



Analyzing Safe Practices in Water Jet Cutting Machine using Risk Matrix

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Abstract:

The aim of the project is to provide users of water- jet Cutting systems with guidance on safe practices to protect workers and other people who are near water jetting operations. It outlines a process to assist with the development of workplace-specific Safe Operating Procedures (SOP) for plant, equipment, hazardous chemicals, work tasks and processes that have the potential to cause harm to persons, plant, material or the environment as identified from risk assessments This is based on considering the certain underlying risks involved in the operation based on likelihood (probability) of occurrence and severity (potential of causing injury).

Keywords: Water-jet cutting, Safe Practices, Risk

1. INTRODUCTION

Abrasive water jets are powerful cutting tools. As is the case with all industrial machinery, water jet machines have certain inherent hazards that go beyond the obvious cuts. Knowledge of these hazards involved in water jet machine and proper protective measures are necessary to execute for safe operation. This article presents an overview of the hazards and recommending ways to ensure safety practices in workplace.

2. DUTIES OF PROCESS OWNERS & END USERS IN DIFFERENT STAGES OF WATER JET MACHINE

High pressure water jetting is a process using a stream of pressurized water to remove material, coatings or contamination and debris from the surface of a work piece or material substrate including. High pressure water jetting systems consist of an energy source like an electric motor or internal combustion engine, a pump, control mechanism, hoses, pipes, nozzles and various other components necessary for the equipment to function as a system. Common hazards and risks include the water jet piercing the skin, being hit by flying debris and exposure to noise. Other hazards associated with high pressure water jetting include working in confined spaces, fall hazards, respiratory and eye hazards, electric shock and potential exposure to hazardous chemicals maintaining the Integrity of the Specifications

Process Owners	Duties
A person who conducts a business or undertaking	Ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking. This duty requires the person to manage risks by eliminating health and safety risks so far as is reasonably practicable, and if this is not reasonably practicable, by minimising those risks so far as is reasonably practicable.

Designers, manufactures, importers, suppliers or installers of plant, substances or structures	Ensure, so far as is reasonably practicable, the plant, substance or structure they design, manufacture, import or supply is without risks to health and safety. This duty includes carrying out testing and analysis as well as providing specific information about the plant, substance or structure.
Officers such as company directors	Exercise due diligence to ensure the business or undertaking complies with the Regulations. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks from high pressure water jetting operations.
Workers	Take reasonable care for their own health and safety and to not adversely affect other people's health and safety. Workers must co-operate with reasonable policies or procedures relating to health and safety at the workplace and comply, so far as they are reasonably able, with reasonable instructions. If personal protective equipment (PPE) is provided by the business or undertaking, the worker must so far as they are reasonably able, use or wear it in accordance with the information, instruction and training provided.
Other persons at the workplace, like visitors	Take reasonable care for their own health and safety and must take reasonable care not to adversely affect other people's health and safety. They must comply, so far as they are reasonably able, with reasonable instructions given by the person conducting the business or undertaking to allow that person to comply with acts

3. MANAGING HAZARD IN WATER JET MACHINE

A. Identifying the hazards

The first step in managing risks associated with high pressure water jetting operations is to identify all hazards that could potentially cause harm to people. These may be identified by conducting a walk through assessment of the workplace, observing the work and talking to workers about how water jetting is carried out reading product labels, safety data sheets and manufacturer's instruction manuals, reviewing incident reports. Some examples of high pressure water jetting hazards include: cutting and reaction forces from high pressure water jets, flying debris, hazardous chemicals and biological materials, noise, and water jetting plant and equipment.

B. Assessing the risks

A risk assessment is mandatory for high pressure water jetting operations & it can help:

Identify which workers are at risk determine what sources and processes are causing the risks Identify what kind of control measures should be implemented, and Assess check the effectiveness of existing control measures.

C. Controlling the risks

Some control measures are more effective than others. Control measures can be ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of control.

4. GENERAL SAFETY RECOMMENDATIONS

The following safety recommendations should be considered when managing the risks to workers from the hazards associated with high pressure water jetting operations. Persons conducting a business or undertaking who have management or control of plant at a workplace must ensure, so far as is reasonably practicable, the plant is without risks to the health and safety of any person. Designers of plant must ensure, so far as is reasonably practicable, the plant is designed to be without risks to the health and safety of persons. Water jetting plant, equipment and attachments should only be used in accordance with the manufacturer's recommendations. No rigid lance attachment should be used unless it is fitted with a handle and a hold-to-activate device. It should only be used in accordance with the manufacturer's instructions. Jetting equipment and attachments should not be modified without the manufacturer's approval. The equipment should only be carried out by a competent person with relevant engineering skills. Such modifications or developments should be consistent with relevant safety recommendations.

A. Limits & Use

A high pressure water jetting system should not be used unless it has been inspected or serviced in accordance with the manufacturer's recommendations, and is free from any fault identified at the last inspection or service which may adversely affect the performance and safe operation of the equipment.

