

High-risk management standard

# HIGH-PRESSURE WATER, HYDROBLASTING, JETTING





Using a stream of pressurized water to remove material, coatings or contamination and debris from the surface of a work piece or material substrate makes High-Pressure Water Jetting operations hazardous processes which lead to serious injuries and illnesses. Thereby and because of the workplaces diversity, of the devices and used equipments, this standard is intended to ensure that all measures are taken to prevent and to control the risks of exposure to the identified hazards.

#### SCOPE:

This document applies to all activities and sites of Veolia. Contractors of Veolia must also comply with this standard. It provides practical guidance for persons conducting a business or undertaking on how to manage the health & safety risks associated with high or/and very high-pressure water jetting.

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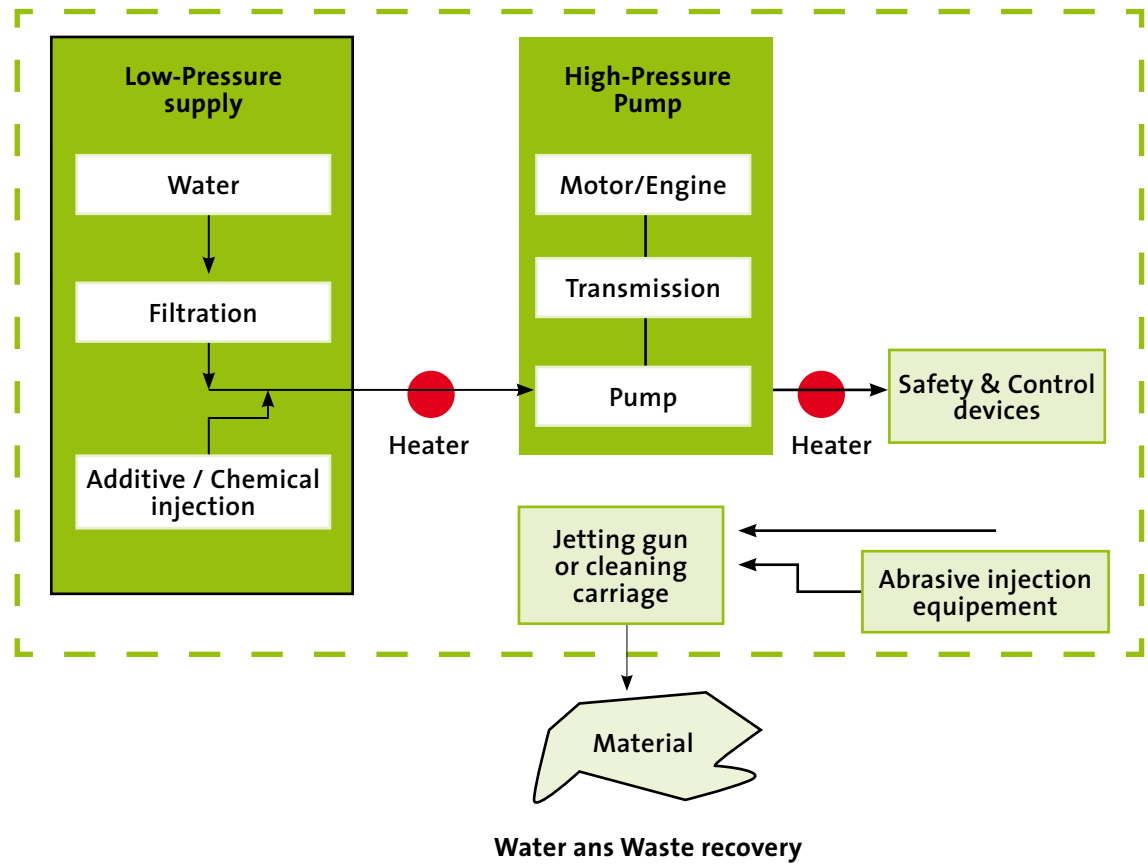


1.0 > Definitions

The term High-Pressure Water Jetting covers processes where a stream of water is pressurized and used on a material to clean, blast, cut or hydro-demolish this material.

This includes a wide variety of processes and equipment, from mobile to fixed equipment,

with some processes including the use of additives, abrasives or chemicals. Still, all encountered units can be considered as variations of, with more or less simplifications, the functional drawing given below.



• High-Pressure (HP) Domain:

In this standard, the term High-Pressure defines the domain of operation where:

Power of the jet (JP) is above 5 000 bar.l/mn.

The power of the jet is defined by the formula:

JP = Q x P , with:

- Q: Flow in litres per minute (l/mn),
- P: Pressure at the pump (P) in bar.

