Harpur Hill, Buxton
Derbyshire, SK17 9JN
Tel: +44 (0)114 289 2000
Fax: +44 (0)114 289 2500

HEALTH & SAFETY LABORATORY

Hand-arm vibration and noise measurements of high pressure water jetting equipment

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Project Leader: Rebecca Hutt
Author(s): Rebecca Hutt BEng MIOA
Elizabeth Brueck BSc MIOA
Science Group: Human Factors Group

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EXECUTIVE SUMMARY

Noise and hand-arm vibration measurements of ultra high pressure water jetting equipment have been carried out. The measurements were conducted at the premises of two water jetting equipment manufacturers.

The primary objective was to carry out hand-arm vibration measurements in order to investigate the difference in vibration between water jetting nozzles with rotating jets and water jetting nozzles with a single straight jet. A difference in vibration between these types of nozzles could have implications on the specific vibration data requirements for operator vibration exposure risk assessments. It was recognised that these visits were an opportunity to record the operator's noise exposure at the same time.

Hand-arm vibration

The orbital and multiple rotating jets cause significantly higher vibration than the single straight jet. If water jetting operators are likely to use orbital and rotating jet nozzles for longer than 1 or 2 hours (in total) within a typical working day, then there is a likelihood that they will exceed the daily exposure action value of 2.5 m/s² A(8)[1] as set by the forthcoming Control of Vibration at Work Regulations [3]. In which case, the employer has a duty to reduce exposure to a minimum by establishing and implementing a programme of organisational and technical measures appropriate to the activity.

From the limited measurements conducted, there is no indication that a similar programme of vibration exposure control measures would be required for water jetting with a single straight jet. However, there may be disadvantages in terms of the time taken to do a particular task with a single straight jet.

The measurement results for orbital and multiple rotating jets show quite a wide variation, depending on the nozzle. Therefore, a single vibration magnitude representing the worst case vibration from these types of nozzles, may be an over-estimate in some cases. Consequently, the outcome of a risk assessment could place unduly restrictive measures on water jetting.

Noise

Under the current Noise at Work Regulations [4], a water jetting operator's noise exposure is likely to exceed the second action level within a few minutes, requiring hearing protection to be worn and the noise exposure to be reduced as far as is reasonably practicable by means other than the use of hearing protection. Under the proposed Control of Noise at Work Regulations [5], a water jetting operator's noise exposure is likely to exceed the exposure limit value within 45 minutes (despite taking hearing protection into account), in which case the employer has a duty to take immediate action to reduce exposure to below the limit value.

Hearing protectors should be chosen to give maximum protection. This cannot be achieved unless ear plugs are properly fitted and/or ear muffs seal around each ear (they will not be effective worn over the hood of the operator's protective suit). Hearing protection alone may not give adequate protection unless the daily exposure time of the operator is limited.

The noise emission is highly dependent on the distance travelled by the jet; shorter jets from close working are a smaller noise source giving a lower noise level. Keeping the water-jetting gun close to the workpiece and the jet short, is clearly an effective way of reducing the noise exposure of the operator.

[1] A(8) indicates that the value is normalised to an 8-hour reference period.

1 INTRODUCTION

Noise and hand-arm vibration (HAV) measurements of ultra high pressure water jetting equipment have been carried out by Rebecca Hutt and Liz Brueck from the Health & Safety Laboratory, at the request of Steve Catterall, HSE Inspector with responsibility for high pressure water jetting health and safety. The measurements were conducted at the premises of two water jetting equipment manufacturers, referred to in this report as Site A and Site B.

The primary objective was to carry out HAV measurements in order to investigate the difference in vibration between water jetting nozzles with rotating jets and water jetting nozzles with a single straight jet. A difference in vibration between these type of nozzles could have implications on the specific vibration data requirements for operator vibration exposure risk assessments.

A separate project on noise emission from water jetting is in progress and it was recognised that these visits were an opportunity to record the operator's noise exposure at the same time.

The results of both the noise and hand-arm vibration measurements are presented and discussed in this report.

2 WATER JETTING EQUIPMENT

2.1 BACKGROUND INFORMATION

Water jetting systems generate a very high pressure jet by forcing water through a small bore nozzle. The nozzle is mounted on the end of a jetting gun which is held by the operator. The water is supplied via a hose from a jetting unit which has a source of water, a high pressure pump and a prime mover (e.g. a diesel engine). The continuous stream of liquid (water only or water and abrasive) travelling at up to 900 m/s, has very high energy and the potential to cause serious injury. It has a wide variety of applications in the offshore, marine, construction and manufacturing industries. For example: removing marine growth, scale, rust and old paintwork from offshore structures and ships; scabbling and cutting concrete; cleaning tube bundles, heat exchangers and boiler tubes; removing graffiti, paint, rust, cement, grease and oil from any surface.

The range of operating pressures for high pressure (HP) and ultra high pressure (UHP) water jetting equipment are shown in Table 1 [1]. The equipment available for the noise and HAV measurements was UHP, operating at greater than 2000 bar.

Table 1 Range of operating pressures

Descriptor	**Pressure**		
	PSI	**bar**	**MPa**
High pressure water jetting (also known as high pressure hydroblasting/waterblasting	10000 - 25000	680 - 1700	68 - 170
Ultra high pressure water jetting (also known as ultra high pressure hydroblasting/waterblasting/hydrodemolition)	> 25000	> 1700	> 170

A straight jet is a uniform stream of liquid emitted through a circular hole. This is the most powerful and concentrated of all the jet patterns. Straight jet nozzles have a typical energy loss of 20%. Steep angles concentrate the power into a small area. Shallow angles result in larger impact area with reduced power. Straight jets are more effective on hard, brittle deposits which shatter when hit by the jet.

A rotating jet nozzle uses two or more forward pointing high velocity jets, off-set from the nozzle's axis and at an angle from the straight ahead position. These nozzles rotate at 1000 rpm and above, producing quick and effective cleaning of many surfaces well above that achieved with a straight jet. An air powered rotary gun uses a compressed air supply to power the rotation of the nozzle, whereas a rotary nozzle uses the water supply to power the rotation of the jets.

The dump type gun is designed with a dump tube to allow for depressurisation at the cleaning site. With the dump gun valve closed, the gun is activated in the jetting mode - water passes through the gun and out through the nozzle. With the dump gun valve open, the gun is placed in the dump mode - water bypasses through the dump tube to waste, safely at almost zero pressure.

2.2 SITE A EQUIPMENT

The jetting guns used at Site A for the measurements are shown in Figures 1, 2 and 3. The equipment configurations for the measurements are given in Table 2. The workpiece was a 5 mm thick rusty metal plate, propped against a wall.

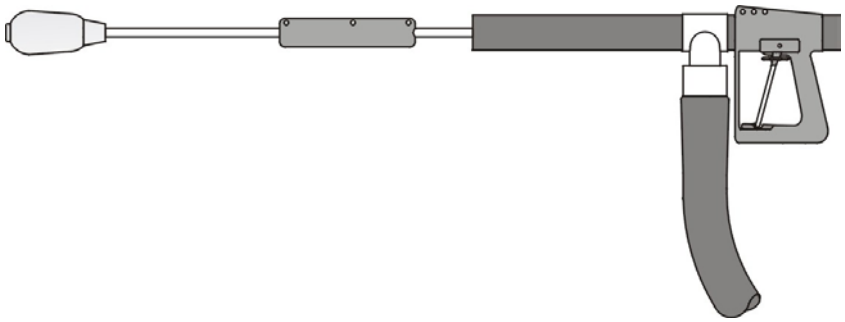


Figure 1 HP 2500-VDG dump gun, with plastic support and throttle handgrips

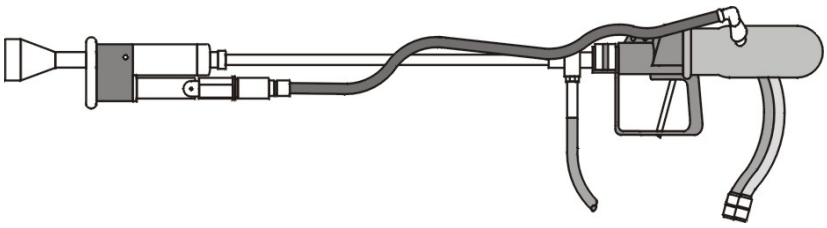


Figure 2 Air driven rotary gun, with plastic throttle handgrip

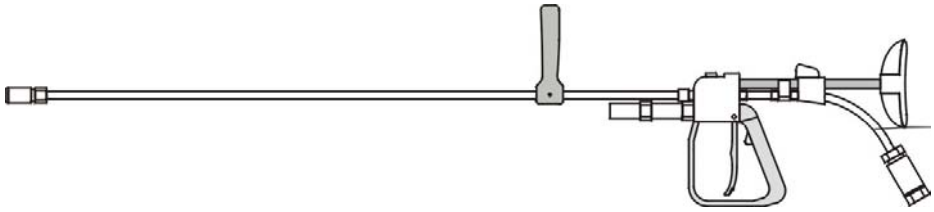


Figure 3 HGLT dump gun, all steel/aluminium construction

Table 2 Site A equipment

Ref	Gun	Nozzle	No. of jets	Rotation	Water pressure @ flow rate
A1	HP 2500-VDG dump gun	2500 bar orbital jet	1 oscillating	YES	2540 - 2570 bar @ 11.2 litres/min
A2	HP 2500-VDG dump gun	Straight jet	1	NO	2200 bar @ 11 litres/min
A3	Air driven rotary gun	Fixed nozzle	6	YES	2000 bar @ 20 litres/min
A4	HGLT dump gun	Straight jet	1	NO	2200 bar @ 11 litres/min
A5	HGLT dump gun	2500 bar orbital jet	1 oscillating	YES	2200 bar @ 11 litres/min

2.3 SITE B EQUIPMENT

The jetting guns used at Site B for the measurements are shown in Figures 4 and 5. The equipment configurations for the measurements are given in Table 3. The workpiece was a 20 mm thick rusty metal plate, lying on the ground.

Figure 4 Pneumatically powered rotary gun,
all steel/aluminium construction, driven by belt drive air motor

Figure 5 UHP dump gun, with plastic support and throttle handgrips

Table 3 Site B equipment

Ref	Jetting gun	Nozzle	No. of jets	Rotation	Water pressure @ flow rate
B1	Air driven rotary	Fixed nozzle	5	YES	2200 - 2500 bar @ 20 litres/min
B2	UHP dump gun	Rotary 2500 bar surface prep	3	YES	2200 bar @ 20 litres/min
B3	UHP dump gun	2500 bar orbital jet	1 oscillating	YES	2200 bar @ 20 litres/min
B4	UHP dump gun	Straight jet	1	NO	2200 bar @ 20 litres/min

3 MEASUREMENT PROCEDURES

3.1 WATER JETTING OPERATION

For each equipment configuration, noise and vibration measurements were made while the water jet was directed downwards but not at the workpiece, to represent "free air" operation, as shown in Figure 6. The jet angle and length tended to vary between operators.

Figure 6 Free air water jetting at Site B

Noise and vibration measurements were then made while the water jet was directed at close proximity to a workpiece to simulate a realistic task, as shown in Figure 7.

Figure 7 Water jetting towards workpiece at Site B

The operators were experienced and trained to use high pressure water jetting equipment. Where time allowed, measurements were repeated for three operators using the same equipment configuration.

Noise measurements were also made of the jetting unit in the absence of water jetting noise. One measurement was made just before jetting when the jetting unit was operating at less than full load and a second measurement was made with a test valve fitted to the water jetting gun so that the jetting unit ran at full load without emitting a water jet.

3.2 HAND-ARM VIBRATION DATA ACQUISITION AND ANALYSIS

Accelerometers were mounted on the water jetting gun at both hand locations so that they were measuring the vibration transmitted to the hands, without restricting the operator's safe use of the water jetting equipment. At each measurement location, three piezoelectric accelerometers were oriented in orthogonal axes and mounted rigidly on an aluminium block. This measurement assembly was fastened to the water jetting gun by a plastic cable tie which was tightened using a tensioning gun to provide a rigid interface between the surface of the gun and the accelerometers over the frequency range of interest. The outputs from the accelerometers were processed via charge amplifiers and input to a vibration analyser (Brüel & Kjær PULSE system) for real-time analysis. Appendix A shows the accelerometer mounting locations and orientation of the axes. A list of the measurement instrumentation used at both measurement sites is given in Appendix B and the configuration is shown in Appendix C.

The vibration analyser was activated a few seconds after the start of water jetting (once stable operation had been achieved) and a measurement duration of 1 minute for free air operation was captured. The operator was then signalled to start work on the workpiece. The vibration analyser was activated once the operator had achieved a stable water jetting action and de-activated after 1 minute, before the water jetting was powered down.

The measurement system was checked using a field calibrator (10 m/s² at 160 Hz vibration source) before and after all the measurements and whenever a cable or component was replaced in the measurement system.

