



WORKING CONDITIONS CATALOGUE

Working under Hyperbaric Conditions

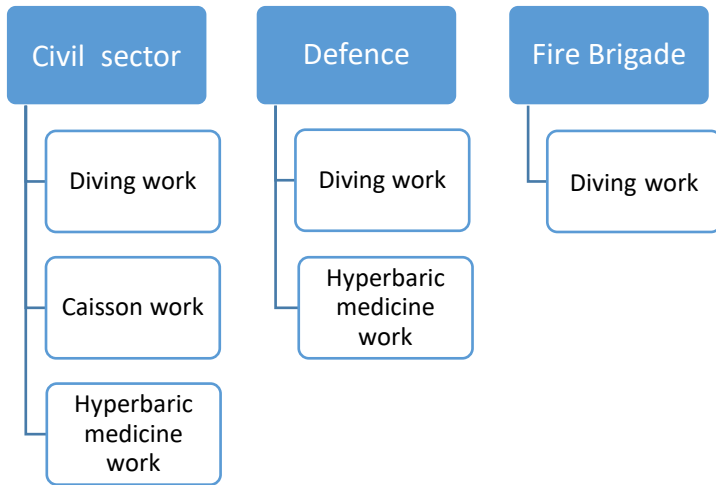
Information Note Diving No. 2
Risks and control measures of
High pressure jetting gun operations

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Preface

The Foundation Working under Hyperbaric Conditions -SWOD for short- represents the three fields of activity: diving work, caisson work and work hyperbaric medicine within the three sub-sectors: Defence, Fire Brigade and the Civil sector in the field of Working Conditions.



The Diving Information Notice No. 2 “Risks and Control Measures of High Pressure jetting gun operations” is based on guidelines and information from the diving industry in various countries, as well as from the Dutch diving industry and employee organization.

This information note was approved by the SWOD Central College of Experts (CCvD) on 23rd June 2020 and is in force from 1st October 2020.

Disclaimer

Although the Diving Information Sheet No. 2 “Risks and Control Measures of High Pressure jetting gun operations” has been compiled with the greatest possible care, the Foundation Working under Hyperbaric Conditions, neither the website manager nor the authors accept liability for any incorrect data and the possible consequences. thereof.

If any questions arise concerning the accuracy of the requirements in this information note No. 2, please refer to the Dutch version of this document, which is the official version.

Project group Working Conditions Catalogue Working under Hyperbaric Conditions

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1 TERMS AND DEFINITIONS

DMAC	Diving Medical Advisory Committee
DP	Dynamic positioning. A computer system including reference systems that automatically monitors and maintains the desired position and course of a ship, by means of propulsion systems.
End lance marking	There is little or no visibility during cleaning work underwater. This means that the diver cannot see the end of the jet gun barrel (or “lance”). An end of lance marking is intended when holding a lance as indication where the end of the lance is. This can be a ring around the lance.
High pressure	Working pressure higher than 250 bar, or when the pump power is more than 10 kW at a working pressure higher than 25 bar (SIR).
IMCA	International Marine Contractors Association.
LMRA	Last Minute Risk Analysis. The LMRA is performed at the workplace prior to the work to determine whether previously assessed risks and measures match the situation at the workplace and may need to be adjusted (management of change).
LSA scale	Natural radioactive substances that can be released during the production of crude oil and natural gas. These substances are originally contained in the rock from which the crude oil and natural gas are extracted. It is also referred to as NORM (Naturally Occurring Radioactive Material)
Project RI&E	An RI&E performed for a specific project by the diving contractor, client and competent persons .
RI&E	Risk Inventory and Evaluation (RI&E); every company with personnel must have a health and safety service or health and safety expert assess whether and how the work can be dangerous or unhealthy for employees. This must be recorded in writing. This RI&E must also include a Plan of Action (PVA). It describes which measures an employer will take to tackle the identified risks
Retro lance	The retro lance is a lance with a nozzle that balances the reaction force of the cleaning nozzle. The retro lance is in the opposite direction of the cleaning and therefore towards the diver. The retro nozzle has a solid and reliable cover that allows the water jet to come out behind the diver at a safe distance.
Safety catch	The safety catch is a provision that requires an extra action before the operating mechanism of the gun can be operated. This provision is intended to prevent inadvertent pressurization of the jetting lance.
SIR	Stichting Industriële Reiniging(NL)
Two hands control	Two-handed operation is a double activation of the lance. Two hands are needed to operate, which reduces the risk of jetting into hands or other limbs. If one of the levers is not operated, no pressure will build up at the nozzle.
Work plan	Description of project specific tasks and risks.