(This is equivalent to: Power (JP) > 20 000 psi. US gal/mn).

Note: This limit was defined by examining the accidents over the last years, and excludes pressure washers from the scope of this standard.

Considered HPW		PSI*					Bar**				
gal/mn	l/mn	Below 1,000	1,001-2,000	2,001-3,000	3,001-4,000	Above 4,000	Below 69	69-137	138-206	207-275	Above 275
Less than 5	<19	No	No	No	No	Yes	No	No	No	No	Yes
6-10	22.7-37.9	No	No	No	Yes	Yes	No	No	No	Yes	Yes
11-15	41.6 – 56.8	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
16-20	60.6 – 75.7	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Above 20	>75.7	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

\*1 PSI = 0.06894 bar \*\* 1 bar = 14,51 PSI

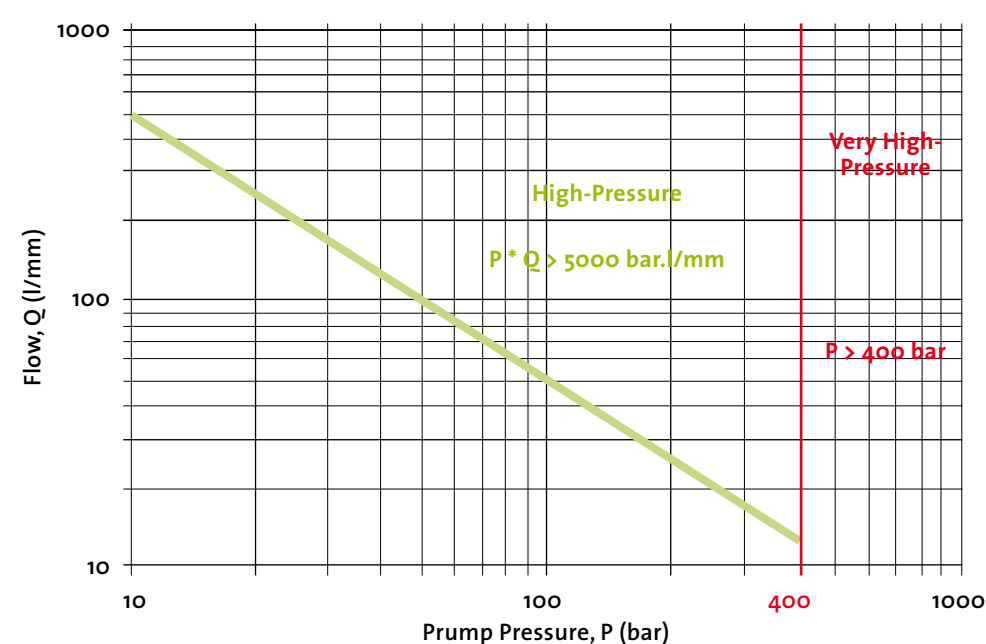


- **Very High-Pressure (VHP) Domain:**

$P > 400$  bar (equivalent to  $P > 6\,000$  psi)

In this standard, the term “Very High-Pressure” defines the domain of operation where the pressure at pump (P) is:

The High-Pressure (HP) and Very High-Pressure (VHP) domains are shown in the figures below (with Pressure on the X-axis and Flow on the Y-axis).



This standard will apply for all operations within Veolia in the “High-Pressure” domain and with additional specific requirements for operations in the “Very High-Pressure Domain”.

## 2.0 > Main High-Pressure Water Jetting Hazards

In this paragraph are highlighted the hazards and specific risks to high-pressure water jetting.

### 2.0.1 Risk of cut / perforation by the water jet

One of the main risks resulting from high-pressure jetting activity is the risk of perforation and making cuts, or even severing of a body part, by direct action of the jet:

- Directly from the spray nozzle.
- Or from an accidental leakage on the high-pressure circuit (with severe injuries on Very High-Pressure systems).

Wounds due to water jetting are always very serious, even when they appear superficial. With the penetration of contaminated water in body tissues, this can lead to severe infections, necrosis and gangrene. Pay attention to contaminated water or considered as such.

Because of the specific characteristics of water jetting wounds, in the case of an accident the victims must always be taken to hospital and information on the circumstances given to

medical staff (see in appendix, template of information sheet).

It is difficult to define in a precise way the dangerousness of a water jet, as the destructive power of the water jet is a function of various parameters (the power of the high-pressure pump, water pressure, shape of water jet, flow, distance between nozzle and impact point, time of exposure...).