The vibration analyser produced a one-third-octave band frequency spectrum of r.m.s. acceleration for each measurement axis. The frequency weighting, as defined by BS EN ISO 5349-1: 2001 [2], was applied to each spectrum to give the hand-arm weighted acceleration value for each measurement axis.

The accelerometer outputs were also recorded on to Digital Audio Tape (DAT) as a backup measurement system in case post-analysis at HSL was required. The water jetting operation was recorded to video (which was synchronised to the DAT recorder) so that the appropriate sections of the DAT recording could be analysed. A calibration signal was also recorded on to DAT to check signal output accuracy.

3.3 NOISE DATA ACQUISITION AND ANALYSIS

Noise measurements were made to the side of the operator with a tripod mounted Brüel and Kjær (B&K) 4134 microphone and gooseneck extension, powered from a B&K 2619 preamplifier and 2804 microphone power supply. The microphone signal was taken to measurement and recording equipment in an indoor workshop area nearby. The microphone signal was measured with a B&K 2260 sound level analyser (which stores the data from the noise measurement). A backup recording was also made using a Norsonics/Sony DAT recording system. The sensitivity of this measurement and recording equipment was checked with a B&K 4231 sound calibrator providing a 1 kHz tone of 94 dB, at the beginning and end of the measurements and periodically throughout the day.

Noise measurements were also made with a CEL 460 personal noise dosemeter worn by the operator. This recorded two five second internal time histories of the noise: the first history was a record of the A-weighted L_{eq} (the average level) in each interval; the second was a record of the C-weighted maximum peak sound pressure during each interval. The dosemeter microphone was fitted to the ear muff headband worn over the hood of the operator's protective clothing. The dosemeter was calibrated at the start of the measurements using the associated CEL 282 sound calibrator providing a nominal 1 kHz tone of 114 dB and the calibration was rechecked at the end of the day's measurements.

Measurements with a noise dosemeter are generally regarded as less precise than those from a remote meter or microphone because the dosemeter microphone is in the disturbed sound field created by the presence of the operator's body. In this case, the dosemeter had the advantage of providing a fixed measurement position relative to the operator. The measurements from the tripod mounted microphone were sensitive to variations in the position of the operator.

A full list of the noise measurement instrumentation is given in Appendix D.

4 MEASUREMENT RESULTS

4.1 HAND-ARM VIBRATION

The detailed HAV measurement results for Sites A and B are presented in Appendices E and F respectively. Summaries of the results are presented in Tables 4 and 5.

Table 4 Site A HAV summary of results

Ref	Jet action	Total weighted acceleration (m/s²) mean ± 1 standard deviation		Time to reach 2.5 m/s² A(8) exposure (hours)
		Support	Throttle	
A1	Free air	4.34 ± 0.57	2.67 ± 0.13	2:39
	Workpiece	4.76 ± 0.63	2.73 ± 0.12	2:12
A2	Free air	1.38 ± 0.14	1.56 ± 0.52	20:32
	Workpiece	1.28 ± 0.61	1.52 ± 0.96	21:38
A3*	Free air	1.32	0.60	28:41
	Workpiece	1.04	0.47	46:13
A4*	Free air	1.25	0.86	32:00
	Workpiece	1.07	0.61	43:40
A5*	Free air	3.33	1.35	4:30
	Workpiece	3.20 (overloads)	1.41	4:52
* One operator only.				

Table 5 Site B HAV summary of results

Ref	Jet action	Total weighted acceleration (m/s²) mean ± 1 standard deviation		Time to reach 2.5 m/s² A(8) exposure (hours)
		Support	Throttle	
B1	Free air	2.85 ± 0.64	1.56 ± 0.18	6:08
	Workpiece	2.80 ± 0.34	1.77 ± 0.28	6:22
B2	Free air	4.07 ± 0.72	2.63 ± 0.07	3:01
	Workpiece	4.19 ± 0.98	3.91 ± 1.08	2:51
B3	Free air	6.05 ± 0.28	4.09 ± 0.48	1:22
	Workpiece	5.85 ± 1.04	4.29 ± 0.14	1:27
B4*	Free air	1.79	2.01	12:22
	Workpiece	1.27	2.13	11:03
* One operator only.				

4.2 NOISE

The detailed noise measurement results for Sites A and B are presented in Appendices G and H respectively. Each measurement is contained within the steady operating period and does not include the initial start up, transition from free air to the workpiece, or powering down of the water jet.

The measurement parameters are:

- L_{Aeq} (the A-weighted average level)
- L_{Ceq}-L_{Aeq} (the difference between the C and A-weighted L_{eq})
- Maximum C-weighted peak pressure
- Unweighted L_{eq} in third octave bands (referenced with the sound level analyser file number)

The measurement parameters obtained from the dosemeter worn by the operator are:

- Overall L_{Aeq} (logarithmic average of the sample L_{eq} values during steady operation)
- Range of the component five second L_{eq} values
- Maximum C-weighted peak pressure

The A-weighted L_{eq} and the C-weighted peak are used to assess operator exposure relative to the action levels given in current legislation (Noise at Work Regulations 1989 [3]) and action and limit values in proposed legislation (Control of Noise at Work Regulations 2005 [4]). The C and A-weighted L_{eq} difference and the frequency analysis can be used to estimate the effectiveness of hearing protection from the manufacturer's performance data.

Dosemeter results are not available for all combinations of gun and nozzle. The upper limit of the dosemeter operation is 143 dB peak and in some cases the unweighted sound pressure level exceeded this and caused an overload.

Extracts of the results are presented in Tables 6 and 7.

Table 6 Site A - highest measured levels

Ref	Jet action	Tripod microphone	Dosemeter	
		L_{eq} dB(A)	Max peak dB(C)	L_{eq} dB(A)
A1	Free air	107.5	121.5	-
	Workpiece	110.0	125.0	108.0
A2	Free air	114.5	128.0	114.5
	Workpiece	106.5	124.0	115.0
A3*	Free air	108.0	121.5	-
	Workpiece	101.5	116.0	108.5
A4*	Free air	114.0	128.0	114.5
	Workpiece	111.5	129.5	115.0
A5*	Free air	104.5	123.5	108.5
	Workpiece	95.5	113.5	95.0
* One operator only.				

Table 7 Site B - highest measured levels

Ref	Jet action	Tripod microphone	Dosemeter	
		L_{eq} dB(A)	Max peak dB(C)	L_{eq} dB(A)
B1	Free air	121.0	136.0	120.0
	Workpiece	108.5	129.0	111.5
B2	Free air	124.5	-	-
	Workpiece	113.5	131.0	113.5
B3	Free air	127.5	141.5	-
	Workpiece	112.5	134.5	114.5
B4*	Free air	123.5	-	-
	Workpiece	110.5	129.5	113.0
* One operator only.				

5 DISCUSSION

5.1 HAND-ARM VIBRATION

Under the proposed Control of Vibration at Work Regulations [3] due in 2005, an employer is required to conduct a vibration exposure risk assessment. If the risk assessment indicates that the daily exposure (normalised to an 8-hour reference period) exceeds 2.5 m/s², then the employer has a duty to reduce exposure to a minimum by establishing and implementing a programme of organisational and technical measures appropriate to the activity and consistent with the risk assessment. The time taken to reach the daily exposure action value of 2.5 m/s² A(8), has been calculated for each equipment configuration and is presented in Tables 4 and 5.

Apart from A3 (which only had one operator measurement), all the water jetting guns with orbital and rotating jets would need to be limited to less than 8 hours use a day to avoid exceeding the exposure action value. The time restrictions range from 6 hours 22 minutes to 1 hour 22 minutes depending on the equipment configuration. In general, the orbital jets caused the highest vibration, restricting use to as little as 1 hour 22 minutes a day. The measurements from the three water jetting guns with single straight jets indicate that 8 hours use a day will not exceed the exposure action value. This result is expected since the orbital and rotating water jets are changing orientation at high speed, whereas the single straight jet is stationary.

The Control of Vibration at Work Regulations will also impose a daily exposure limit value of 5 m/s² A(8). If exceeded, the employer is required to take immediate action to reduce exposure to below the limit value, identify the reason for the limit being exceeded and amend the organisational and technical measures to prevent it being exceeded again. The results for equipment B3 indicate that there is a risk of exceeding the daily exposure limit value if the equipment is used for more than 5 hours per day.

In general, the support hand grip position has greater vibration than the throttle. This seems logical as the support hand is closer to the nozzle and is either directly on the shaft of the water jetting gun or on a handle around the shaft.

The measurement results show that vibration during free air operation was similar or slightly higher than when water jetting towards a workpiece. Therefore, a vibration exposure assessment needs to include water jetting time before and after the "real work" towards a workpiece.

The frequency spectra for all the measurements are given in Appendices E and F. Figures 8 and 9 compare the frequency spectra (for the highest axis of vibration) from the orbital jet and the straight jet nozzles mounted on the same water jetting gun. It can be seen that the orbital jet causes a peak in vibration around 125 Hz which is not apparent from the straight jet. This peak is presumably a result of the oscillating jet.

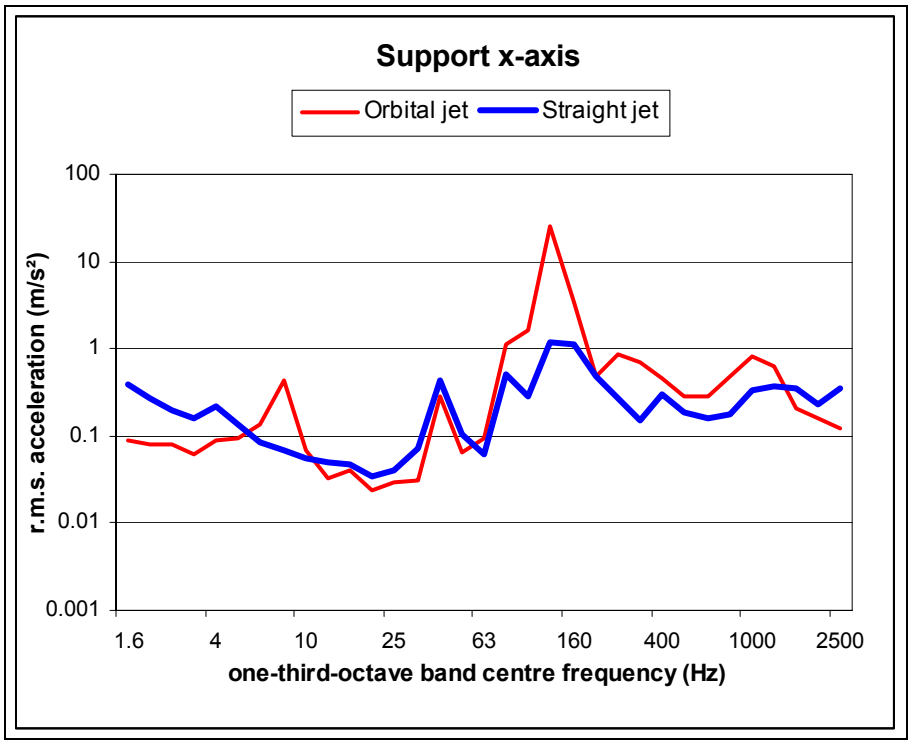


Figure 8 Equipment A1 compared to A2

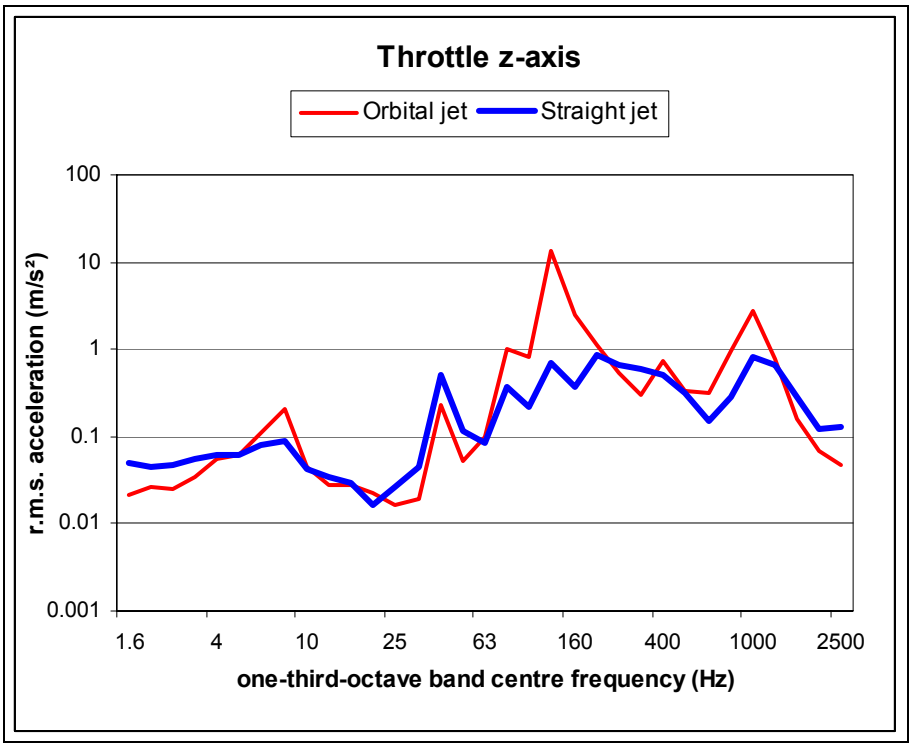


Figure 9 Equipment A1 compared to A2

5.2 NOISE

5.2.1 Noise levels at operator's ear

From examining the results from both sites, it can be seen that during free-air operation, the water jetting produced an L_{Aeq} that varied from 104.5 to in excess of 125 dB(A) at the operator's ear. These levels are very high and adequate control and protection measures are essential to avoid operator hearing damage. The noise levels varied because each operator directed the jet differently, some directing the jet across the full length of the working area, some directing it forward and down producing a much shorter jet. The highest levels were recorded when a long jet was directed across the area.

