the hydrojet equipment. Comply with these safety precautions.

12.1.1 Read and heed all warning labels posted on the equipment or accessories and in the manuals.

12.1.2 Check hose and hose fittings for wear, damage, etc. each time before starting the unit.

12.1.3 Do not wind hose tightly around the hose reel.

12.1.4 Make sure pressure hoses are suitable for the pump's maximum pressure rating (2.5 times maximum operating pressures). Check hose pressure rating (see name plate for pump pressure rating).

12.1.5 Do not point the spray pistol or hose at any person, at any time, whether unit is operating or not.

12.1.6 Pressurized discharge at spray nozzle can lead to severe personal injury if not properly used in accordance with the instructions.

12.1.7 If the spray pistol is being used in the system and the unit is shut down, the trigger of the pistol must be depressed to relieve pressurized water still remaining in the pistol.

12.1.8 When tightening any connections on the pressure side of the pump, be sure the pump is shut off and pressure is released.

12.1.9 The pump must be shut off and pressure released when adjusting any screw connections.

12.1.10 Use proper tools for maintaining the pump and attaching accessories.

12.1.11 All mobile units must be chocked or blocked when in operation.

12.1.12 The interlocked guard on the coupling connection to the driver shall be in place at all times.

12.1.13 When adding oil to the pump, do not overfill.

12.1.14 When ordering or using replacement parts or accessories for existing equipment, be sure they can withstand maximum pressures as stated on the pump nameplate.

12.1.15 Disconnect pump and driver from all utilities prior to maintenance. Lock out and tag equipment.

12.1.16 When cleaning tubes, a nozzle adapter must be used to eliminate the possibility of the nozzle and lance doubling back toward the operator.

13. Keywords

13.1 abrasive blasting; cleaning; construction; cutting; demolition; hydrojetting; lancing; moleing; shotgunning; water blasting

APPENDIX

(Nonmandatory Information)

X1. RESERVICE AND OPERATIONAL CHECKLIST FOR PRESSURE WATER-JET CLEANING AND CUTTING EQUIPMENT

X1.1 The following information should be verified before starting work:

X1.1.1 Date.

X1.1.2 Location.

X1.1.3 Equipment being cleaned.

X1.1.4 Is the area, including the other end of unit being cleaned, roped off and proper warning signs posted?

X1.1.5 Have precautions been taken to protect all electrical equipment?

X1.1.6 Is there any hazard to personnel resulting from damage to the equipment such as release of corrosive chemicals, flammable liquids, gases, or the like?

X1.1.7 Are all fittings of the correct pressure rating?

X1.1.8 Are all hoses of the correct pressure rating?

X1.1.9 Are all hoses in good operating condition?

X1.1.10 Are all fittings in good operating condition?

X1.1.11 Are all nozzles free from plugging and in good operating condition?

X1.1.12 Have precautions been taken to prevent line-mole reversal?

X1.1.13 Is the filter on the pump suction clean and in good operating condition?

X1.1.14 Is there an adequate water supply?

X1.1.15 Have precautions been taken against freezing?

X1.1.16 Do all personnel have proper personal protective equipment for this job?

X1.1.17 Do all personnel have the proper training for this job?

X1.1.18 Are all personnel qualified to perform this work?

X1.1.19 Has the complete hookup been flushed and air removed from the system prior to installing the nozzle?

X1.1.20 Has hookup including pipes, hoses, and connections been pressure tested with water at the maximum operating pressure?

X1.1.21 Is the dump system operating properly (will it dump when released)?

X1.1.22 Are all control systems operational?

X1.1.23 Is the location of emergency medical aid known?