Still, to assess the risk the 3 following parameters can be retained:

- Pressure.
- Flow.
- Shape of the jet (diverging or tightly “focused”).

The first 2 parameters are used to define the “High-Pressure” activities in this standard.

### 2.0.2 Physical trauma (other than cut/perforation)

The second mechanical risk due to High-Pressure jetting activity is the risk of physical trauma, bruises or wounds due to:

- Whipping by a hose following a hose rupture or unscrewing/release of a hose assembly device.

- Getting hit by an uncontrolled head of flexible lance.
- Projection of debris due to the jet action.
- Or direct action of the jet (after losing perforating power).

### 2.0.3 Noise

There are many sources of noise when working in HP jetting (noise of the jet, the tools, and the sound of the HP pump engine...). Exposure to these noises, if no precautions are taken, can cause hearing damage up to total loss of hearing.

Additionally, the high noise level can cause secondary incidents due to the misunderstanding between the operators.

#### 2.0.4 Risk of slips and falls

Falls are due to:

- Slipping on the wet ground created by the jetting water.
- Contraction of the hose (pulling operator backwards) when the hose is pressurized.
- Losing equilibrium because of the high reaction force of the jet, or sudden changes of reaction force at start or stop of the jet.
- Work in congested area.

Regarding the reaction force, the following figures are considered as the acceptable limit when using manual equipment:

- In confined spaces: max. 15 daN.
- In open space: max. 25 daN.

The reaction force is calculated according to the following formula:  $F = 0.023 \times Q \times \sqrt{P}$

$F$  = reaction force in daN (deca Newton)

$Q$  = flow in l/mn or US gal/mn

$P$  = pressure in bar or in psi

Unless specific risk analysis is performed, these values must be used as limits during the work preparation and while performing water jetting activities.

#### 2.0.5 Electrical Risk

The electrical risk can be generated by:

- The water jet reaching electric equipment.
- Work in a humid/wet environment.
- Malfunctioning of the High-Pressure Jetting equipment (for electric equipment).

*Please refer to Veolia High-Risk Management Standard on electrical safety for further guidance on how to manage safely electrical risk.*

#### 2.0.6 Exposure to chemicals, or dangerous substances

Chemical risks can be mainly linked to the following situations:

- Use of additives in the water jetting activity.
- Reaction of substances with water (emission of gases, projection of chemical droplets).
- Accumulation of vapours and gases in the work area (in confined spaces).
- Water fog containing the material or product touched by the jet.

- Sudden release of accumulated substances by breaking their container (pipe...) during the water jetting activity (typically gases and vapours but this can also include materials such as asbestos or biological contaminants such as legionella).

*Please refer to Veolia High-Risk Management Standard on hazardous materials and chemicals delivery, storage and handling for further guidance on how to manage safely chemicals hazards.*

#### 2.0.7 Static electricity

The impact of a high-pressure water jet on a surface generates an electrostatically charged mist. The higher the speed of the jet, the higher the risk is.

During cleaning activities of capacities which have contained flammable material,

an explosion can be caused due to a spark generated by a static electricity discharge. Such events have been documented in the cleaning of Crude Oil ships in the 1960s for example.

#### 2.0.8 Heat

Using hot water enables to get better cleaning results than using cold water. For that reason the use of water at high temperatures is sometimes associated with High-Pressure jetting. When this is the case, operators and

other persons in the vicinity of the jetting activity are exposed to the additional risk of burns by the heating equipment and/or the jetting equipment.

#### 2.0.9 Other risks

Some risks exist that are not specifically generated by the HP jetting activity or HP jetting equipment. But the level of risks can be increased by working with HP equipment jet. This includes in particular the following risks:

- Confined space.
- Working at heights.
- Traffic areas.
- Vibrations due to devices.

This should be taken into account during work preparation (refer to the relevant existing Veolia High-Risk Management Standards).



3.0 > Risk Management

Control measures are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the HIERARCHY OF CONTROL or RISK MANAGEMENT HIERARCHY, going from the highest to the lowest:

HIGHEST	ELIMINATION	Can the high-pressure jetting activity be totally eliminated?	MOST
Health and Safety Protection ↑	SUBSTITUTION	Can the considered way of working be replaced by a less hazardous method, material or system?	Reliability of control measures ↓
	ENGINEERING	Can the equipment be designed in a way that will keep personnel remote from exposure at all times?	
	ISOLATION COLLECTIVE PROTECTIVE EQUIPMENT	Can the danger be contained or can shields/ screens be put in place to prevent personnel exposure to it?	
	ADMINISTRATIVE CONTROLS	Can training, increased supervision, procedures and signage minimize exposure?	
LOWEST	PERSONAL PROTECTIVE EQUIPMENT	Can personal protective equipment (PPE) protect the person from exposure?	LEAST

In theory, one must always aim to eliminate a hazard, which is the most effective control. Still water jetting is one of the services Veolia provides to its customers, and it is impractical to eliminate completely the hazard of this activity.