When the jet was directed towards the workpiece, the sound pressure level by the operator's head was between 95 to 115 dB(A), with the lowest levels occurring when the jet worked close to the workpiece.

5.2.2 Minimising operator noise exposure

There is a requirement under current and proposed legislation for the noise exposure to be reduced as far as is reasonably practicable by means other than the use of hearing protection.

The noise emission is highly dependent on the distance travelled by the jet; shorter jets from close working are a smaller noise source giving a lower noise level. Keeping the water-jetting gun close to the workpiece and the jet short, is clearly an effective way of reducing the noise exposure of the operator.

Due to the varying jet lengths between operators, it is impossible to say which gun and nozzle combination was the quietest. During free air operation, equipment A5 with the orbital jet was the quietest combination but equipment B3 with the same orbital jet was the noisiest.

The duration of any jetting operation should be kept to a minimum. Hearing protection alone may not give adequate protection unless the daily exposure time of the operator is limited.

5.2.3 Jetting unit noise

At both sites, the jetting units were trailer-mounted enclosures which house the high pressure pump and diesel engine. All doors on the jetting units were closed during the measurements. It can be seen from the Figures in Appendices G and H that the jetting unit is a significant noise component between 80 and 125 Hz. At higher frequencies the noise of the water jet dominates. There is a further peak in jetting unit noise around 1.25 kHz but this is less significant than the water jet noise at this frequency range. Therefore, the jetting unit noise alone is not a major contributor to the overall A-weighted L_{eq} (which allows for the fact that the human ear is less sensitive to low frequencies). The jetting unit noise at the operator's position is generally in the region of 70 to 80 dB(A), whereas the L_{Aeq} for water jetting with jetting unit noise is much higher.

5.2.4 Hearing protection

The current Noise at Work Regulations [4] sets action levels based on the daily total personal exposure to noise (normalised to an 8-hour day). The first action level is a daily personal noise exposure ($L_{EP,d}$) of 85 dB(A). The second action level is a daily personal noise exposure ($L_{EP,d}$) of 90 dB(A). An operator's noise exposure exceeding the first action level means that hearing protection must be provided; above the second action level, the hearing protection must be worn. The results presented in Tables 6 and 7 indicate that both these action levels are exceeded within a few minutes for the water jetting operator. For example, a noise level of 115 dB(A) means that the first action level would be exceeded after a daily exposure of just 30 seconds, and the second action level after 90 seconds.

Under the proposed Control of Noise at Work Regulations [5] due in 2006, the action levels will be replaced by lower and upper exposure action values and an exposure limit value. The lower action value will be a daily personal noise exposure ($L_{EP,d}$) of 80 dB(A), requiring the employer to provide information and training to employees and their representatives and make hearing protection available. The upper action value will be a daily personal noise exposure ($L_{EP,d}$) of 85 dB(A), requiring the employer to introduce a programme of risk control measures and ensure that hearing protection is worn. The daily personal noise exposure for comparison with the exposure action values takes no account of any hearing protection worn. The exposure limit value will be a daily personal noise exposure ($L_{EP,d}$) of 87 dB(A), requiring the employer not to expose anyone above this limit. Where, exceptionally, an employee's exposure has, despite the programme of controls, exceeded the exposure limit value, the employer must take immediate action to reduce exposure below the exposure limit value and prevent it being exceeded in the future. Unlike the exposure action values, the daily personal noise exposure for comparison with the exposure limit value takes account of the attenuation provided by hearing protection. The results presented in Tables 6 and 7 indicate that the upper exposure action value is exceeded within a few minutes for the water jetting operator. Also, there is a likelihood of exceeding the exposure limit value within 45 minutes (despite taking hearing protection into account).

The measurements also show there is a risk of peak sound levels exceeding 140 dB(C). Under the current Noise at Work Regulations, hearing protection must be worn where there is risk of exposure to this level, however short the duration. Under the proposed Control of Noise at Work Regulations, hearing protection will be mandatory at a peak level of 137 dB(C).

Hearing protectors should be chosen to give maximum protection. The operators at Site A used heavy duty helmet mounted muffs. Against the mid to high frequency noise, heavy duty muffs will provide around 25 to 30 dB attenuation. The operators at Site B used foam plugs. Against the high frequency noise, foam plugs are capable of providing similar attenuation if properly fitted. In practice, plugs are often not properly fitted and may provide less than 5 dB attenuation. Each operator should have expert help to ensure the plugs they use are suitable for their ears, and receive one-to-one training in fitting. The muffs worn over the hood of the operator's protective suit are unlikely to provide any significant noise reduction. Muffs must seal around the ear to be effective.

6 CONCLUSIONS

6.1 HAND-ARM VIBRATION

The orbital and multiple rotating jets cause significantly higher vibration than the single straight jet. If water jetting operators are likely to use orbital and rotating jet nozzles for longer than 1 or 2 hours (in total) within a typical working day, then there is a likelihood that they will exceed the Control of Vibration at Work Regulations exposure action value [3]. In which case, the employer has a duty to reduce exposure to a minimum by establishing and implementing a programme of organisational and technical measures appropriate to the activity.

From the limited measurements conducted, there is no indication that a similar programme of control measures would be required for water jetting with a single straight jet. However, there may be disadvantages in terms of the time taken to do a particular task with a single straight jet.

The measurement results for orbital and multiple rotating jets show quite a wide variation in the associated time restrictions, depending on the nozzle. Therefore, a single vibration magnitude representing the worst case vibration from these types of nozzles, may be an over-estimate in some cases. Consequently, the outcome of an exposure risk assessment could place unduly restrictive measures on water jetting.

6.2 NOISE

Under the current Noise at Work Regulations [4], a water jetting operator's noise exposure exceeds the second action level, requiring hearing protection to be worn. Under the proposed Control of Noise at Work Regulations [5], a water jetting operator's noise exposure will exceed the exposure limit value, in which case the employer has a duty to take action to reduce exposure to below the limit value.

Hearing protectors should be chosen to give maximum protection. This cannot be achieved unless ear plugs are properly fitted and/or ear muffs seal around each ear (they will not be effective worn over the hood of the operator's protective suit). Hearing protection alone may not give adequate protection unless the daily exposure time of the operator is limited.

The noise emission is highly dependent on the distance travelled by the jet; shorter jets from close working are a smaller noise source giving a lower noise level. Keeping the water-jetting gun close to the workpiece and the jet short, is clearly an effective way of reducing the noise exposure of the operator.

7 REFERENCES

[1] The Water Jetting Association, 17 St. Judith's Lane, Sawtry, Cambridgeshire, PE28 5XE.

[2] BS EN ISO 5349-1: 2001 Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 1. General guidelines.

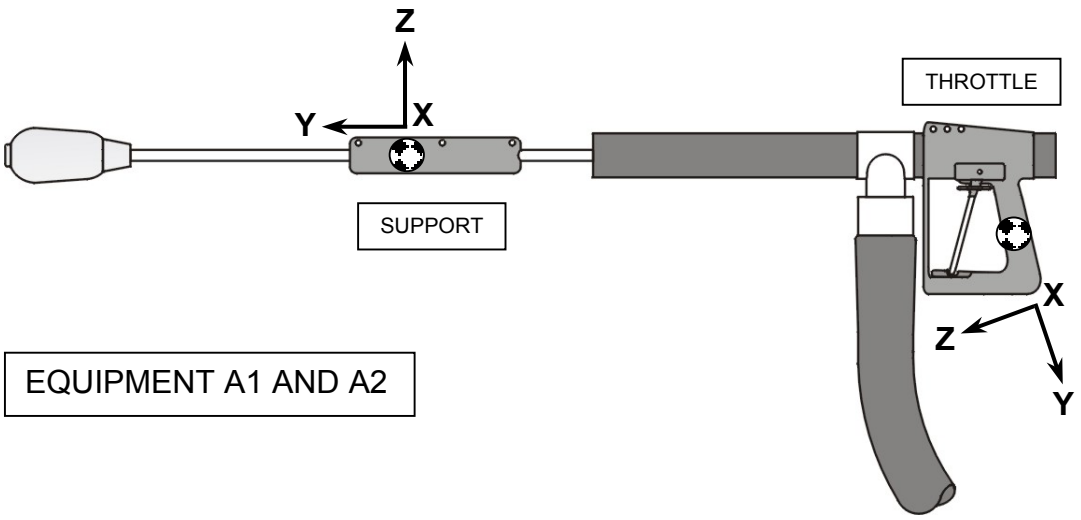
[3] Proposals for new Control of Vibration at Work Regulations implementing the Physical Agents (Vibration) Directive (2002/44/EC). HSE consultative document 2003.

[4] Noise at Work Regulations 1989. Statutory Instrument 1989/1790 amended by SI 1992/2966 and SI 1996/341; and extended by Offshore Electricity and Noise Regulations 1997 (SI 1997/1993).

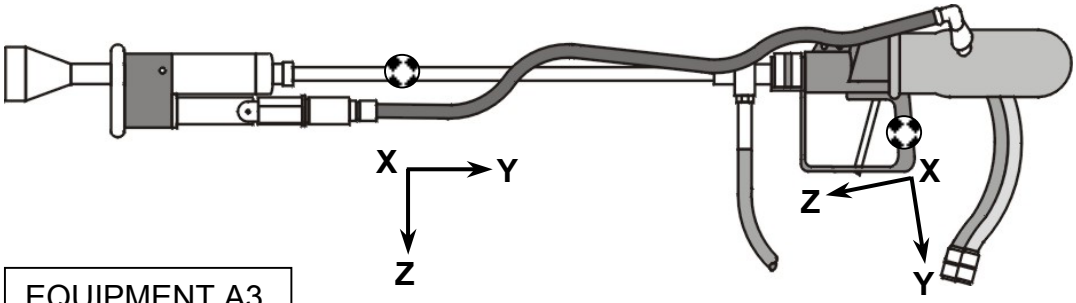
[5] Proposals for new Control of Noise at Work Regulations implementing the Physical Agents (Noise) Directive (2003/10/EC). HSE consultative document 2004.

