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To
FOD Inspectors

PROTECTIVE CLOTHING AND FOOTWEAR FOR USE WITH ULTRA HIGH PRESSURE WATER JETTING

This SIM contains information on new personal protective clothing and footwear now available in the UK which should reduce the likelihood of injury due to accidental contact with an ultra high pressure water jet.

1 Ultra high pressure (UHP) water jets operate above 1,700 bar pressure. They are being increasingly used by industry for removal of surface coatings, cleaning and cutting in particular by the marine, chemical and off shore industries. Whilst some automation has been achieved the majority of the work still requires the operator to manipulate a lance or a jetting gun. When accidents occur the contact time with the jet is usually short. In the case of a lance the second operator immediately dumps/diverts the pressure or with a jetting gun release of the trigger by the operator stops the flow. However with normal water proofs and Kevlar/steel toe capped wellingtons currently used the jetting operator can still receive severe injuries, eg amputation.

2 High pressure (HP) water jetting operates at different pressures and flow rates from UHP water jetting (see table). The higher the pressure the greater the cutting efficiency. With current pumps higher pressures are achieved at reduced flow rates, typically 20 litres per minute. In the case of accidental contact a UHP jet will cut through tissue faster than a HP jet operating at 680-1700 bar. However, the higher flow rates used in HP jetting, typically 50-60 litres per minute, cause greater damage to surrounding tissues as contaminated water is forced between the muscle planes. The actual energy applied to the body is related to both pressure and flow rate. Therefore pressure and flow rate should be considered in selecting appropriate personal protective equipment (PPE). The PPE manufactures provide appropriate guidance in their sales literature.

Jetting	Pressure	Typical flow rates
High pressure (HP)	680-1700 bar	50-60 l/m
Ultra high pressure (UHP)	Above 1700 bar	20 l/m

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3 A risk assessment should be carried out for each UHP water jetting operation. Where reasonably practicable automatic jetting systems should be used, eg boiler tube cleaning. If manual jetting has to be done then the risk assessment should identify the appropriate PPE for that particular job. As regards PPE, a generic assessment is acceptable providing it identifies PPE suitable for the highest pressures and flow rates the jetting equipment is capable of producing.

4 The extent of any injury will also be affected by the time the jet is in contact with the body (swipe speed), its distance from the nozzle (stand off distance) and the type of nozzle (eg single, multi-orifice). These subsidiary factors will be very variable and may not be included in the risk assessment.

5 It must be strongly emphasised that the PPE described below does not give complete protection. However it will provide enhanced resistance to penetration of the water jet thereby giving time to avoid further contact or stop the water flow and hence reduce the potential injury.

FLEXIBLE OUTER CLOTHING

6 A variety of garments are now available made from a fabric which provides increased resistance to penetration by a water jet. The fabric is made from an outer layer of polyurethane coated polyamide, to provide water resistance, over a multi-layer of synthetic fibres derived from polyethylene. It is currently available as a jacket, overalls, arm protection, high trousers, apron and gaiters. There is currently no harmonised European standard for this type of clothing so the CE mark has been affixed through the ‘technical file’ route.

7 An independent test house carried out tests on the fabric. A piece of the fabric was clamped in a steel frame. A water jet 75 mm from the surface of the fabric was then moved across at a swipe speed of approximately 0.5 metres/second. Water pressures varied from 180 bar to 2000 bar with flow rates of 13 litres/min to 17 litres/min. A block of cellular foam placed behind the fabric did not record any damage.

8 Protection against higher pressures is achieved by adding extra layers. To prevent penetration at the higher pressures up to 10 layers of the fabric are required. The manufacturers therefore provide clothing for use with jetting pressures varying from 180 bar to 2000 bar. By wearing additional garments the appropriate degree of protection can be achieved for parts of the body at greater risk, eg gaiters over overalls to protect the lower leg. Also extra layers can be sewn into high risk areas of a garment, eg the front side of the legs on the overalls.

HINGED COMPOSITE PANEL SYSTEM

9 This is made from a tight weave of Kevlar. To allow for body movements it comes in 12 light weight panels for different parts of the body. Each panel is held in place by straps. There are also hinged joints to allow bending at

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both the knees and waist The jetter can therefore choose protection for the most at risk parts of the body.

10 This product has now received CE approval using the same test house as used for the flexible outer clothing. This involved testing at pressures ranging from 700 bar to 2800 bar with flow rates up to 21 litres per minute. Swipe speeds ranged from 0.5 to 2.4 meters per second. As with the previous tests the jet stand off distance was 75 mm.

PROTECTIVE BOOTS

11 Until recently the only protective foot wear available for water jetting was the 'yellow wellington'. This has a steel insole, steel toe cap with some additional reinforcing across the top of the foot section. It is claimed to withstand a pressure of 400 bar. Such wellingtons are not acceptable for use with ultra high pressure water jets as they provide an inadequate level of protection.

12 Ultra high pressure protective boots are now available from the same manufacturer as the flexible clothing. The protected areas are over the top of the foot and approximately half way up the front of the upright part of the boot.