Hence, the most efficient way to remove the hazard in our activities is to move to automated systems.

In this standard we define a system as automated when the following criteria are met:

- The operator does not hold the tool.
- The operator stands at a safe distance, or behind screens, which protects him from

the risk of being injured by the jets.

- The operator controls the pressure from that safe distance.

In some industry documents such systems are sometimes called “fully automated”.

They include in particular: blasters, hydro-demolition robots, exchanger cleaning robots. One additional advantage of these systems is that they reduce or remove the exposure to the various substances involved in the activity.

The next most effective way to minimize the risks is to apply a combination of engineering, collective protective equipment, administrative controls and personal protective equipment.

4.0 > Requirements

**Application**

This high-risk management standard applies as soon as operating in the “High-Pressure” Domain. This is the case when the power of the jet (JP in bar.l/mn), expressed as outlet pressure of the pump (P in bar) x Flow (F in litres/minute) is above 5 000 bar.l/mn.

This in US units is expressed as Jet Power above 20 000 psi. US gal/mn.

This standard applies to all Veolia business undertakings and operations involving employees, contractors, visitors or any other person.

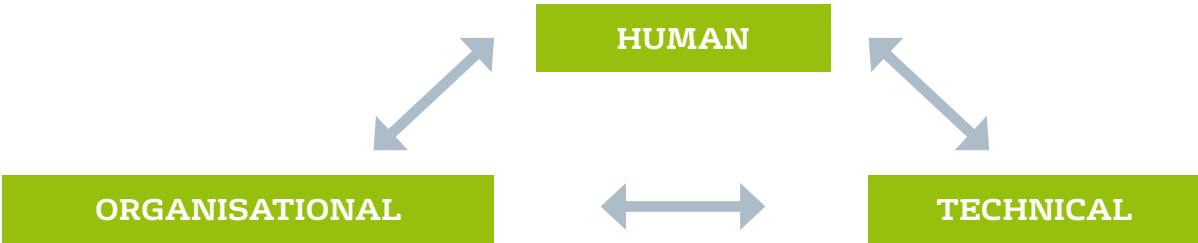
This Standard applies in addition to requirements prescribed by prevailing legislation, Codes of Practice, international standards and the manufacturer’s safety recommendation.

The additional requirements for VHP Domain must be applied when the pressure at the pump : P is above 400 bar (equivalent to P > 6 000 psi in non-metric unit).

**Requirements and Departure (Adoption of Alternative Control Measures)**

Use of the word “**must**” within this Protocol means a requirement is mandatory.

Use of the word “**should**” within this Protocol means the primary intent is that the requirement is mandatory but specific circumstances may mean implementation of the requirement is not reasonably practicable.



#### 4.0.1 Human Requirements

1. The operators of High-Pressure jetting systems must be trained to use the equipment that they will operate.
2. Appropriate training in the correct use, storage and maintenance of Personal Protective Equipment (PPE) must be provided to all employees, contractors and visitors.
3. The training must include safety considerations, detailing the risks of High-Pressure jetting and the relevant preventive and protective measures.
4. The training must include a part on the compatibility of the tools and accessories with the pressure group.
5. The training must include specific “on the job” sessions (practical session) with the system that will be used by the operator.
6. The training must be followed by a mentoring period.
7. The training must be validated by a formal “High-Pressure jetting” clearance delivered by the Operational Unit, Operations Manager or delegate.
8. The specific “on the job training” must be renewed if the system has not been used by the operator for a long period of time and if the operator has not succeeded a practical test. This period of time is to be defined by the Operational Unit, depending on the operator’s background but will not exceed 2 years.
9. The operators of the High-Pressure jetting equipment must be trained to know the emergency measures to be applied in case of accident (including the delivery of the information card for medical staff).
10. This safety training must be renewed at regular intervals defined by the operational unit and in line with local regulation, but should not exceed 5 years.
11. Workforce must have a medical certificate of fitness to perform HP Jetting work.
12. The persons involved in the work preparation (supervisors and business developers selling the service to the customer) must either have acquired the competence on HP and VHP jetting through their professional experience, or followed a technical and safety training on HP and VHP jetting before taking over their position.
13. Behaviour-based observations (Safety visits) must be performed and any need for additional specific training must incorporate the results of these observations.