APPENDIX A ACCELEROMETER MOUNTING AND AXES

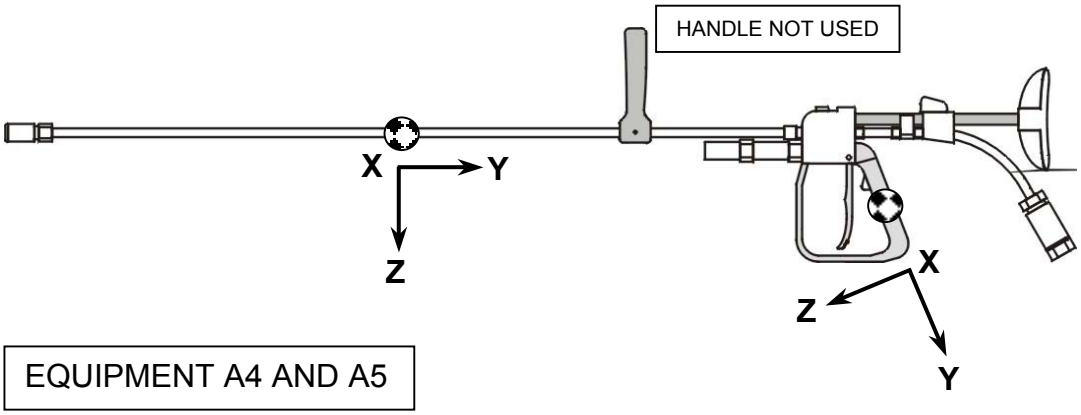
TRIAXIAL ACCELEROMETERS



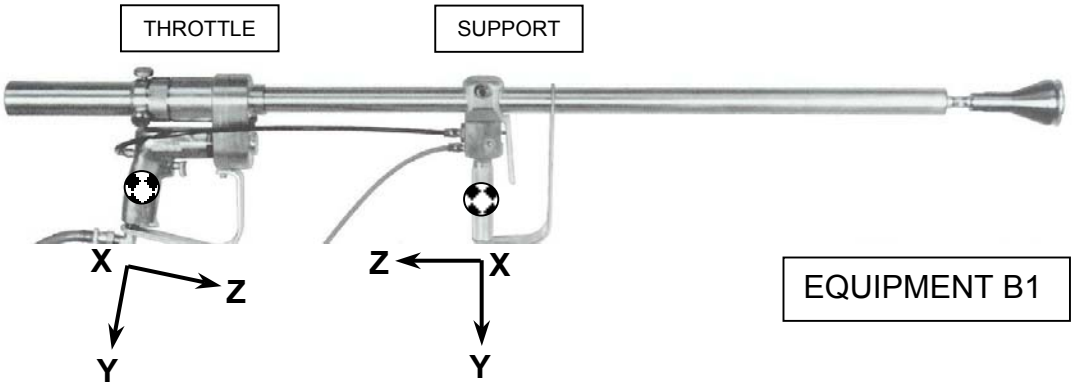
EQUIPMENT A1 AND A2



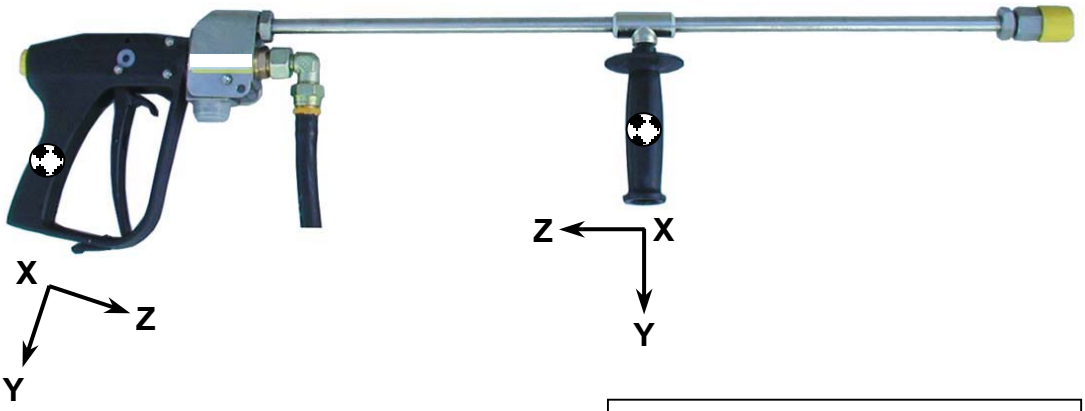
EQUIPMENT A3



EQUIPMENT A4 AND A5



EQUIPMENT B1



EQUIPMENT B2, B3 AND B4

APPENDIX B HAV MEASUREMENT INSTRUMENTATION

Instrumentation for Site A measurements

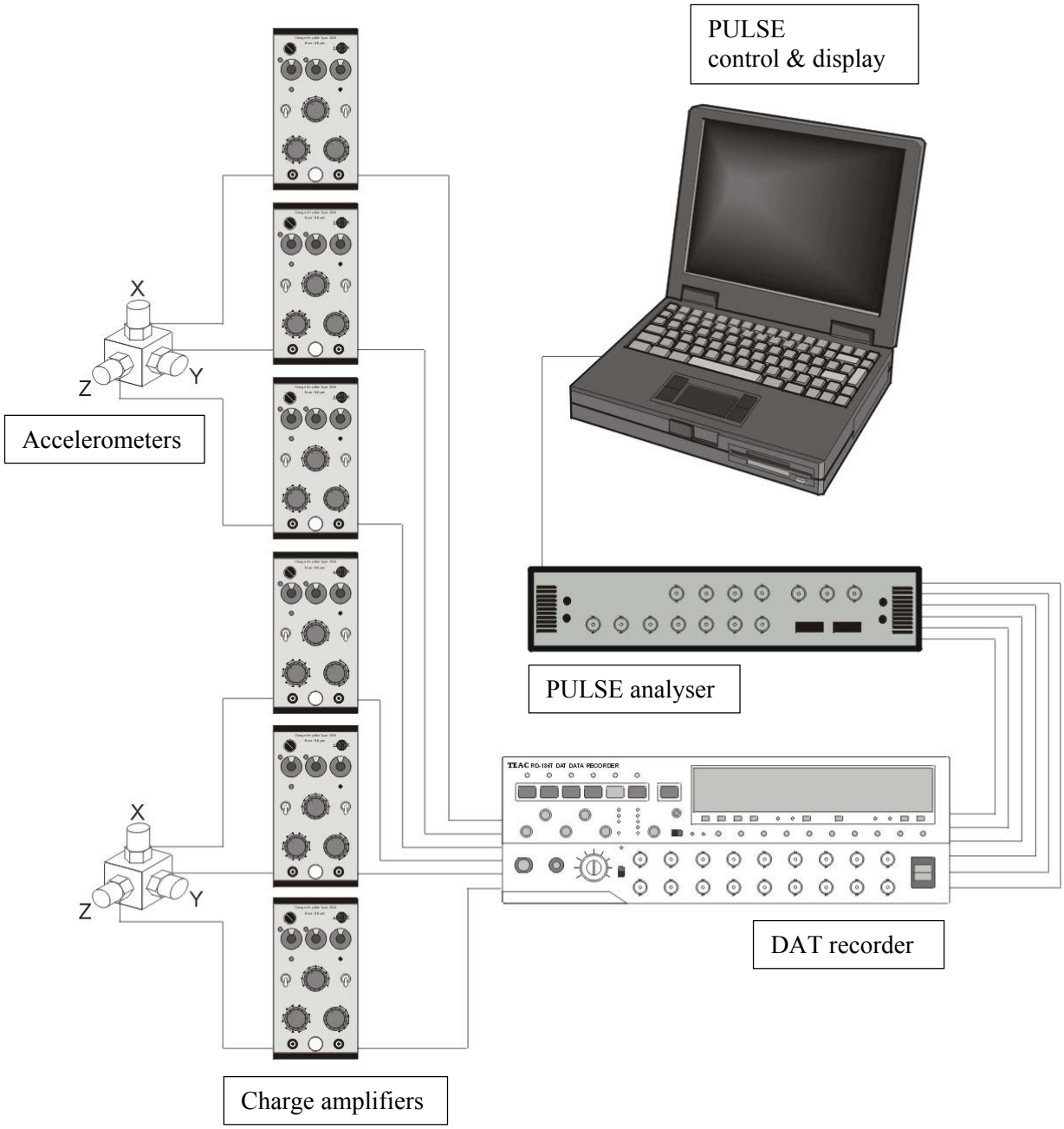
Calibrator	Brüel & Kjær 4294	
- serial number	2361765	
Accelerometer type	Brüel & Kjær 4393	
- serial numbers	Ch1 2259956	Ch4 2279750
	Ch2 11877	Ch5 10701
	Ch3 10693	Ch6 10692
Mounting block	solid aluminium 10 g with mounting screws accelerometers 10 mm above measurement surface	
Charge amplifier type	Brüel & Kjær 2635	
- serial numbers	Ch1 1709921	Ch4 1709839
	Ch2 1493484	Ch5 1493483
	Ch3 1473734	Ch6 1473733
Cabling	Brüel & Kjær microdot	
8-ch DAT recorder	TEAC RD-135T	
- serial number	730217	
Vibration analyser	Brüel & Kjær Portable PULSE	
- serial number	2324868	

Instrumentation for Site B measurements

As for Site A except:

Calibrator	Brüel & Kjær 4294
- serial number	1688502
8-ch DAT recorder	TEAC RD-135T
- serial number	723517
Vibration analyser	Brüel & Kjær Portable PULSE
- serial number	2423351

APPENDIX C HAV INSTRUMENTATION CONFIGURATION



APPENDIX D NOISE MEASUREMENT INSTRUMENTATION

Instrumentation for Site A and B measurements

Tripod mounted microphone and associated equipment:

- B&K 4134 half-inch pressure response microphone serial number 929525
- B&K gooseneck extension
- B&K 2619 microphone preamplifier serial number 702383
- B&K 2804 microphone power supply serial number 761755
- B&K 2260 precision sound level analyser serial number 2305154 fitted with unmodified JJ 2614 dummy microphone
- Sony Pro II DAT recorder with Norsonics front-end serial number 16634
- B&K 4231 sound calibrator serial number 2309005

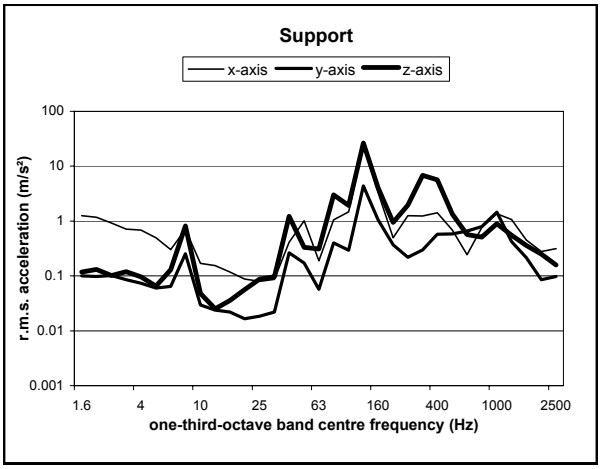
Personal dosemeter and associated equipment:

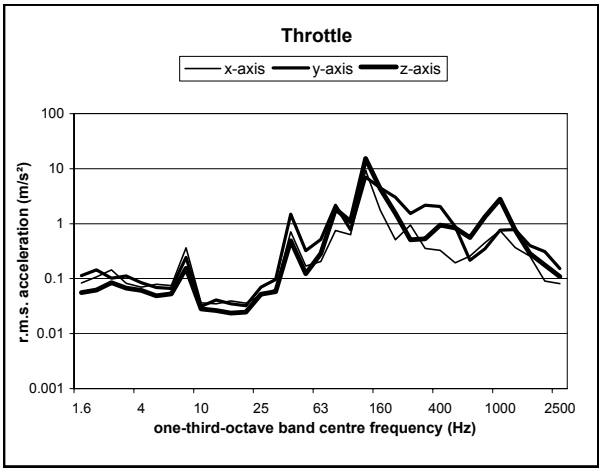
- CEL 460 logging personal noise dosemeter serial number 0691603
- CEL 282 sound calibrator serial number 3/06920800

APPENDIX E SITE A HAV MEASUREMENT RESULTS

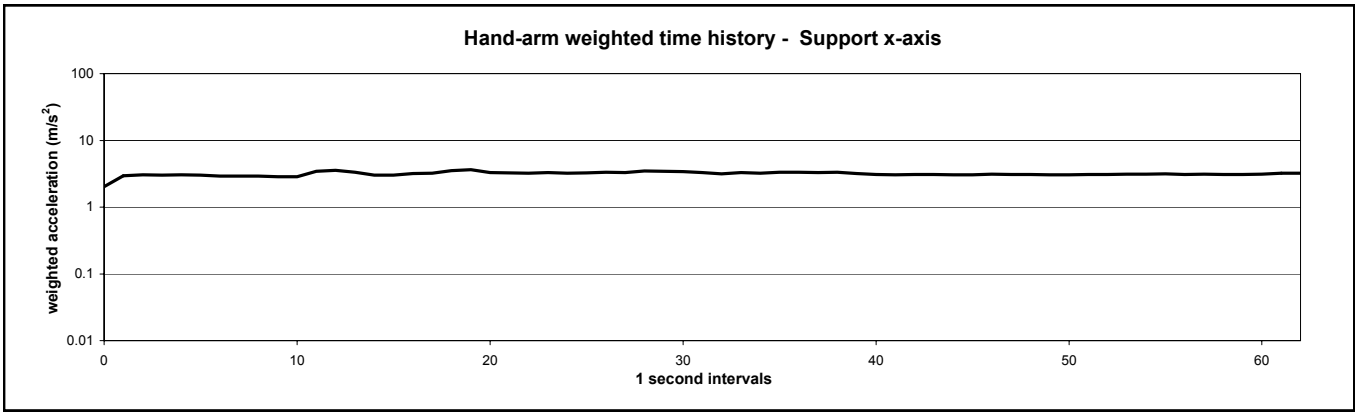
Results ID	JS2003826 200404 live tool1a op1
Equipment reference	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	1
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis	Throttle r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis
1.6	1.25 *	0.10	0.12	0.08	0.11	0.06
2	1.17	0.10	0.13	0.11	0.14	0.06
2.5	0.92	0.10	0.10	0.14	0.10	0.08
3.15	0.71	0.09	0.12	0.08	0.11	0.07
4	0.69	0.07	0.10	0.07	0.08	0.06
5	0.50	0.06	0.07	0.08	0.07	0.05
6.3	0.30	0.06	0.13	0.07	0.07	0.05
8	0.70	0.25	0.81	0.36	0.24	0.15
10	0.17	0.03	0.05	0.04	0.03	0.03
12.5	0.15	0.02	0.03	0.03	0.04	0.03
16	0.12	0.02	0.04	0.04	0.04	0.02
20	0.09	0.02	0.06	0.04	0.03	0.02
25	0.08	0.02	0.09	0.05	0.07	0.05
31.5	0.09	0.02	0.10	0.06	0.10	0.06
40	0.41	0.26	1.22	0.71	1.49	0.49
50	1.01	0.17	0.33	0.17	0.32	0.12
63	0.19	0.06	0.31	0.20	0.52	0.29
80	1.05	0.40	3.00	0.75	2.16	1.84
100	1.47	0.29	1.92	0.63	0.77	1.09
125	23.96	4.35	26.32	9.36	7.04	15.29
160	3.30	1.05	4.01	1.75	4.48	4.28
200	0.50	0.37	0.94	0.51	3.01	1.55
250	1.25	0.22	1.95	0.95	1.53	0.51
315	1.23	0.30	6.76	0.35	2.17	0.53
400	1.40	0.57	5.64	0.32	2.05	0.95
500	0.68	0.58	1.35	0.19	0.88	0.84
630	0.24	0.66	0.57	0.26	0.21	0.56
800	0.77	0.79	0.51	0.45	0.35	1.33
1000	1.36	1.45	0.89	0.75	0.76	2.81
1250	1.07	0.42	0.55	0.37	0.78	0.77
1600	0.45	0.22	0.36	0.26	0.40	0.29
2000	0.28	0.09	0.25	0.09	0.31	0.18
2500	0.31	0.10	0.16	0.08	0.15	0.11
Band limited	**24.46**	**4.89**	**28.44**	**9.72**	**9.97**	**16.41**
Band limited total (BS EN ISO 5349-1: 2001)		**37.83**			**21.52**	
Hand-arm weighted	**3.18**	**0.63**	**3.57**	**1.30**	**1.32**	**2.05**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**4.83**			**2.77**	