B. Safeguards

Anyone using high pressure water jetting equipment should follow these safety recommendations: Where necessary all equipment near jetting operations should be

shielded or protected from debris and the ingress of water from operating the jetting equipment.

- People other than the operating team should be kept out of barricaded work areas.
- Work activities should be planned to provide safe access to the equipment and item or surface being jetted.
- Overhead work should be avoided where possible, as this may cause unstable worker positioning and increase the risk of musculoskeletal disorders.
- Operators using manually operated jetting systems should be in a safe and well-balanced position before starting jetting operations.
- Jetting operations should not be performed from ladders or other surfaces not intended for use by workers, as this can lead to loss of control of the jetting equipment.
- Operators should check there is no interruption or interference to the release mechanism of any hand or foot controls that could stop the equipment operating safely and consistent with the manufacturer's specifications.
- Jetting operations should stop when conditions change or new hazards are introduced unauthorized people enter the barricaded area, recommended safe work practices are not being followed or a malfunction occurs.
- Jetting systems should be depressurized and secured when not in use and left unattended and components are being replaced or repairs are being made to the system.

5. PLANNING AND PRE-OPERATIONAL PROCEDURES

The Assessing and planning each job is important. This ensures high pressure water jetting is carried out in a way that is without risks to health and safety. Planning usually starts with initial customer liaison and a job or site inspection. People planning the work and people familiar with the work environment and the item or material to be jetted, should meet with the workers who will be carrying out the work to identify and discuss:

- Potential hazards of the work area
- Control measures to be implemented
- Potential environmental problems
- Safety standards, and
- Emergency procedures

Based on this information, the job can then be planned on consulting, co-operating and coordinating activities with other process owners

As a minimum the planning process should include:

- The number of workers and any special skills, qualifications or training required over - and above the safe use of high pressure water jetting e.g. such as an elevated work platform licence
- Isolation procedures including locking and tagging
- Equipment required including PPE's
- Barricading and signage requirements

- Notifying other workers nearby
- Providing safe work instructions for workers
- The crew completing a pre-start hazard assessment before starting jetting operations.

6 RISK ASSESSMENT

Risk identification is the process of recognising hazards associated with an event. It is helpful to identify risks by considering the people involved and their roles to ensure their safety at all times. Risk ‘groupings’ that can assist in the identification process include:

- **Human** – type and size of crowd expected, level of crowd participation
- **Technological** – mechanical, utilities such as gas and electricity
- **Natural** – the physical location and site area conditions
- **Environmental** – weather, Environment Protection Authority controlled ground impact etc.

A. Analyse Risk

Having identified vulnerabilities to assets, they should be analysed to determine the asset’s current risk exposure with current controls in terms of:

- **Likelihood** of occurrence; and
- **Consequence** of realisation.

Each of these parameters is to be determined in accordance with appropriate scales suited to the organisation’s internal risk management framework. The scales used in this generic framework are shown in below table.

TABLE.6.1. LIKELIHOOD OF OCCURRENCE

Likelihood Descriptor	Likelihood Description Statements
Very High	The event is EXPECTED to occur in most circumstances.
High	The event will PROBABLY occur in most circumstances and is expected at some time.
Medium	The event MIGHT occur at some time but is not expected.
Low	The event COULD occur at some time.
Very Low	The event MAY occur in exceptional circumstances.

B. Evaluating Risk

Current risk exposure, in terms of likelihood and consequence values, can be determined using the risk matrix table below.

Table .6.2 Risk Calculation Matrix

C (CONSEQUENCES)	
Catastrophic	Numerous death
Major	Fire, Explosion & Suspension Loads leads to few death
Fatality	Individual loss of Life
Serious	Disabling Injuries
Mild	Non Disabling Injuries or Minor injury

C. Treat the Risk

Once risk exposure has been determined all risks must be treated. Treatment options include:

- **Acceptable Risk:** - Corrective action does not required
- **Moderate Risk:** - Not an emergency but corrective action must be taken to control
- **Considerable Risk:** - Needs corrective action and to be corrected on the spot
- **High Risk:** - Immediate action to be taken to get mitigate the risk.
- **Very High Risk:** - Hold the activity till the corrective actions implemented in equipment

TABLE .6.3 RISK CALCULATION MATRIX

		Consequence				
		Mild	Serious	Fatality	Major	Catastrophic
Likelihood	Very Low	Low	Low	Low	Medium	Medium
	Low	Low	Medium	Medium	Medium	High
	Medium	Low	Medium	High	High	High
	High	Medium	Medium	High	High	Extreme
	Very High	Medium	High	High	Extreme	Extreme