#### Additional requirements for “Very High-Pressure Domain”:

14. The “Very High-Pressure” training must be validated by a dedicated “Very High-Pressure jetting” clearance certificate delivered by the Operational Unit Operations Manager or delegate.

#### 4.0.2 Organizational Requirements

1. Purchase and design of equipment (including hired and contracted) must meet the requirements.
2. The Operational Unit must have a “training and clearance register”. This register must list all the staff having a clearance certificate for the operation of “High-Pressure” equipment or “Very High-Pressure” equipment.
3. The “training and clearance register” must record the dates of trainings, validity period of the clearance certificate, and validity period of trainings when relevant.
4. The roles and responsibilities of the different crew members must be defined in a procedure of the operational unit.
5. All equipment used in HP jetting and VHP jetting must be provided by competent and referenced suppliers in link with technical specifications. Procedures should be in place to prevent supply through unauthorized channels (operational or purchasing procedures).
6. High-Pressure Water Jetting (HPWJ) activities must be planned by a competent person.
7. All the delivered equipment must be checked when received on site and delivered to the proper installation. (The compliance to the regulations and the norms must be checked when the equipment first arrives on site)
8. Depending on local legislation and what is most appropriate, the following elements must be recorded, either in the “equipment register”, or in a dedicated maintenance book for each equipment, or in both:
  - Manufacturer’s name.
  - Year of construction.
  - Technical specifications (max pressure, flow...).
9. A management of change procedure must be in place for changes of processes, equipment or safety devices with impact on the high pressure safety. Technical and/or organizational changes to high-pressure jetting must be subjected to a review of the existing risk assessment.
10. Modification to HPWJ equipment must be subject of a rigorous safety change management process to either the original equipment manufacturer’s approval or a review of engineering parameters.
11. A system must be provided requiring formal reporting and investigation of breaches associated with high (very high) pressure jetting.
12. Hoses must be tested when new (this can be done by the manufacturer, if it is, we must have all the certificates).
13. Hoses repairs must be done by competent and referenced suppliers.
14. Hoses should be tested when they have been repaired, or when they have been re-ended.
15. Hoses must be visually inspected at regular intervals defined by the Operational Unit, not exceeding 6 months. This requirement must be integrated into an operational procedure (and included in operators training).
16. Nozzles should be inspected by the operators before each use for blocked or damaged orifices, or any damage that could affect their safe operation. This requirement must be translated into an operational procedure such as a Job Safety Analysis (JSA) or/and the pre-job briefing (and included in operators training).



17. A Risk analysis must be performed for all High-Pressure jetting work. The risk analysis should be performed in a pragmatic way and adapted to the specific work under consideration. For example, it can be a generic risk analysis when performing sewer cleaning in a known location. In a difficult environment it must be a dedicated risk analysis, with one or more site visits and meetings with the customer (e.g. presence of overhead electrical line, or live equipment nearby the jetting area).
18. High-pressure pump and HPWJ equipment selection must be based upon a risk assessment taking account of tasks, application, environment and accessories compatibility.
19. Work in confined space with hand-held HP tools should be avoided whenever possible. When this cannot be avoided, the Veolia high risk management standard for confined space must be applied and a dedicated risk analysis must be performed for the work.
20. The risk analysis must be communicated to the operators before the work is performed in a pre-job briefing.
21. The risk analysis must ensure that the relevant measures are taken to guarantee that when working with hand held tools (gun works) the calculated reaction force ( $F = 0.023 \times Q \times v/P$ ) is below 15 daN (34lbs) for work in confined space, and below 25 daN (56 lbs) for work in open space.
22. A safe area must be established around the planned jetting operation and clearly defined by using a physical limit.
23. Water jetting operators should carry, in the truck or on them, a medical alert card (see example in appendix 2).

24. Operators of HP jetting equipment should be regularly audited by the operational unit management. Safety visits must include work behaviour observations.
25. The nozzle operator should be in control of the primary stopping device and the safety observer must have control of the secondary stopping device (emergency stop).
26. The requested personal protection equipment (for example Kevlar® clothes) for the considered pressure level are defined in the operational procedure and risk analysis for each work (e.g. head protection (helmet), eye protection (glasses or facial screen), personal hearing protection, leg and body protection, use of Kevlar® body suits, hand protection and over sleeve, foot and lower leg protection, respiratory protection when required...). They must be worn by the operators during the jetting activities.
27. All the accidents and incidents caused by operating high and very pressure devices must be reported, recorded and investigated.