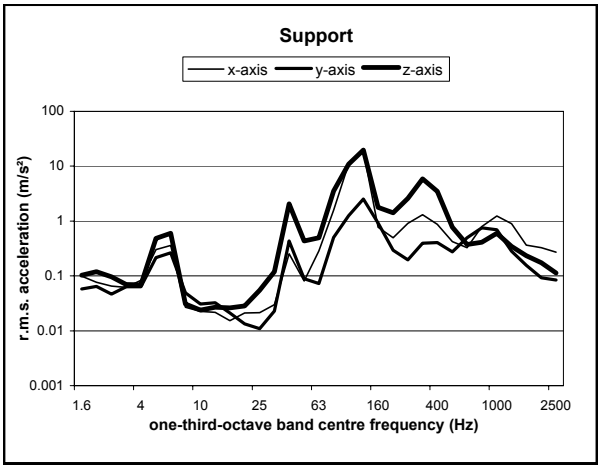


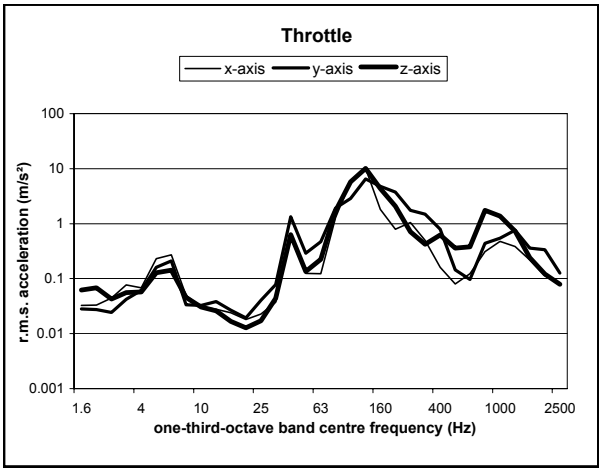
* estimated displacement > 10 mm

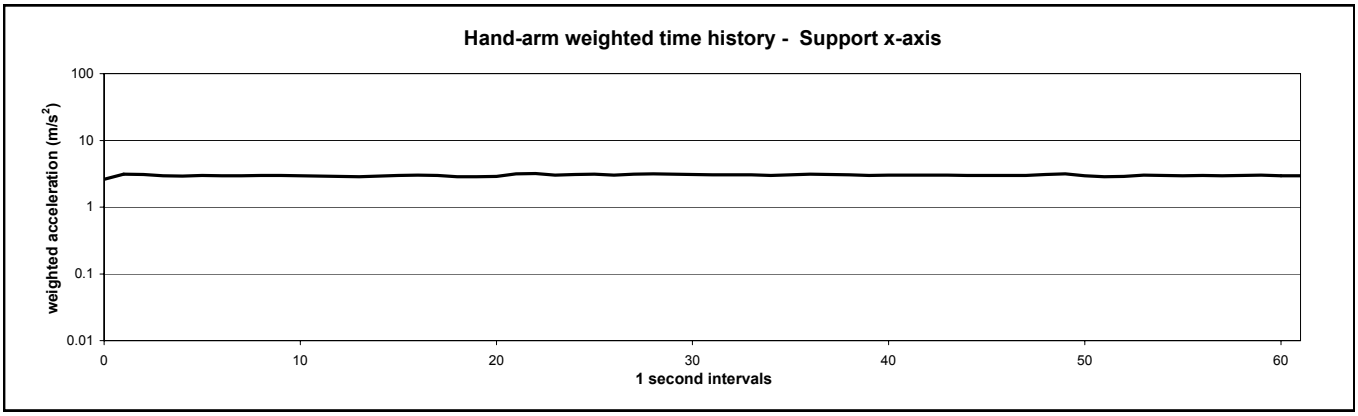


Results ID	JS2003826 200404 live tool1a op2
Equipment reference	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.10	0.06	0.10	0.03	0.03	0.06
2	0.08	0.06	0.12	0.03	0.03	0.07
2.5	0.06	0.05	0.10	0.04	0.02	0.04
3.15	0.06	0.06	0.07	0.08	0.04	0.06
4	0.08	0.06	0.07	0.07	0.06	0.06
5	0.30	0.22	0.48	0.23	0.16	0.13
6.3	0.36	0.26	0.60	0.27	0.21	0.14
8	0.03	0.05	0.03	0.05	0.03	0.05
10	0.02	0.03	0.02	0.03	0.03	0.03
12.5	0.02	0.03	0.03	0.03	0.04	0.03
16	0.02	0.02	0.03	0.02	0.03	0.02
20	0.02	0.01	0.03	0.02	0.02	0.01
25	0.02	0.01	0.05	0.02	0.04	0.02
31.5	0.03	0.02	0.12	0.04	0.08	0.04
40	0.25	0.43	2.06	0.56	1.34	0.63
50	0.08	0.09	0.43	0.12	0.29	0.13
63	0.29	0.07	0.50	0.12	0.47	0.22
80	1.57	0.50	3.54	1.29	1.93	1.69
100	11.00	1.25	10.84	5.91	2.87	5.75
125	18.84	2.52	19.68	10.10	6.54	10.09
160	0.78	0.91	1.77	1.82	4.77	4.32
200	0.50	0.29	1.41	0.79	3.73	2.09
250	0.91	0.20	2.58	1.05	1.74	0.71
315	1.31	0.40	5.88	0.50	1.48	0.42
400	0.87	0.41	3.48	0.16	0.79	0.63
500	0.42	0.27	0.77	0.08	0.15	0.36
630	0.33	0.50	0.37	0.12	0.10	0.38
800	0.80	0.75	0.41	0.31	0.44	1.75
1000	1.23	0.69	0.60	0.48	0.55	1.37
1250	0.89	0.28	0.34	0.38	0.76	0.74
1600	0.37	0.16	0.23	0.22	0.36	0.24
2000	0.33	0.09	0.17	0.11	0.33	0.12
2500	0.27	0.08	0.11	0.08	0.13	0.08
Band limited	**22.02**	**3.30**	**24.12**	**12.03**	**10.00**	**12.92**
Band limited total		**32.83**			**20.28**	
(BS EN ISO 5349-1: 2001)						
Hand-arm weighted	**3.01**	**0.49**	**3.30**	**1.66**	**1.32**	**1.71**
Hand-arm weighted total		**4.49**			**2.72**	
(BS EN ISO 5349-1: 2001)						

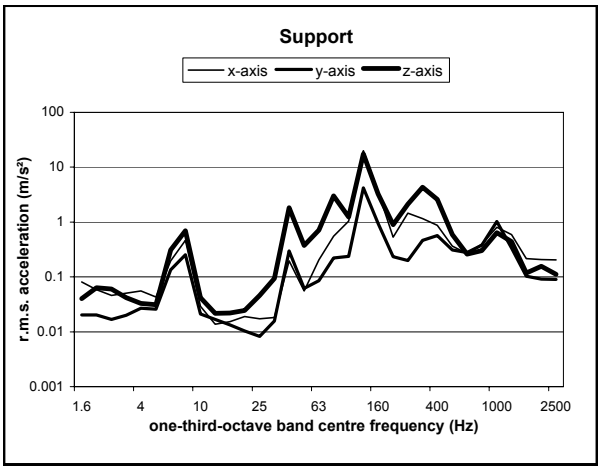


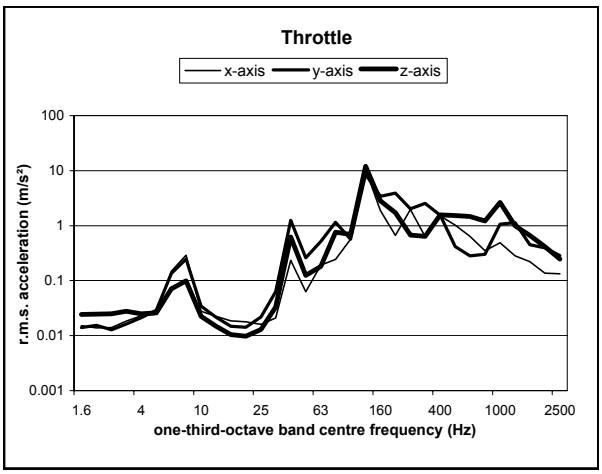


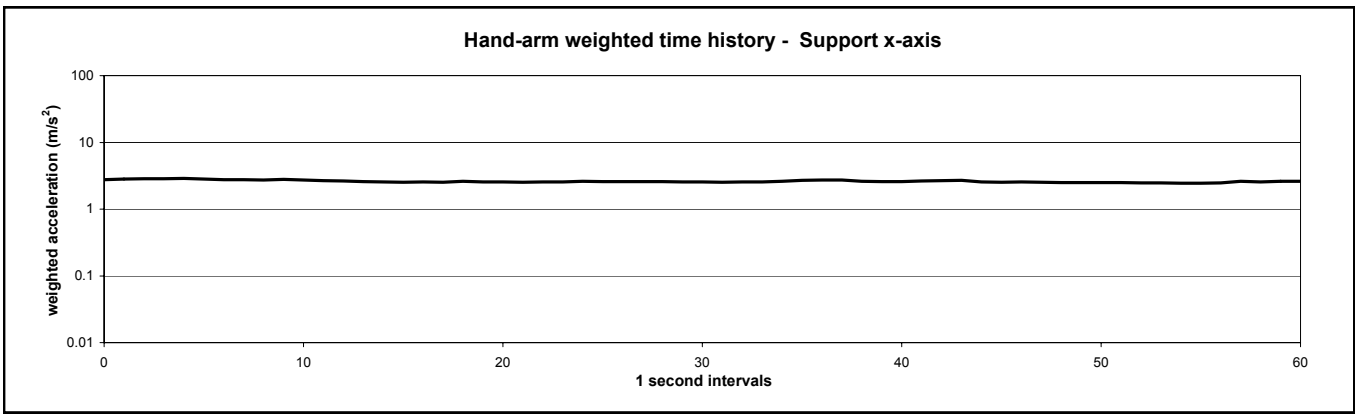


Results ID	JS2003826 200404 live tool1a op3
Equipment reference	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.08	0.02	0.04	0.02	0.01	0.02
2	0.06	0.02	0.06	0.01	0.02	0.02
2.5	0.05	0.02	0.06	0.01	0.01	0.03
3.15	0.05	0.02	0.04	0.02	0.02	0.03
4	0.06	0.03	0.03	0.02	0.02	0.02
5	0.04	0.03	0.03	0.02	0.03	0.03
6.3	0.20	0.13	0.31	0.15	0.13	0.07
8	0.46	0.25	0.69	0.29	0.25	0.10
10	0.03	0.02	0.04	0.03	0.03	0.02
12.5	0.01	0.02	0.02	0.02	0.02	0.01
16	0.02	0.01	0.02	0.02	0.01	0.01
20	0.02	0.01	0.02	0.02	0.01	0.01
25	0.02	0.01	0.05	0.02	0.02	0.01
31.5	0.02	0.02	0.09	0.02	0.06	0.03
40	0.20	0.30	1.83	0.23	1.26	0.62
50	0.06	0.06	0.37	0.06	0.26	0.12
63	0.20	0.09	0.71	0.19	0.51	0.18
80	0.55	0.22	3.00	0.24	1.16	0.76
100	1.04	0.24	1.23	0.57	0.57	0.69
125	20.03	4.20	17.46	10.59	8.64	11.99
160	3.57	0.95	3.25	1.90	3.42	2.83
200	0.53	0.23	0.90	0.67	3.92	1.73
250	1.45	0.20	2.11	1.97	2.02	0.67
315	1.16	0.46	4.32	0.63	2.55	0.64
400	0.87	0.57	2.60	1.50	1.55	1.56
500	0.36	0.31	0.59	1.02	0.42	1.53
630	0.27	0.28	0.26	0.63	0.28	1.47
800	0.40	0.38	0.30	0.35	0.30	1.21
1000	0.80	1.02	0.64	0.49	1.06	2.63
1250	0.59	0.34	0.44	0.28	1.14	0.99
1600	0.21	0.10	0.12	0.22	0.45	0.67
2000	0.21	0.09	0.16	0.14	0.40	0.41
2500	0.20	0.09	0.11	0.13	0.28	0.25
Band limited	**20.52**	**4.53**	**19.02**	**11.18**	**10.96**	**13.06**
Band limited total (BS EN ISO 5349-1: 2001)		**28.34**			**20.38**	
Hand-arm weighted	**2.62**	**0.61**	**2.56**	**1.40**	**1.37**	**1.60**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.71**			**2.53**	