2 INTRODUCTION

This SWOD diving information note No. 2 is part of a series of information notes. The purpose of these information notes is to create awareness of the potential risks involved in working with a high pressure jetting gun while diving.

Risks of working with a high pressure jetting gun are serious injuries that can even be fatal. By emphasizing these significant risks and by providing guidelines on methods to assess and manage these risks as well as possible, the risks of high pressure jetting activities can be reduced or even eliminated.

In this information note diving "high pressure" means a working pressure higher than 250 bar, or when the pump power is more than 10 kW at a working pressure higher than 25 bar.

3 RISKS OF WORKING WITH HIGH PRESSURE JETTING GUN

3.1 INJURY WHILE WORKING WITH HIGH PRESSURE JETTING GUN

One of the risks the diver runs when working with the high pressure jetting gun is an injury caused by injecting water (or a mixture of water with grit and / or other additives) under high pressure through the skin.

Injuries resulting from the use of a high pressure jetting gun are in many cases serious and can even be fatal. At first, an injury may seem harmless, but extensive and deep subcutaneous tissue damage can cause a serious infection. This can ultimately have serious consequences if this injury is not treated immediately. This also applies to other types of high pressure fluid injections through the skin such as hydraulic oil, grease, paint, etc.



Figure 1: Example of High pressure jetting gun injury



Figure 2: Example after treatment

Failure to recognize the risks can lead to amputation or possible death if treatment is delayed. Thus, diving personnel must be well aware of the potential seriousness of such an injury, must be well prepared and, in the event of an actual injury, must be able to act promptly and appropriately:

- Contact numbers for medical assistance and the nearest medical facility must be available at the workplace and included in the Emergency Procedures and Provisions before commencing work with a high pressure jetting gun .
- A "FIRST AID" card must be present at the dive site, indicating how to act and what actions to take in the event of an injury. There must also be a "TREATMENT" card with information for the treating physician. An example of the "FIRST AID" and "TREATMENT" cards of the Industrial Cleaning Foundation (SIR) is included in APPENDIX 1.
- In the event of an injection injury, immediately contact a medical specialist. It should be specifically stated that this is an injury from a high pressure jetting gun . It should also be stated whether other additives such as grit and chemicals have been used in addition to water. (See also DMAC 03).
- Any injury caused by a high pressure jetting gun must also be reported.

3.2 SPECIFIC RISKS WHEN USING HIGH PRESSURE JETTING GUN UNDER WATER

There are some specific risks associated with working with the high pressure jetting gun underwater. The main ones are:

3.2.1 Risks related to surrounding area

- The diver has reduced visibility of the work site, equipment and high pressure hose;
- The diver can often not fully see the end of the high pressure jetting gun ;
- A leak in the high pressure hose is not or barely detectable underwater;
- The diver may suffer hearing loss from harmful noise from the high pressure jetting gun ;
- Grit and / or other materials that are added to the jetting liquid and materials that are removed by the high pressure jetting gun can damage the diving equipment.

3.2.2 Risks when the position of the diver is instable

- Adverse effects of the flow of the surrounding water on the diver;
- Adverse effects of the flow of the surrounding water on the high pressure hose;
- The resistance on the jetting lance when moving underwater;
- The reaction force of the jetting lance when used without a retro nozzle or when using an unbalanced retro lance.

3.2.3 Risks when using the retro lance

- Breaking off the protective sleeve from the retro nozzle;
- The diving suit of the diver can get sucked into the holes in the cover, causing the diving suit to leak;
- There is a risk that the retro nozzle or jetting nozzle can become clogged, causing the high pressure jetting gun to become unbalanced.