13 There is currently no standard test for such boots. However, to support their technical file the supplier commissioned a test house to verify that if the boot was exposed to a reaction force of 250 Newtons, penetration would not occur. This was achieved by a pressure of 1700 bar with a flow rate of 25.8 litres/minute. Whilst the pressure is lower than that applied in the fabric tests it was achieved at a far greater flow rate. The nozzle of the jetting gun was again set at 75 mm from the surface of the boot and the swipe speed was 0.2 metres/second. The rate of traverse was therefore 2.5 times slower. The test cut through approximately half the thickness of the boot thus proving a very good resistance to penetration.

14 The manufacturers of the hinged composite panel system also manufacture sections to cover the foot, including ankle, metatarsal and toe panels. These are made from the same material as the body panels and have therefore been subject to the same tests.

15 An all steel boot is currently being developed in the UK which should be available during 2002. Early tests suggest it will be able to withstand the test criteria detailed in para 13.

STANDARD TEST METHODS

16 The current lack of an EU standard for testing makes comparisons between the different products difficult. There are indications that at least one manufacturer wishes to work on developing a manufacturers standard method for testing. HSE and the Water Jetting Association are prepared to assist in such work. At a later date it may be possible to incorporate this into an EU standard.

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ACTION BY INSPECTORS

17 The versatility of the flexible clothing and the panel arrangements of the hinged composite panel system means a suitable combination can be found for a specified job. For instance if a vertical boiler is being cleaned the operator will be pushing the lance upwards. If the jet were to be directed downwards injuries could be received to the upper part of the body. Protection could include a jacket, apron/upper body panels and additional arm protector. By contrast when carrying out surface preparation on the decking plates of a ship injury is more foreseeable to the legs and feet. In this situation trousers/leg panels and wellingtons would be appropriate. This risk-led approach has been accepted due to the current high cost of immediately providing full body protection for all UHP jetters.

18 Currently no information has been made available to HSE on injuries that can still occur even with the new PPE as the reaction force applied to the body will still have to be dissipated. This is referred to as blunt trauma injury and is more commonly associated with bullet proof clothing. However, this reduced level of injury should be contrasted with the possibility of amputation and severe infection due to water being forced into the soft tissues.

19 With HP jetting ranging from 680 bar to 170 bar the pressures are obviously lower but the flow rates are usually much higher than with UHP jetting. In the case of contact with a HP jet the energy applied to the body will be much greater as will be the consequential blunt trauma injuries, even when wearing PPE. Whilst the above PPE will prevent penetration at lower pressures and low flow rates, no tests have been done to assess likely tissues damage at higher flow rates. Hence why at present we are only currently requiring the provision of such PPE for UHP jetting. Further test work using HP jetting should be completed during 2002 after which, consideration can be given to the wider use of the PPE. However, inspectors can still bring to the attention of employers the availability of the PPE for possible use with HP jetting and suggest the manufacturers be contacted for further advise. This is particularly relevant to the footwear which is rigid and therefore is likely to provide additional protection against blunt trauma injuries to the foot.

20 Operators must appreciate that this new PPE whilst lessening the likelihood of a severe injury will not give them complete protection and therefore high standards of training, supervision and operator vigilance will still be required.

EMM GUIDANCE

21 This guidance is based on the Enforcement Management Model (EMM) guidance version 3.0 and applies to the risks associated with UHP water jetting. Any action should reflect any subsequent changes to the EMM. The final decision on enforcement should also take account of any dutyholder or strategic factors.

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Actual risk

22 There is a risk of 'serious personal injury' to an employee coming into contact with a UHP water jet whilst carrying out manual jetting, eg amputation, extensive tissue damage/infection.

23 Inspectors witnessing such work being done without appropriate enhanced penetration clothing and footwear should consider issuing a prohibition notice as discussed in EMM Section 2. A risk gap analysis should then be used to decide on subsequent action.

Compliance issues

24 Even if adequate PPE is provided for the job taking place a risk assessment is still needed to demonstrate that the employer understands how to select the most appropriate equipment. For instance to achieve the required level of protection for a particular part of the body, two separate pieces of the flexible clothing may have to be worn.

25 Jetting teams usually work without direct management supervision. It is therefore important that employees receive appropriate training to ensure they understand why certain pieces of protective clothing must be used for specified jobs. Without such training employees may wrongly believe they are protected from injury by the water jet.

26 To achieve the benchmark inspectors should use the guidance to the Personal Protective Equipment at Work Regulations which provides an 'established standard'. The local situation will dictate the most appropriate 'descriptor' leading to an initial enforcement expectation using table 5.2.

27 This SIM was launched on 24 May at the Annual General Meeting of the Water Jetting Association. Member companies had been consulted in advance and are therefore aware of the requirement to use enhanced PPE for UHP jetting. Non-members will be informed by means of a press release sent to the appropriate trade press. The two main types of PPE have been available since last year therefore employers have had adequate time to decide on the most appropriate type for their needs.

28 Inspectors should be aware that UHP jetting equipment can be hired. The same standard of PPE protection will be required for jetters using hired equipment. Some types of the PPE are now also available for hire.

29 The Utilities National Group (UNG) in Nottingham should be informed of any difficulties in gaining acceptance of these new types of PPE. The UNG will be monitoring the effectiveness of the new PPE with a view to extending its use to lower pressure water jetting.

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