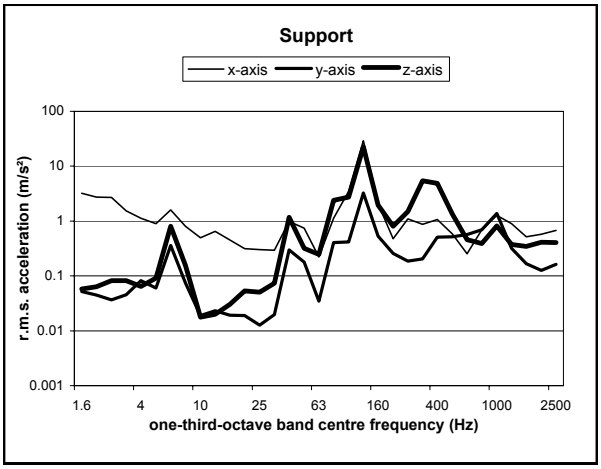


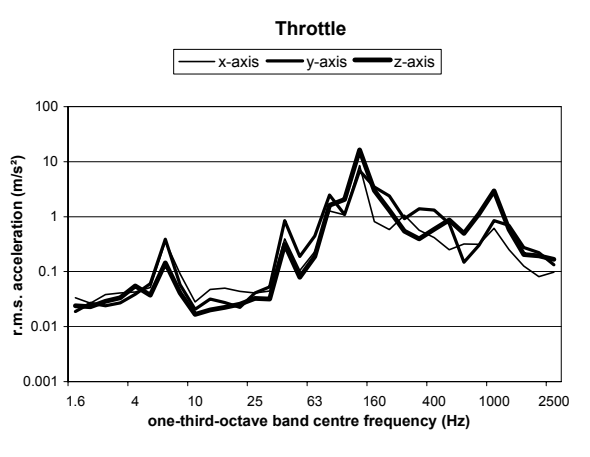




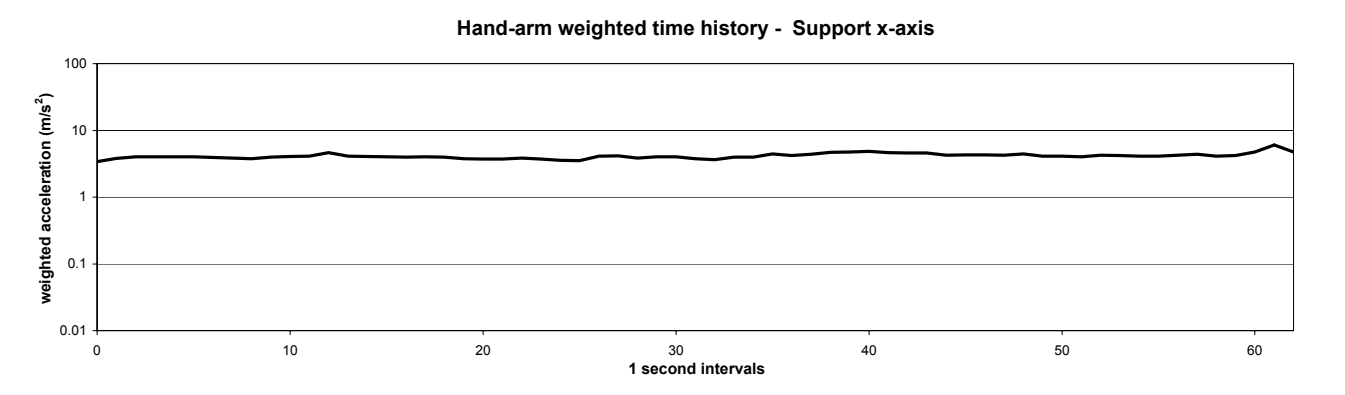
Results ID	JS2003826 200404 live tool1b op1
Field visit location	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	1
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	3.22 *	0.05	0.06	0.03	0.02	0.02
2	2.73 *	0.05	0.06	0.03	0.03	0.02
2.5	2.70 *	0.04	0.08	0.04	0.02	0.03
3.15	1.54	0.05	0.08	0.04	0.03	0.03
4	1.13	0.08	0.06	0.04	0.04	0.06
5	0.90	0.06	0.09	0.05	0.06	0.04
6.3	1.59	0.36	0.81	0.35	0.39	0.14
8	0.81	0.07	0.16	0.09	0.06	0.04
10	0.50	0.02	0.02	0.03	0.02	0.02
12.5	0.65	0.02	0.02	0.05	0.03	0.02
16	0.45	0.02	0.03	0.05	0.03	0.02
20	0.31	0.02	0.05	0.04	0.02	0.03
25	0.30	0.01	0.05	0.04	0.04	0.03
31.5	0.30	0.02	0.07	0.04	0.05	0.03
40	0.98	0.30	1.17	0.39	0.84	0.32
50	0.74	0.18	0.32	0.11	0.19	0.08
63	0.22	0.03	0.25	0.23	0.45	0.19
80	1.13	0.40	2.39	1.27	2.48	1.62
100	3.49	0.42	2.75	1.07	1.10	2.06
125	29.11	3.26	22.63	8.45	6.85	16.48
160	2.07	0.53	1.96	0.82	3.48	2.97
200	0.48	0.26	0.80	0.58	2.39	1.30
250	1.09	0.19	1.49	1.06	0.92	0.55
315	0.88	0.20	5.42	0.56	1.38	0.40
400	1.07	0.51	4.86	0.42	1.33	0.59
500	0.58	0.52	1.34	0.25	0.76	0.87
630	0.25	0.57	0.46	0.32	0.15	0.50
800	0.69	0.69	0.39	0.31	0.30	1.13
1000	1.27	1.38	0.82	0.62	0.85	2.94
1250	0.89	0.32	0.38	0.25	0.69	0.58
1600	0.51	0.17	0.34	0.13	0.28	0.20
2000	0.57	0.13	0.41	0.08	0.22	0.19
2500	0.68	0.16	0.40	0.10	0.13	0.17
Band limited	**29.59**	**3.77**	**24.27**	**8.81**	**8.89**	**17.27**
Band limited total		**38.45**			**21.33**	
(BS EN ISO 5349-1: 2001)						
Hand-arm weighted	**4.13**	**0.53**	**3.08**	**1.17**	**1.20**	**2.17**
Hand-arm weighted total		**5.18**			**2.74**	
(BS EN ISO 5349-1: 2001)						



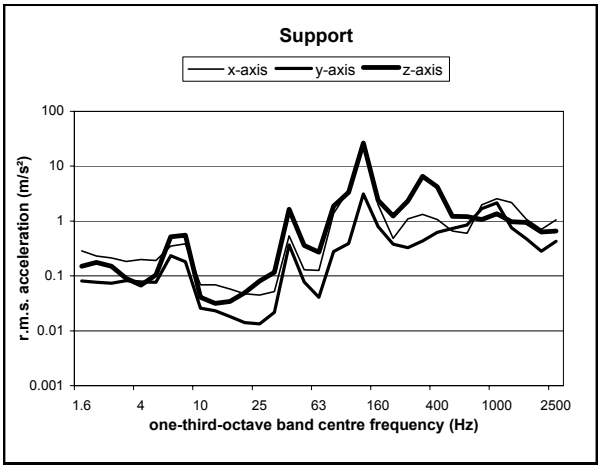


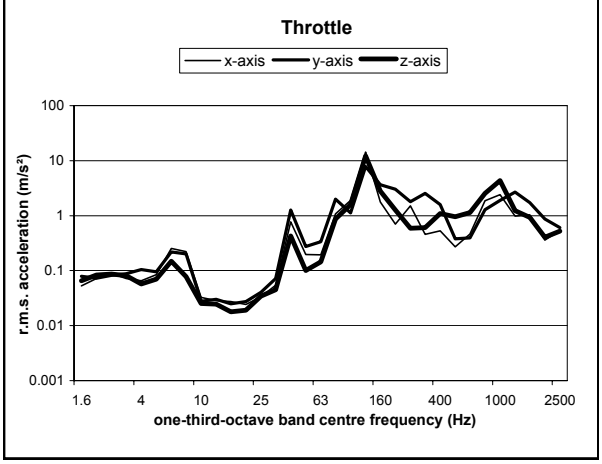
* estimated displacement > 10 mm

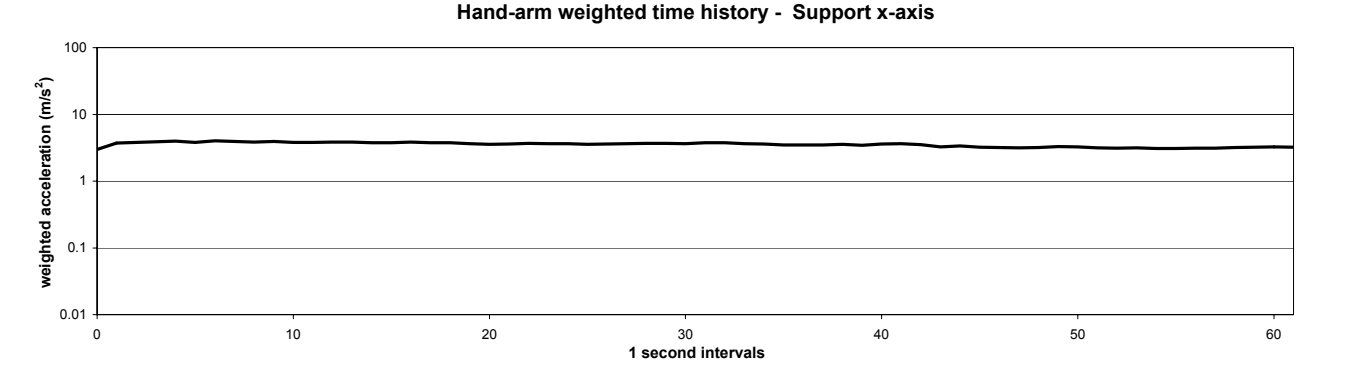


Results ID	JS2003826 200404 live tool1b op2
Equipment reference	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	2
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 30-40 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.29	0.08	0.15	0.05	0.08	0.07
2	0.23	0.08	0.18	0.07	0.07	0.08
2.5	0.21	0.07	0.15	0.09	0.08	0.09
3.15	0.18	0.08	0.09	0.07	0.09	0.08
4	0.20	0.08	0.07	0.07	0.10	0.06
5	0.19	0.08	0.10	0.09	0.10	0.07
6.3	0.35	0.23	0.51	0.25	0.22	0.15
8	0.38	0.18	0.55	0.22	0.20	0.08
10	0.07	0.03	0.04	0.03	0.03	0.03
12.5	0.07	0.02	0.03	0.03	0.03	0.02
16	0.06	0.02	0.03	0.03	0.02	0.02
20	0.05	0.01	0.05	0.02	0.03	0.02
25	0.04	0.01	0.08	0.03	0.04	0.03
31.5	0.05	0.02	0.12	0.05	0.07	0.04
40	0.53	0.37	1.65	0.77	1.27	0.43
50	0.13	0.08	0.36	0.20	0.28	0.10
63	0.13	0.04	0.27	0.19	0.34	0.14
80	1.38	0.28	1.88	1.08	1.99	0.87
100	3.69	0.39	3.34	1.89	1.12	1.58
125	27.23	3.12	26.44	14.24	7.86	12.16
160	1.98	0.79	2.38	1.76	3.67	2.80
200	0.48	0.38	1.23	0.70	3.04	1.27
250	1.09	0.33	2.33	1.51	1.78	0.59
315	1.32	0.43	6.58	0.46	2.53	0.60
400	1.07	0.62	4.19	0.53	1.59	1.09
500	0.65	0.73	1.22	0.27	0.38	0.95
630	0.60	0.85	1.21	0.46	0.39	1.14
800	1.98	1.69	1.06	1.87	1.28	2.53
1000	2.55	2.16	1.35	2.40	1.89	4.36
1250	2.19	0.76	0.97	0.98	2.67	1.23
1600	1.08	0.48	0.94	1.03	1.73	0.92
2000	0.70	0.28	0.63	0.36	0.86	0.40
2500	1.05	0.43	0.66	0.53	0.61	0.52
Band limited	**27.87**	**4.35**	**28.20**	**14.92**	**10.56**	**13.59**
Band limited total (BS EN ISO 5349-1: 2001)		**39.89**			**22.78**	
Hand-arm weighted	**3.56**	**0.51**	**3.58**	**1.91**	**1.33**	**1.62**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**5.07**			**2.84**	