4 APPLICATION AREA, HAZARDS AND RISKS OF HIGH PRESSURE JETTING ACTIVITIES

4.1 APPLICATION AREA

For example, a high pressure jetting gun is used underwater for:

- The removal of fouling on platforms and ships and sheet piling;
- The removal of paint and corrosion;
- Loosening clay and other solid soil types before it is sucked up with the aid of air (the airlift);
- Loosening solid components to underwater structures and pipelines;
- Loosening drilling fluid and cement on the seabed;
- Cleaning of pipes.

In general, pressures between 350 and 690 bar are used to remove fouling, but in specific cases even installations with pressures up to 1000 bar can be used.

In addition to cleaning, the high pressure jetting gun can also be used for cold cutting of materials such as concrete and steel. In this form of cutting, with or without the addition of grit, pressures in excess of 690 bar are generally used.

In specific cases, so-called "ultra-high pressure" (UHP) installations or "ultra-high pressures" are nowadays also used for cold cutting of metal. The pressures used here can be as high as 1700 bar.

4.2 HAZARDS AND RISKS

- Injury when using a high pressure jetting gun;
- Contamination that may arise during the work, for example, due to paint and antifouling residues, drilling fluid and cement in the soil and LSA scale in pipelines;
- Danger of collapse if the bottom is blown away too deeply.
- Entanglement of the diver due to differential pressure (Delta P) when working near inlets, propellers, thrusters and water jets.

5 PREVENTION AND CONTROL OF HAZARDS WHEN USING A HIGH PRESSURE JETTING GUN

5.1 CLIENT

The client is responsible for providing the diving company with correct information about the activities, the workplace, the working conditions, the hazardous substances present and all other matters that may affect safety at the workplace. The provision of this information must take place before the start of making the Work plan and the execution of the project RI&E. Any changes must also be communicated immediately.

5.2 DIVING COMPANY

The diving company is responsible for the quality and safety, the good condition and the correct equipment of the high pressure jetting gun installation with accessories, including the Personal Protective Equipment (PPE). The diving company is also responsible for ensuring that personnel are trained in the use of a high pressure jetting gun and all the equipment that is necessary for it. This applies to both the divers and the surface personnel.

5.3 PROJECT RI&E AND WORK PLAN

When carrying out a project RI&E, the following must be taken into account, among other things:

- Other dive personnel in the vicinity of the diver who is engaged in high pressure jetting gun work;
- Other work above water and shipping;
- Underwater obstacles;
- Inlets and outlets, propellers, thrusters and water jets (Delta P);
- Contaminated soil and contaminants released during high pressure jetting gun activities;
- Suitable diving equipment and high pressure jetting installation, suitable Personal Protective Equipment and cleaning procedures of diving equipment;
- Precautions when using high pressure jetting gun and installation;
- Communication;
- Training of personnel.

Competent persons must be involved in the preparation of the Work plan. Think of onsite supervisors, area competent persons and the client. Project-specific tasks, responsibilities, authorities, the results of the project RI&E and the control points of an LMRA are laid down in the Work plan.

5.4 RISK MANAGEMENT

5.4.1 Control of breathing apparatus and other equipment

Grit and other additions to the water supply of the high pressure jetting gun or contamination caused by the use of the high pressure jetting gun may cause personal diving equipment to malfunction.

Great care must be taken to thoroughly clean and check the diving equipment after each dive. In particular diving helmets, regulators and other parts of the breathing apparatus deserve extra attention.

Other parts of the diving equipment can also be affected by the use of a high pressure jetting gun underwater such as lifting equipment for the divers (the diving cage, the wet- and dry diving bell) and construction / installation material used underwater such as wires, discs and (chain) hoists. With this equipment, too, great care must be taken during work to thoroughly clean and check for damage.

5.4.2 Ear protection

Due to the high noise level caused by the use of a high pressure jetting gun, its effect on the diver and surface personnel should be limited as much as possible. Measures to control these effects as much as possible are:

- Use a hard diving helmet with inner lining and suitable hearing protection if necessary. Band masks and similar breathing equipment should be avoided;
- Surface personnel must wear hearing protection in the vicinity of the high pressure pump installation.