#### Additional requirements for “Very High-Pressure Domain”:

28. For all activities above 400 bar (6 000 psi), the jetting systems must either
  - be an automated system, or
  - be operated with presence of a safety observer assigned with the tasks of observing the jetting operation and
  - shutting down the operation in case of emergency.

#### 4.0.3 Technical Requirements

1. The Operational Unit must have an “equipment register” listing all the “High-Pressure” systems and “Very High-Pressure” systems (including tools and accessories) in use in the Business Unit.
2. All systems must include a relief device (relief valve, rupture disc ...) at outlet of the HP pump, which can safely relieve the pressure of the system (in a safe location) should it exceed its intended limit. These devices must be verified periodically (depending on the local regulation and / or supplier’s recommendations).
3. The maximum pressure of tools and accessories must always be greater than or equal to
  - the maximum operating pressure of the HP group.
  - or the maximum pressure set on the safety device.
4. All hand held (foot held) equipment must include a “hold to run” safety control.
5. A stopping device (emergency stop) must be available at the work face to shut down the engine in an emergency.
6. Two forms of control devices must be utilised – a primary control device being “hold to activate” or “fail safe” that controls the pressurised flow of water and a secondary control device (emergency stop) that stops the engine.
7. All jetting equipment should be equipped with electric earthing connections.

8. When the equipment is used to jet clean a vessel containing flammable liquids that itself is not earthed, equipotential bonding connections must be used. In case of impossibility to do so, a specific risk analysis must be realized and dedicated actions must be put in place.
9. For all lancing equipment, anti-withdrawal devices should be used.
10. In order to avoid the nozzle to go back outside the pipe, an anti-return system must be put in place.
11. For lancing activities the hose should be tape marked (for example change of color in the hose material, ring) to indicate the end of the hose (to indicate to the operator when extracting the hose that he is approaching the nozzle end of the hose).
12. Anti-whip devices must be fitted on all connections except for pipe cleaning.
13. Gun barrels should be a minimum length of 1,200 mm.

#### Additional requirements for “Very High-Pressure Domain”:

14. All Very High-Pressure tools and accessories (hoses and hose connections in particular) should be marked with the manufacturer’s name and the maximum pressure rating.



## 5.0 > Glossary

**Anti-whip device:** Strap or cable that creates a bridge between two hoses, or fixed connection and hose, to prevent the hose from whipping, should it accidentally get disconnected.

**Anti-withdrawal device:** A device that prevents accidental removal of a flexible lance or rigid lance from a tube bundle or pipe while the lance is operating.

**Automated system:** In this standard an automated system is defined by the following criteria:

- The operator does not hold the tool.
- The operator stands at a safe distance, or behind screens, which protects him from the risk of being injured by the jets.
- The operator controls the pressure from that safe distance.

**Bar:** pressure unit, in metric system.  
1 bar = 14.5 psi.

**Change management procedure:** Procedure at Operational Unit level defining how changes in hardware and organization are to be validated before being implemented in the field.

**Competent person / supplier:** A person who has acquired the knowledge and skills to carry out the task through training or experience. Competency is a combination of these attributes that enables a worker to identify both the risks arising from a situation and the measures needed to deal with them.

**High-Pressure:** In this documents, “high-pressure” is defined as the work conditions where the Power of the jet expressed as Flow (Q) x Pressure (P) is above 5 000 bar.l/mn (or 20 000 psi. US gal/mn).

When in this case the requirements of the Standard apply.

**Job Safety Analysis (JSA) / Job Hazard Analysis (JHA):** Methods that can be used to identify, analyse and record the steps involved in performing a specific job, the existing or potential safety and health hazards associated with each step, and the recommended action(s) / procedure(s) that will eliminate or reduce these hazards and the risk of a workplace injury or illness.

**Management of Change (MOC):** Process to evaluate and properly manage any modifications to the design, control or operations (including staffing) of a covered process. Change management includes adapting to the change, controlling the change and effecting new change. Management of change requires an organization to take a proactive approach to change.

**Operational Unit:** In this document, an operational unit that can either be a site, an agency, a country or other organization. The Business Units are the organizational unit at which the standard is best applied.