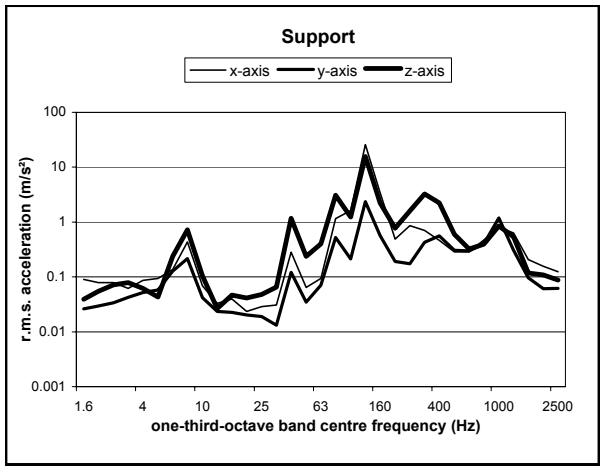


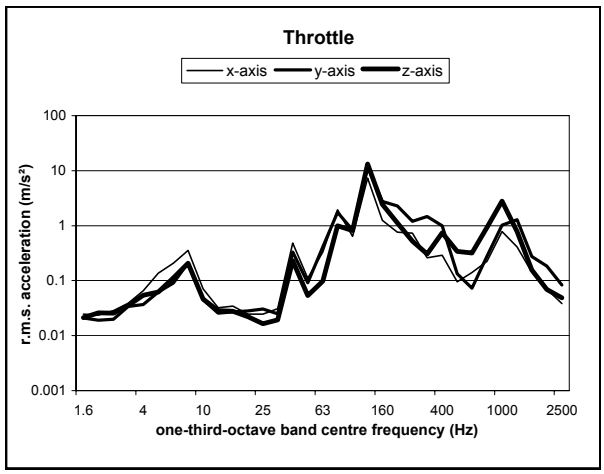


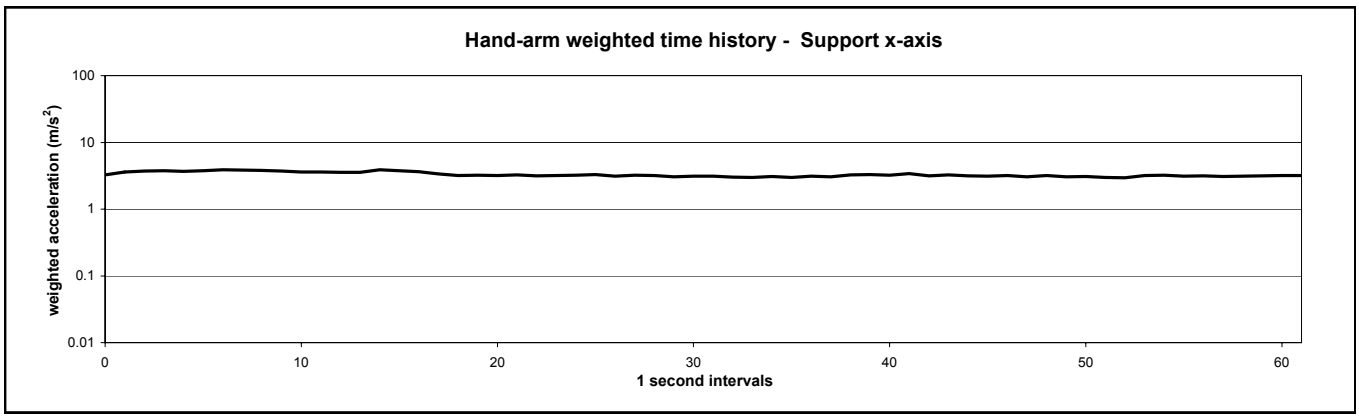


Results ID	JS2003826 200404 live tool1b op3
Equipment reference	A1
Jetting unit	Fully enclosed system producing 11 litres/min at 2540 - 2570 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	2500 bar orbital jet
Operator	3
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle less than 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.09	0.03	0.04	0.02	0.02	0.02
2	0.08	0.03	0.05	0.02	0.02	0.03
2.5	0.08	0.03	0.07	0.03	0.02	0.03
3.15	0.06	0.04	0.08	0.04	0.03	0.04
4	0.09	0.05	0.06	0.07	0.04	0.05
5	0.09	0.06	0.04	0.14	0.06	0.06
6.3	0.14	0.13	0.24	0.21	0.09	0.11
8	0.44	0.21	0.72	0.35	0.21	0.21
10	0.07	0.04	0.10	0.07	0.05	0.05
12.5	0.03	0.02	0.03	0.03	0.03	0.03
16	0.04	0.02	0.05	0.03	0.03	0.03
20	0.02	0.02	0.04	0.02	0.03	0.02
25	0.03	0.02	0.05	0.02	0.03	0.02
31.5	0.03	0.01	0.06	0.03	0.03	0.02
40	0.28	0.12	1.17	0.48	0.33	0.23
50	0.06	0.03	0.24	0.11	0.09	0.05
63	0.09	0.07	0.40	0.33	0.41	0.10
80	1.15	0.52	3.07	1.94	1.74	0.99
100	1.63	0.21	1.24	0.64	0.83	0.81
125	25.60	2.35	15.67	7.30	11.67	13.19
160	3.43	0.57	2.24	1.26	2.74	2.45
200	0.49	0.19	0.77	0.76	2.27	1.12
250	0.86	0.17	1.60	0.73	1.20	0.52
315	0.71	0.43	3.26	0.26	1.46	0.31
400	0.47	0.56	2.23	0.29	1.00	0.74
500	0.29	0.31	0.60	0.10	0.13	0.34
630	0.29	0.30	0.32	0.14	0.07	0.32
800	0.47	0.40	0.39	0.22	0.28	0.93
1000	0.81	1.19	0.85	0.78	1.03	2.77
1250	0.63	0.31	0.54	0.41	1.28	0.78
1600	0.21	0.10	0.12	0.14	0.28	0.16
2000	0.16	0.06	0.11	0.07	0.18	0.07
2500	0.12	0.06	0.09	0.04	0.08	0.05
Band limited	**25.96**	**2.86**	**16.83**	**7.84**	**12.61**	**13.81**
Band limited total (BS EN ISO 5349-1: 2001)		**31.07**			**20.28**	
Hand-arm weighted	**3.31**	**0.40**	**2.27**	**1.11**	**1.59**	**1.73**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**4.04**			**2.60**	

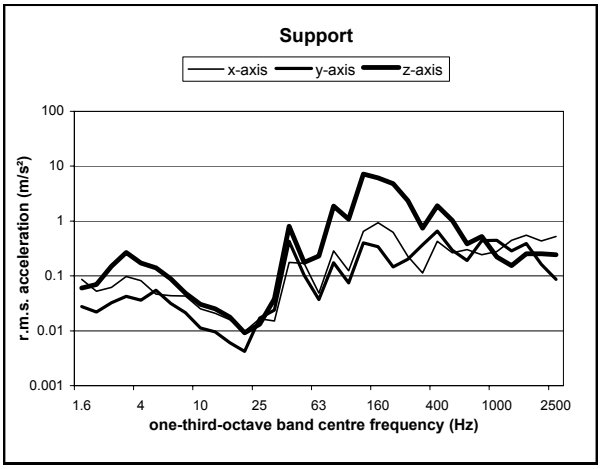


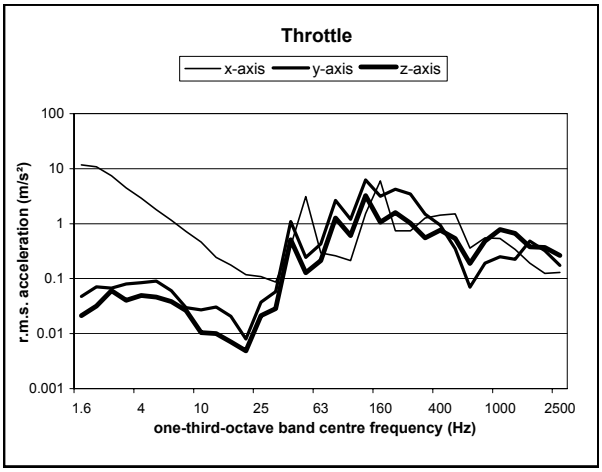




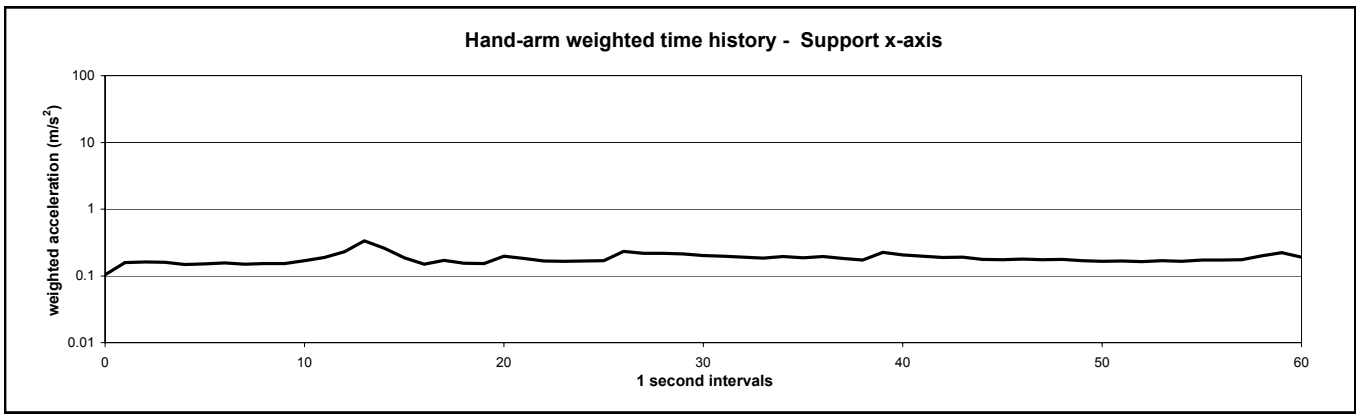
Results ID	JS2003826 200404 live tool2a op1
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	1
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.09	0.03	0.06	11.74 *	0.05	0.02
2	0.05	0.02	0.07	10.75 *	0.07	0.03
2.5	0.06	0.03	0.15	7.42 *	0.07	0.06
3.15	0.10	0.04	0.27	4.47 *	0.08	0.04
4	0.08	0.04	0.17	2.90	0.08	0.05
5	0.05	0.05	0.14	1.80	0.09	0.05
6.3	0.04	0.03	0.09	1.16	0.06	0.04
8	0.04	0.02	0.05	0.72	0.03	0.03
10	0.03	0.01	0.03	0.47	0.03	0.01
12.5	0.02	0.01	0.03	0.24	0.03	0.01
16	0.02	0.01	0.02	0.18	0.02	0.01
20	0.01	0.00	0.01	0.12	0.01	0.00
25	0.02	0.02	0.01	0.11	0.04	0.02
31.5	0.02	0.02	0.04	0.09	0.06	0.03
40	0.18	0.43	0.80	0.40	1.09	0.51
50	0.17	0.10	0.18	3.11	0.24	0.13
63	0.05	0.04	0.23	0.29	0.43	0.21
80	0.29	0.17	1.87	0.26	2.65	1.27
100	0.12	0.07	1.09	0.21	1.20	0.60
125	0.65	0.40	7.15	1.52	6.24	3.24
160	0.94	0.34	6.12	6.01	3.16	1.06
200	0.62	0.15	4.80	0.75	4.22	1.59
250	0.23	0.20	2.36	0.74	3.48	1.02
315	0.11	0.37	0.74	1.26	1.50	0.55
400	0.43	0.66	1.89	1.43	0.94	0.76
500	0.26	0.29	1.02	1.51	0.35	0.54
630	0.30	0.19	0.39	0.36	0.07	0.19
800	0.24	0.44	0.52	0.55	0.19	0.48
1000	0.28	0.44	0.22	0.54	0.25	0.78
1250	0.45	0.29	0.15	0.34	0.23	0.66
1600	0.55	0.39	0.25	0.19	0.48	0.38
2000	0.43	0.16	0.25	0.12	0.32	0.37
2500	0.52	0.09	0.24	0.13	0.17	0.26
Band limited	**1.56**	**1.27**	**11.32**	**7.57**	**9.59**	**4.42**
Band limited total (BS EN ISO 5349-1: 2001)		**11.50**			**13.00**	
Hand-arm weighted	**0.19**	**0.20**	**1.30**	**1.69**	**1.20**	**0.57**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.32**			**2.15**	