The disadvantage of using hearing protection is that the effectiveness of communication is limited between the dive supervisor, deck personnel and the diver. If necessary, surface personnel should use hearing protection with a built-in speaker system.

5.4.3 Personal Protective Equipment (PPE)

While working with the high pressure jetting gun, the diver must wear protective clothing, footwear and gloves. The project RI&E must determine which PPE are necessary and suitable. This will depend on the equipment to be used, the position of the diver and other working conditions under water.

5.4.4 Training of diving personnel

Using a high pressure jetting gun is a risky operation and should only be performed by trained personnel. The dive supervisor must have a thorough knowledge of the equipment to be used and the working method used:

- A diver performing work with a high pressure jetting gun must be familiar with the use of the equipment and must be familiar with the work he is to perform;
- The dive supervisor must verify that the diver is familiar with the necessary safety equipment and procedures, that he is competent to use it, and that he is fully aware of the potential hazards and risks associated with the use of a high pressure jetting gun;
- It is the responsibility of the diving company to ensure that personnel are adequately trained and familiar with the equipment. Training may be provided internally within the company or externally by a competent training agency;
- To ensure that everyone is fully aware of the operation of the equipment, instruction must take place at the workplace. It must be indicated how this equipment can be used safely and provide instruction on emergency shutdown mechanisms and emergency shutdown procedures when necessary.

5.4.5 Safe distance to work activities with a High Pressure jetting gun

Divers who are in the vicinity of the work involving the use of a high pressure jetting gun must keep a minimum distance of 5 meters unless a different safe distance is agreed during the project RI&E.

5.5 HIGH PRESSURE JETTING EQUIPMENT

5.5.1 Main parts of a High pressure jetting installation

An installation generally consists of:

- a diesel or electric drive motor;
- a high pressure pump;
- safety devices and pressure relief valve (s);
- high pressure hoses;
- hose connections;
- a reel for the high pressure hose;
- a jetting gun (high pressure jetting gun) with various nozzles;
- a safety valve;
- a dump valve (optional)
- valves;
- an emergency stop.

5.5.2 Requirements for new equipment

There are two European, harmonized standards in which the requirements for a high pressure jetting gun installation are described

- The NEN-EN 1829 -1 “High water jet machines- Safety requirements- Part 1: Machines”;
- The NEN-EN 1829 -2 “High water jet machines- Safety requirements- Part 2: Hoses, hose lines and connectors”.

All equipment used underwater must be suitable for use by divers.

5.5.3 Requirements for equipment in use

- Before use, all equipment must be inspected;
- Periodically, but at least once a year, the material must be tested and inspected by a specialized company, independent competent person or institution with demonstrable specific knowledge in the relevant field, with access to the necessary testing facilities;
- Depending on the use and condition of the material, it must be determined whether it should be tested and inspected more often.

5.5.4 The High pressure pump

The high pressure pump must comply with the standard NEN-EN 1829-1, be suitable for use at a diving location and be mounted in such a way that it cannot become loose during bad weather and / or movement of the work platform on which it is standing.

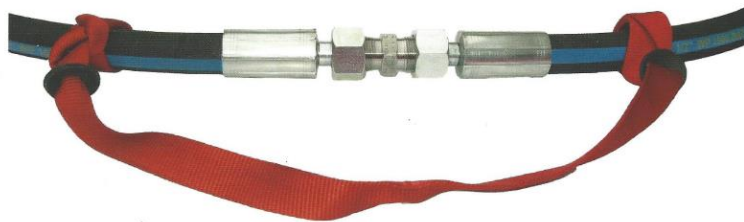
5.5.5 The High pressure hose

The high pressure hose must meet the following minimum requirements:

- The hose must comply with the NEN-EN 1829-2 standard;
- Only high pressure hoses may be used that can withstand the forces of high water pressures, possibly with grit and / or other additives.