**PSI:** Pounds per square inch, pressure unit in Imperial System. Conversion factor is:  
14.5 psi = 1 bar

**Reaction Force:** Force pushing backward the operator due to the energy in the jet because of its velocity and flow. The risk associated with the reaction force is of losing equilibrium and falling (or because of the sudden changes such as start and stop of the jet). The reaction force calculated with the following formula:

$$F \text{ (force in daN)} = 0.023 \times Q \text{ (flow in l/mn)} \times \sqrt{P} \text{ (P (pressure in bar))}.$$

**Safety Observer:** Competent person to implement control measures in case of an emergency and be competent to rescue the worker who is carrying out the high pressure work.

**Very High-Pressure:** In this documents, “Very High-Pressure” is defined when the pressure at pump discharge is above 400 bar (or above 6 000 psi).

When in this case, the “Very High-Pressure Requirements” applies, in addition to the “High-Pressure Requirements”.



APPENDIX 1 > Applicability and compliance Assessment check-list

> REQUIREMENTS	C	NC
HUMAN		
1. The operators of High-Pressure jetting systems must be trained to use the equipment that they will operate.		
2. Appropriate training in the correct use, storage and maintenance of Personal Protective Equipment (PPE) must be provided to all employees, contractors and visitors.		
3. The training must include a safety part, detailing the risks of High-Pressure jetting and the relevant preventive and protective measures.		
4. The training must include a part on the compatibility of the tools and accessories with the pressure group.		
5. The training must include specific “on the job” sessions (practical session) with the system that will be used by the operator.		
6. The training must be followed by a mentoring period.		
7. The training must be validated by a formal “High-Pressure jetting” clearance delivered by the Operational Unit, Operations Manager or delegate.		
8. The specific “on the job training” must be renewed if the operator has not used the system for a long period of time and if the operator has not succeeded in a practical test. This period of time is to be defined by the Operational Unit depending on the operator’s background, but it will not exceed 2 years.		
9. The operators of the High-Pressure jetting equipment must be trained to know the emergency measures to be applied in case of an accident (including the delivery of the information card for medical staff).		
10. This safety training must be renewed at regular intervals defined by the operational unit and in line with local regulation, but should not exceed 5 years.		
11. Workforce must have a medical certificate of fitness to perform HP Jetting work.		
12. The persons involved in the work preparation (supervisors and business developers selling the service to the customer) must either have acquired the competence on HP and VHP jetting through their professional experience, or followed a technical and safety training on HP and VHP jetting before taking over their position.		
13. Behaviour-based observations (safety visits) must be performed and any need for additional specific training must incorporate the results of these observations.		
14. Additional requirements for “Very High-Pressure Domain”: The “Very High-Pressure” training must be validated by a dedicated “Very High-Pressure jetting” clearance certificate delivered by the Operational Unit Operations Manager or delegate.		

ORGANIZATIONAL		
1. Purchase and design of equipment (including hired and contracted) must meet the requirements.		
2. The Operational Unit must have a “training and clearance register”. This register must list all the staff having a clearance certificate for the operation of “High-Pressure” equipment or “Very High-Pressure” equipment.		
3. The “training and clearance register” must record the dates of trainings, validity period of the clearance certificate, and validity period of trainings when relevant.		
4. The roles and responsibilities of the different crew members must be defined in a procedure of the operational unit.		
5. All equipment used in HP jetting and VHP jetting must be provided by competent and referenced suppliers in link with technical specifications. Procedures should be in place to prevent supply through unauthorized channels (operational or purchasing procedures).		
6. High-Pressure Water Jetting (HPWJ) activities must be planned by a competent person.		
7. All the delivered equipment must be checked when received on site and delivered to the proper installation. (The compliance to the regulations and the norms must be checked when the equipment first arrives on site).		
8. Depending on local legislation and what is most appropriate the following elements must be recorded, either in the “equipment register”, or in a dedicated maintenance book for each equipment, or in both: <ul style="list-style-type: none"><li>• Manufacturer’s name.</li><li>• Year of construction.</li><li>• Technical specifications (max pressure, flow...).</li><li>• Maintenance records.</li><li>• Inspection checks.</li></ul>		
9. A management of change procedure must be in place for changes of processes, equipment or safety devices with impact on the high pressure safety. Technical and/or organizational changes to high-pressure jetting must be subjected to a review of the existing risk assessment.		
10. A system must be provided requiring formal reporting and investigation of breaches associated with high (very high) pressure jetting.		
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12. Hoses must be tested when new (this can be done by the manufacturer. If it is, we must have all the certificates).		
13. Hoses repairs must be done by competent and referenced suppliers.		
14. Hoses should be tested when they have been repaired, or when they have been re-ended.		
15. Hoses must be visually inspected at regular intervals defined by the Operational Unit. This requirement must be integrated into an operational procedure (and included in operators training).		
16. Nozzles should be inspected by the operators before each use for blocked or damaged orifices, or any damage that could affect their safe operation. This requirement must be translated into an operational procedure (and included in operators training).		