Table.6.4 Risk Assessment

Activity	Potential Risk	Pr	Co	Risk Level	Control Measures
1. Low Pressure Circuit	Slip ,Trip & Electrical Shock	L	S	Moderate Risk	<ul style="list-style-type: none"> Use moisture-absorbent mats with beveled edges in operator area. Anti-skid adhesive tape in troublesome areas. Clean up any oil leaks or spills immediately.
	Electrical Shock	L	F	Moderate Risk	<ul style="list-style-type: none"> Ensure that all electrical components stay dry. Have only licensed electricians install, repair and dismantle jobsite wiring. Use lockout and tag out procedures to ensure that the equipment remains de energized or in case of any maintenance activities. Ensure all the electrical connections are suitably concealed to prevent exposure to water
2. High-pressure Circuit	Pressure System	M	F	High Risk	<ul style="list-style-type: none"> Hoses ends must be secured to prevent whipping if an accidental cut or break occurs. Goggles, Face shields or other eye protection must be worn by personnel using compressed air for cleaning equipment. All pipes, hoses and fittings must have a rating of the maximum pressure of the compressor. Compressed air pipelines should be identified (psi) as to maximum working pressure. Pneumatic impact tools, riveting gun should never pointed a person. Only authorized and trained personnel should service or maintain or to operate.
3. Water Preparation & Supply	Environmental	L	M	Moderate Risk	<ul style="list-style-type: none"> Water hose nozzle should never pointed on any person. Used Water should be treated in a proper way before discharge to surrounding to avoid ground water contamination. Periodical maintenance & visual inspection to be carried out before executing or starting the equipment, Avoid usage of water with excess mineral content
4. Abrasive Supply	Respiratory tract injury	M	M	High Risk	<ul style="list-style-type: none"> Proper instruction should be given on safe handling of abrasive and metal waste. Suitable eye protection should be worn when Hands should be washed thoroughly after contact with metals and coolants. Wear a dust particle mask. Suitable Protection to cover all the parts of body to prevent the occupational illness. Use a respirator device and it cleans the air before it enters your body Know and follow workplace safety precautions. Increase ventilation in work area. Eye Wash Pad should kept nearby the area to handle an emergency.
5. Machining	General Hazards	H	S	Moderate	<ul style="list-style-type: none"> Emergency Stop button should kept nearby working area in order to control in an accidental situation. Ensure the noise level of equipment in working premises if its exposure limit is high(Above 80 dB) then use appropriate ear protection PPE's. Working Area should be clearly marked to avoid the unauthorized entry or operating the equipment. Don't not wear any loose clothes, hair, other ornaments during the equipment operation. Keep the working premises clean, tidy, free from obstacles. Automatic machine trip and warning mechanisms to prevent equipment damage and personnel injury
6. Abrasive Water Jet Control	Abrasive Operation	H	F	High Risk	<ul style="list-style-type: none"> Working pressure should not exceed the manufacture's recommendation or working chart. Follow the Standard Operating Procedure provided by the manufacturer.

LEGEND:

Pr= PROBABILITY (VL: Very Low/ L: Low/ M: Medium / H: High/ VH: Very High);

Co= CONSEQUENCES (C: Catastrophic / M: Major / F: Fatality/ S: Serious/ M: Mild);

R= Risk (A: Acceptable Risk / M: Moderate Risk / C: Considerable Risk / H: High Risk / V: Very High Risk)

7. CONCLUSIONS

Work safety with water-jet in various production technologies must make provision for not only safety work with water-jet technology, but also safety work with all devices, which are on that workplace situated and also material manipulation. In case of other workplace devices, manipulation with material, interoperable transport, storage, control and overall work environment, i.e. production logistic, safety regulations valid for technology operation are applied and followed, in accordance with law, in terms of Inspectorate of work safety and State health authority.

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9. REFERENCES

- [1]. **Jan Kmec**, developed the process of Safe Operating Procedure based on the systematic assessment and analysis of hazards present in the abrasive water jet operation.
- [2]. **Ing. Agáta Radvanská**, Risk Analysis of Abrasive WaterJet Technology by means FMEA Method.
- [3]. **Sinay, J.** Risk assessment and safety management in industry. In: The Occupational Ergonomics Handbook. [S.l.] : CRC
- [4]. **M. Grasso, M.Goletti, M.Annoni, B.M. Colosimo**, A new approach for online health assessment of abrasive waterjet cutting systems.
- [5]. **Sergej Hloch, Stanislav Fabian**, Qualitative analysis of AWJ factors affecting the surface roughness.
- [6]. Anonymous. 2010.Guide for Managing High Pressure Water Jet Cutting.
- [7]. **P.P. Badgujar**, Abrasive Water Jet Machining- A State Of Art.Vol 11 Issue: 3 pp 59-64
- [8]. **ISOR** Journal of Mechanical and Civil Engineering.
- [9]. **Anonymous. M 2274 (SAFE WORK PRACTICES) HEALTH & SAFETY EXECUTIVE (HSE)**
- [10]. **SAFE WORK AUSTRALIA** in 2013 provides practical guidance & how to manage health and safety risks associated with high pressure water jetting operations