General safety precautions during use are:

- Before use, the high pressure hose must be checked for damage. If necessary, the hose must be replaced;
- Make sure that the high pressure hose does not run over sharp or protruding parts to prevent damage and possible bursting of the hose during use;
- It is important that the high pressure hose is properly paid out so that the diver is not unnecessarily obstructed by a hose that is too long or too short;
- It is recommended to use a hose reel, possibly with a motor drive. The advantages of this are:
- Orderly storage of the high pressure hose. This prevents damage;
- Easy and controlled lowering and lifting of the high pressure hose;
- Less space is required on deck;
- High pressure hoses must be fitted with hose rupture protection devices at the couplings.



Source: SIR Manual High pressure cleaning

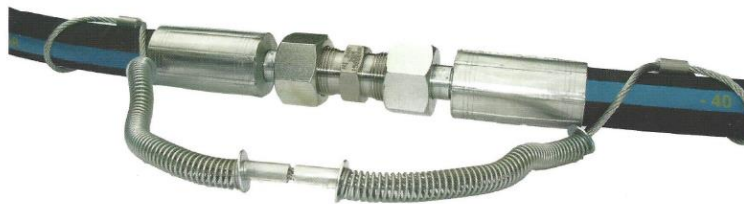


Figure 3: Example of a hose coupling break away protection

5.5.6 The jetting gun

The jetting gun must meet the following minimum requirements:

- The length of the jetting lance is at least 75 centimeters and designed in such a way that the diver cannot injure himself. If the jetting lance is shorter than 75 centimeters, it must be equipped with a so-called "two-hand activation";
- The jetting lance may never be shorter than 50 centimeters because of the risk of injury;
- The end of the jetting lance must be provided with an "end lance marking". This could be, for example, a ring around the lance so that the diver can feel that his hand is close to the end of the jetting lance;
- The water speed of the exhaust retrojet must be such that it cannot injure the diver;
- The retrojet venturi must be shielded in such a way that the diver cannot be injured;
- The retrojet must be attached in such a way that it cannot come loose;
- There must be a protection of the trigger mechanism;
- At least one handle on the gun must be secured with a safety catch;
- The trigger mechanism must not be locked.



Figure 4: High pressure jetting gun lance with a protection for the retrojet venturi

6 MEASURES BEFORE AND DURING DIVING ACTIVITIES

6.1 CHECKS PRIOR DIVING ACTIVITIES AND LMRA

- Check with the parties involved, familiar with the relevant work location, whether all safety measures have been recorded in the project RI&E and included in the Work Plan and record this;
- Discuss with the dive crew and other personnel involved the risk of any potential hazard at the work site such as underwater obstructions, moving parts, inlets and outlets, ship propellers, thrusters and water jets and any passing shipping traffic;
- Discuss emergency scenarios and actions to be taken should unexpected events occur;
- Provide all involved personnel with the necessary information to allow the work to proceed safely;
- Check that control measures are effective before starting diving operations;
- Use SSE to perform the work or another diving method after carrying out a detailed project RI&E;
- Apply a permit to work system for diving and check that measures have been taken to prevent pumps or other mechanical suction devices from being started and / or opened during work on ships and platforms (Delta P).;
- In the event of a change to the Work plan or work situation: adjust the Work Plan and carry out a new project RI&E with all parties involved (Management of Change Procedure). Then communicate this with all parties involved (See also APPENDIX 2) ;
- Perform a Last Minute Risk Analysis (LMRA) and also use a High Pressure Cleaning checklist before the diver enters the water.

6.2 HIGH PRESSURE JETTING GUN ACTIVITIES: CHECKS AND PRECAUTIONARY MEASURES

6.2.1 Testing of equipment before utilization

Before using the high pressure jetting gun, all equipment must be checked for proper operation. In addition, the emergency stop device must also be tested to ensure that it is functioning properly.

It must then be checked whether the equipment has undergone the necessary maintenance in accordance with the maintenance schedule, that the correct certificates are present and that, in combination with the regular maintenance by an competent person , regular visual inspections are also carried out.

6.2.2 Warning signs at work location

Warning signs must be clearly visible. These signs indicate that diving activities are taking place with a high pressure jetting gun . This is to ensure that personnel who are not directly involved in the high pressure activities remain outside the cordoned off area.