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ORGANIZATIONAL		
17. A Risk analysis must be performed for all High-Pressure jetting work. The risk analysis should be performed in a pragmatic ways and adapted to the specific work under consideration. For example, it can be a generic risk analysis when performing sewer cleaning in a known location. In a difficult environment it must be a dedicated risk analysis, with one or more site visits and meetings with the customer.		
18. High-pressure pump and HPWJ equipment selection must be based upon a risk assessment taking account of tasks, application, environment and accessories compatibility.		
19. Work in confined space with hand-held HP tools should be avoided whenever possible. When this cannot be avoided, the confined space high-risk standard must be applied and a dedicated risk analysis must be performed for the work.		
20. The risk analysis must be communicated to the operators before the work is performed in a pre-job briefing.		
21. The risk analysis must ensure that the relevant measures are taken to guarantee that when working with hand held tools (gun works) the calculated reaction force ( $F = 0.023 \times Q \times \sqrt{P}$ ) is below 15 daN (34lbs) for work in confined space, and below 25 daN (56 lbs) for work in open space.		
22. A safe area must be established around the planned jetting operation and clearly defined by using a physical limit.		
23. Water jetting operators should carry, in the truck or on them, a medical alert card (see example in appendix 2).		
24. Operators of HP jetting equipment should be regularly audited by the operational unit management. Safety visits must include work behaviour observations.		
25. The nozzle operator should be in control of the primary stopping device and the safety observer must have control of the secondary stopping device (emergency stop).		
26. The requested personal protection equipment (for example Kevlar® clothes) for the considered pressure level are defined in the operational procedure and risk analysis for each work (e.g. Head Protection (helmet), eye protection (glasses or facial screen), personal hearing protection, leg and body protection, hand protection and over sleeve, foot and lower leg protection, respiratory protection when required...). They must be worn by the operators during the jetting activities		
27. All the accidents and incidents caused by operating high and very pressure devices must be reported, recorded and investigated.		
28. <b>Additional requirements for “Very High-Pressure Domain”:</b> For all activities above 400 bar (6 000 psi), the jetting systems must either <ul style="list-style-type: none"><li>• be an automated system, or,</li><li>• be operated with presence of a safety observer assigned with the tasks of observing the jetting operation and shutting down the operation in case of emergency.</li></ul>		

TECHNICAL		
1. The Operational Unit must have an “equipment register” listing all the “High-Pressure” systems and “Very High-Pressure” systems (including tools and accessories) in use in the Business Unit.		
2. All systems must include a relief device (relief valve, rupture disc...) at outlet of the HP pump, which can relieve the pressure of the system should it exceed its intended limit. These devices must be verified periodically (depending on the local regulation).		
3. The maximum pressure of tools and accessories must always be greater than or equal to <ul style="list-style-type: none"><li>• the maximum operating pressure of the HP group.</li><li>• or the maximum pressure set on the safety device.</li></ul>		
4. All hand held (foot held) equipment must include a “hold to run” safety control.		
5. A stopping device (emergency stop) must be available at the work face to shut down the engine in case of an emergency.		
6. Two forms of control devices must be utilised – a primary control device being “hold to activate” or “fail safe” that controls the pressurised flow of water, and a secondary control device (emergency stop) that stops the engine.		
7. All jetting equipment should be equipped with electric earthing connections.		
8. When the equipment is used to jet clean a vessel containing flammable liquids that is not earthed itself, equipotential bonding connections must be used. If impossible to do so, a specific risk analysis must be realized and dedicated actions must be put in place.		
9. For all lancing equipment, anti-withdrawal devices should be used.		
10. In order to avoid the nozzle to go back outside the pipe, an anti-return system must be put in place.		
11. For lancing activities the hose should be marked (change of colour in the hose material, ring) to indicate the end of the hose (and to indicate to the operator when extracting the hose that he is approaching the nozzle end of the hose).		
12. Anti-whip devices must be fitted on all connections except for pipe cleaning.		
13. Gun barrels should be a minimum length of 1,200 mm		
14. <b>Additional requirements for “Very High-Pressure Domain”:</b> All Very High-Pressure tools and accessories (hoses and hose connections in particular) should be marked with the manufacturer's name and the maximum pressure rating.		





## > Notes

- PLEASE TAKE THESE ELEMENTS INTO ACCOUNT  
WHEN MAKING YOUR DIAGNOSIS**