6.2.3 The use of high pressure hoses

In order to safely use high pressure hoses, the following points must be observed:

- It must be prevented as much as possible that high pressure hoses are damaged by sharp edges, chafing, dents, bending and kinks, etc;
- High pressure hoses should contain as few couplings as possible. It is preferred that the high pressure hose consists of 1 length;

- High pressure hoses should be secured in suitable locations to minimize movement of the hoses caused by tides or currents;
- High pressure hoses should never be attached to diving equipment.

6.2.4 Precautions during freezing temperatures

When frost is expected, measures must be taken to prevent freezing, for example by letting the water out of the equipment as much as possible after use or by using antifreeze. Under no circumstances should the pump be started when it is suspected that the equipment has frozen. It must first be checked whether the equipment is free from ice. Should there be ice in the system and the pump is started, damage could occur.

6.2.5 Malfunction of positioning systems onboard DP-vessels

Noise and turbulence that is released when working with the high pressure jetting gun can cause disturbances in the acoustic reference system of a DP ship. That is why the DP operators on the bridge of the ship must be informed and, if necessary, measures must be taken before starting high pressure jetting gun activities.

6.2.6 Communication

Audio communication can be disrupted to a great extent during high pressure jetting gun operations. It is the responsibility of the dive supervisor to monitor the work and breathing of divers and to intervene immediately if there is a suspicion that something is wrong. Therefore, one should only work with clearly audible communication.

6.2.7 Emergency stop

In an emergency, the dive supervisor must be able to stop the high pressure pump or have it stopped. For this, he must have an emergency shutdown facility in the control room or must be in constant direct contact with the person operating the high pressure pump.

6.3 HIGH PRESSURE JETTING GUN WORK: RISK CONTROL MEASURES

When working with the high pressure jetting gun underwater, the following points must be observed:

- The instruction to the dive supervisor to start the high pressure pump may only be given by the diver when he has arrived at the work site and is ready to commence work with the high pressure jetting gun . The dive supervisor must inform the diver when the high pressure pump is started;
- No other diving activities may be carried out in the vicinity of high pressure jetting gun activities. A safe distance of at least 5 meters is maintained unless a different safe distance is agreed during the project RI&E;
- When performing high pressure jetting gun activities near the surface or in the water / air interface, make sure that no persons are present on the surface in the vicinity of the activities and that they could be injured;
- Umbilical and high pressure hose must be clear of underwater obstructions to prevent damage;
- Function test the operating mechanism (the trigger) of the high pressure jetting gun and make sure that it closes automatically if not operated;
- The diver must make sure that the force from the nozzle is equal to the reaction jet and that they are adjusted together equally;
- Be careful not to entangle the umbilical with the jetting hoses. Keep the umbilical as vertical as possible;

- If possible, try to position a dry diving bell, wet diving bell and diving cage upstream of the location of the high pressure jetting gun operations to prevent them from coming into contact with contaminants during high pressure jetting gun operations;
- Upon termination of the work by saturation divers, before entering the diving bell, ensure that their diving equipment and umbilical are clean of the material removed during work with the high pressure jetting gun. This material may be contaminated;
- Visibility during work with a high pressure jetting gun may be very limited. This must be taken into account when positioning the diver. In addition, he must be constantly aware of where the high pressure hose is located;
- With continuous use of a high pressure jetting gun , regular rest periods should be held to avoid tiredness by the diver;
- The jetting lance can easily be damaged when used to remove particles of fouling. The jetting lance may only be used for high pressure jetting gun work.

7 REFERENCES

- IMCA D 049 “Code of Practice for The Use of high Pressure Jetting Equipment by divers”.
<https://www.imca-int.com/>
- DMAC 03 “Accidents with high pressure-waterjets”.
<http://www.dmac-diving.org/guidance/>
- IMCA Safety Flashes
 - IMCA Safety Flash 5/ 11 “Diver Safety – High Pressure Water Operations”.
 - IMCA Safety Flash 06/07 “Diver injury using Cavitation blaster”.<https://www.imca-int.com/alert/alerts/safety-flash/>
- Stichting Industriële Reiniging (SIR)
- NEN-EN 1829 -1 “High water jet machines- Safety requirements- Part 1: Machines”;
- NEN-EN 1829 -2 “High water jet machines- Safety requirements- Part 2: Hoses, hose lines and connectors”.

APPENDIX 1: FIRST AID & TREATMENT OF HIGH PRESSURE INJURIES

A First Aid and Treatment card must be present at the workplace with all information about first aid for high pressure jetting gun injuries and the treatment thereof.

This First Aid and Treatment card must also contain contact details of doctor (s) who are available 24 hours a day and who are experienced in treating wounds caused by a high pressure jetting gun .

The map below is an example of the Industrial Cleaning Foundation (SIR(NL)). This "First Aid and Treatment card for high pressure injuries" has two sides.

One side of the card is for local first aid (orange borders) and the other side provides information for the treating physician on site or in the hospital (blue borders).

The following information should be given to the doctor treating the injuries:

- The water pressure used during the work;
- The type of water used (filtered salt water, fresh water or another liquid);
- Any added chemicals (including datasheets when available);
- Composition and relevant details of the type of grit or other means used in cleaning (including datasheet when available).The details of the possible residues from the high pressure jetting gun work.

INFO SIDE FOR FIRST AID



FIRST AID for HIGH PRESSURE INJURIES



Hot Oranje Kruis

NEVER UNDERESTIMATE HIGH PRESSURE INJURIES
 A HIGH PRESSURE INJURY MAY LEAD TO VERY SERIOUS COMPLICATIONS

RESCUE

Always ensure your own safety. If necessary, use personal protection equipment

- ensure the victim is brought to safety
- check consciousness, breathing and/or blood circulation. If necessary secure
- reassure the victim
- do not underestimate the injury
- call 1-1-2 and/or the First Aid number of the company

VICTIM STABILISATION

- stop any bleeds
- cool down any affected body parts
- cover injuries aseptically
- support the affected parts of the body if possible
 - limbs: allow them to rest and keep them raised if possible
 - eyes: do not apply any pressure to eyes
- allow the victim to rest
- do not allow the victim to become cold

WAITING FOR VICTIM TRANSPORT

- **wait for ambulance!**
- if the victim is conscious ► in supine position
- if the victim is unconscious ► in recovery position
- ensure that the affected body parts are kept raised if possible

GIVE THIS CARD TO THE VICTIM TO TAKE WITH HIM

HIGH PRESSURE INJURY

- the affected body part may:
 - have an opening in the skin that can barely be seen
 - be painful and/or numb or paralysed
 - start to swell (considerably) shortly after the accident
 - get coloured welts and/or blisters

INFORMATION:	UNIVERSITY HOSPITAL MAASTRICHT	+31 (0)43 387 65 43
	ERASMUS MC ROTTERDAM	+31 (0)10 703 41 56
	ZNA STUIVENBERG ANTWERP	+32 (0)3 217 71 11



INFO SIDE TREATING DOCTOR



TREATMENT of HIGH PRESSURE INJURIES



Het Oranje Kruis

NEVER UNDERESTIMATE HIGH PRESSURE INJURIES A HIGH PRESSURE INJURY MAY LEAD TO VERY SERIOUS COMPLICATIONS

Foreign matter is spread through the channel of least resistance under the skin with regard to injuries that have occurred due to high pressure water jetting. This occurs in accordance with the mechanism of internal explosion. This can occur when a person is doing high pressure water jet activities, working with (grit) blasting machines or spray cans or when paint, oil or grease spraying. By definition, these injuries are contaminated with the jetted matter and possibly also with other particles, such as, particles coming from the cleaning. Treatment must, initially, consist of decompression, cleaning and draining of the injured tissue.

ALWAYS CONSULT THE PRODUCT INFORMATION (MSDS) OR THE CHEMICAL SAFETY CARD

PROBLEM-DETERMINING FACTORS

- The injected matter can, for example, cause oedema in the affected tissue.
An example is loge syndrome.
- A chemically active substance may influence the affected tissue. Consequence: local disturbance of circulation, inflammatory reaction, tissue necrosis.
- Thermal injury if the injected material was warm or hot.
- Inflammatory reaction to foreign material including after treatment.

MEDICAL EXAMINATION

Determine the distribution of the injected material in the affected part of the body through X-rays. Investigate the factors that determine the choice of treatment:

- the condition of the skin; much damage may have been caused under the skin through what appears to be a small wound (appearances may be deceptive),
- the reaction degree of soft tissue; also remember that apparently undamaged soft tissue may have been affected,
- the colour, swelling, temperature and functioning of the damaged part of the body,
- the degree in which the nervous system works and/or the degree in which it has been disrupted.

TREATMENT

The objective of treating injuries is to ultimately prevent the functional disorder of the affected part of the body. All victims must be admitted to hospital for observation. When there is any suspicion of increasing swelling followed by pain, explore the affected part of the body operatively. If necessary, decompress, clean and drain the injured tissue. If necessary, give antibiotics (do not forget tetanus).

POSSIBLE COMPLICATIONS

- allergic reactions; post-operative because not all material could be removed
- infections (tetanus)
- loss of the damaged body parts

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	ERASMUS MC ROTTERDAM	+31 (0)10 703 41 56
	ZNA STUIVENBERG ANTWERP	+32 (0)3 217 71 11



APPENDIX 2: EXAMPLE STEP-BY-STEP PLAN FOR DIVING ACTIVITIES WITH HIGH PRESSURE JETTING GUN

Step	Actors	Action				
1	Diving Company Diving Supervisor Site Supervisor Client	1A/ Project RI&E and Work plan: → Carry out and agree with all involved parties				
		1B/ Management of Change procedure: → adjust Workplan and carry out project RI&E				
Work location						
2	Diving supervisor	LMRA prior starting the work e.g.:				
		<ul style="list-style-type: none"> ✓ Weather situation and forecast ✓ Water flow rate ✓ Other activities in the area ✓ Safe work location ✓ Suitable Work Equipment and breathing gas ✓ Personnel certified and experienced ✓ Communication and emergency communication ✓ Emergency facilities to rescue diver ✓ Precautions high pressure jetting gun work 				
		<ul style="list-style-type: none"> • Results LMRA: 				
		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; width: 30px;">V</td> <td>Work conditions in accordance with Work plan → continue with step 3</td> </tr> <tr> <td style="text-align: center;">X</td> <td>Work conditions NOT in accordance with Work plan → go back to step 1B</td> </tr> </table>	V	Work conditions in accordance with Work plan → continue with step 3	X	Work conditions NOT in accordance with Work plan → go back to step 1B
V	Work conditions in accordance with Work plan → continue with step 3					
X	Work conditions NOT in accordance with Work plan → go back to step 1B					
3	Diving supervisor	Discussion Work plan, control measures and dangers High pressure jetting gun work with divers, client and site supervisor				
4	Diving supervisor Site Supervisor	Work permit (written approval) for diving activities				
5	Diving supervisor Site Supervisor	If applicable in case of Delta P apply Lock out Tag out procedure and verify				
6	Diving supervisor Site Supervisor	Install safety provisions according to the Work plan				
7	Diving supervisor	If applicable in case of Delta P isolate diver from Pressure Differential Danger Zone (PDDZ)				
8	Diving supervisor	Discuss diveplan diver with the diving team				
9	Diver	Execution Work plan:				
		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; width: 30px;">V</td> <td>No deviations from Work plan during diving activities → continue with step 10</td> </tr> <tr> <td style="text-align: center;">X</td> <td>Deviations from Work plan during diving activities → go back to step 1B</td> </tr> </table>	V	No deviations from Work plan during diving activities → continue with step 10	X	Deviations from Work plan during diving activities → go back to step 1B
V	No deviations from Work plan during diving activities → continue with step 10					
X	Deviations from Work plan during diving activities → go back to step 1B					
10	Diving supervisor	Control during work above and underwater				
11	Diving supervisor	When request for extra work → go back to step 1B				
12	Diving supervisor	Job completed: Cancel Work permit for diving activities				
13	Diving supervisor Site Supervisor	Resume diving activities after leaving dive site → go back to step 2				