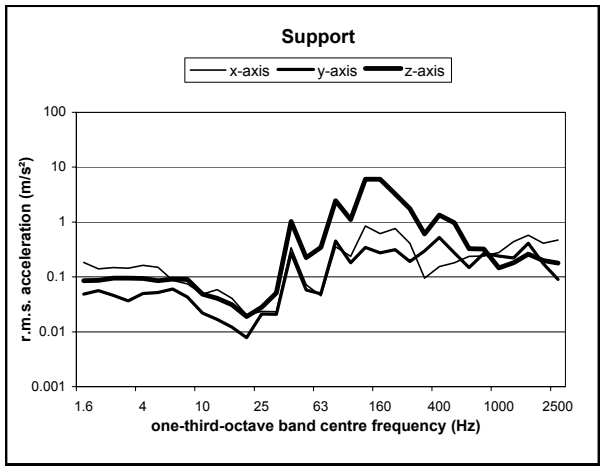


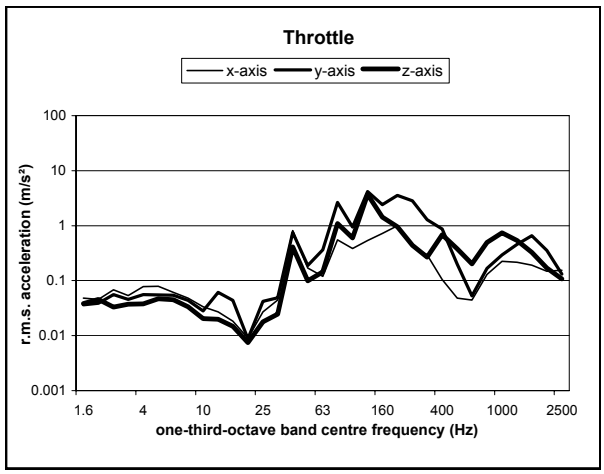
* estimated displacement > 10 mm

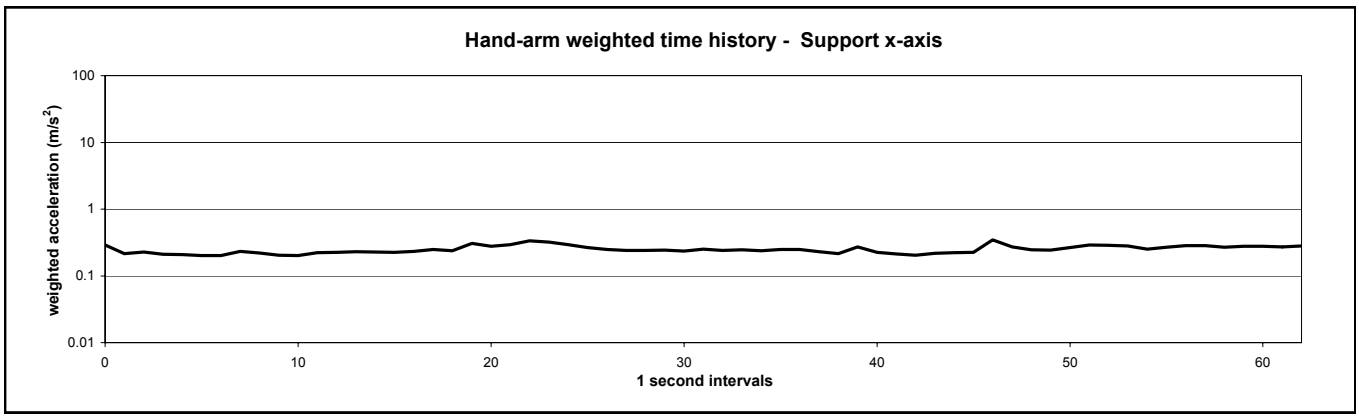


Results ID	JS2003826 200404 live tool2a op2
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2100 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.18	0.05	0.09	0.05	0.04	0.04
2	0.14	0.06	0.09	0.05	0.04	0.05
2.5	0.15	0.05	0.10	0.07	0.06	0.03
3.15	0.14	0.04	0.10	0.05	0.05	0.04
4	0.16	0.05	0.09	0.08	0.06	0.04
5	0.15	0.05	0.09	0.08	0.06	0.05
6.3	0.09	0.06	0.09	0.06	0.05	0.05
8	0.07	0.04	0.09	0.05	0.04	0.03
10	0.05	0.02	0.05	0.03	0.03	0.02
12.5	0.06	0.02	0.04	0.03	0.06	0.02
16	0.04	0.01	0.03	0.02	0.04	0.01
20	0.02	0.01	0.02	0.01	0.01	0.01
25	0.02	0.02	0.03	0.03	0.04	0.02
31.5	0.02	0.02	0.05	0.04	0.05	0.02
40	0.34	0.28	1.02	0.81	0.75	0.41
50	0.07	0.06	0.23	0.17	0.19	0.10
63	0.05	0.05	0.35	0.12	0.36	0.14
80	0.36	0.45	2.46	0.55	2.65	1.09
100	0.24	0.18	1.11	0.38	0.94	0.60
125	0.85	0.35	6.03	0.53	4.17	3.68
160	0.61	0.28	6.07	0.72	2.41	1.43
200	0.76	0.32	3.23	0.99	3.55	0.96
250	0.41	0.19	1.76	0.42	2.82	0.44
315	0.10	0.30	0.61	0.29	1.28	0.27
400	0.15	0.52	1.34	0.10	0.87	0.68
500	0.18	0.28	0.97	0.05	0.20	0.38
630	0.24	0.15	0.33	0.04	0.05	0.20
800	0.24	0.27	0.32	0.13	0.17	0.50
1000	0.28	0.24	0.15	0.23	0.29	0.74
1250	0.44	0.22	0.18	0.22	0.46	0.53
1600	0.57	0.41	0.26	0.19	0.66	0.33
2000	0.41	0.17	0.20	0.15	0.36	0.17
2500	0.47	0.09	0.18	0.15	0.13	0.11
Band limited	**1.58**	**1.11**	**9.93**	**1.82**	**7.42**	**4.46**
Band limited total (BS EN ISO 5349-1: 2001)		**10.12**			**8.84**	
Hand-arm weighted	**0.25**	**0.18**	**1.24**	**0.39**	**0.94**	**0.58**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.27**			**1.17**	

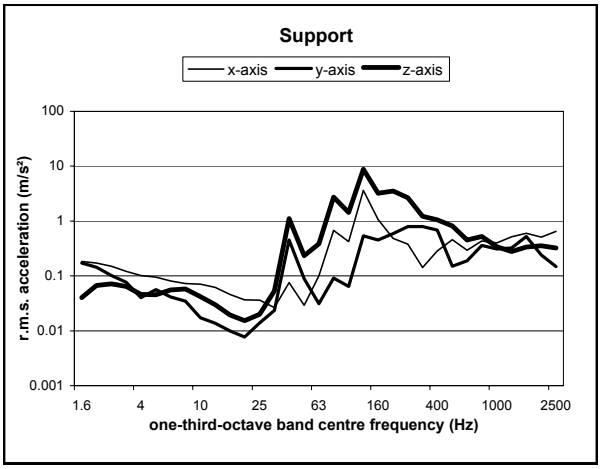


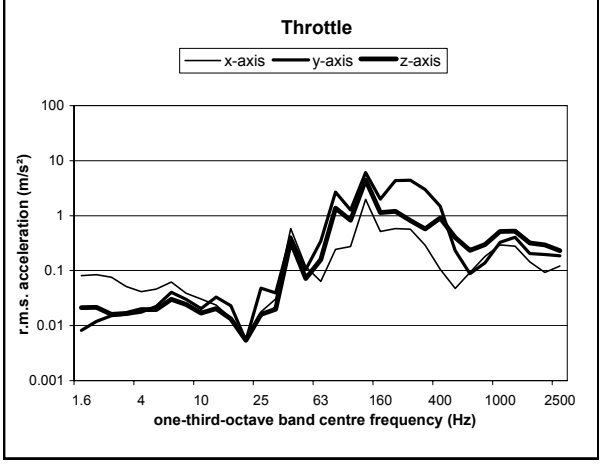


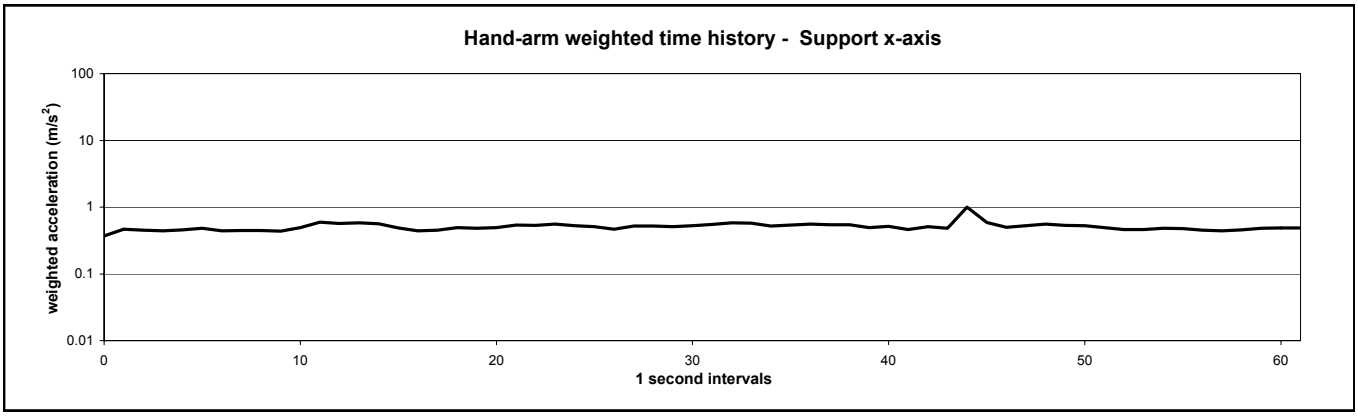


Results ID	JS2003826 200404 live tool2a op3
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.18	0.17	0.04	0.08	0.01	0.02
2	0.17	0.14	0.07	0.08	0.01	0.02
2.5	0.15	0.10	0.07	0.08	0.02	0.02
3.15	0.12	0.08	0.06	0.05	0.02	0.02
4	0.10	0.04	0.05	0.04	0.02	0.02
5	0.10	0.06	0.05	0.05	0.02	0.02
6.3	0.08	0.04	0.06	0.06	0.04	0.03
8	0.07	0.03	0.06	0.04	0.03	0.02
10	0.07	0.02	0.04	0.03	0.02	0.02
12.5	0.06	0.01	0.03	0.02	0.03	0.02
16	0.05	0.01	0.02	0.01	0.02	0.01
20	0.04	0.01	0.02	0.01	0.01	0.01
25	0.04	0.01	0.02	0.02	0.05	0.02
31.5	0.03	0.02	0.05	0.03	0.04	0.02
40	0.08	0.45	1.11	0.58	0.41	0.34
50	0.03	0.09	0.23	0.12	0.10	0.07
63	0.10	0.03	0.38	0.06	0.34	0.16
80	0.67	0.09	2.73	0.24	2.70	1.38
100	0.42	0.06	1.44	0.27	1.27	0.82
125	3.61	0.54	8.80	1.97	6.08	4.45
160	1.07	0.45	3.21	0.51	1.99	1.13
200	0.48	0.59	3.52	0.59	4.34	1.20
250	0.38	0.80	2.65	0.57	4.43	0.81
315	0.14	0.79	1.21	0.29	3.00	0.57
400	0.29	0.68	1.05	0.11	1.49	0.91
500	0.45	0.15	0.82	0.05	0.23	0.40
630	0.29	0.19	0.45	0.09	0.09	0.23
800	0.43	0.36	0.53	0.18	0.14	0.30
1000	0.40	0.31	0.34	0.29	0.33	0.52
1250	0.52	0.32	0.28	0.28	0.40	0.52
1600	0.60	0.52	0.33	0.14	0.20	0.32
2000	0.51	0.24	0.35	0.09	0.20	0.29
2500	0.64	0.15	0.32	0.12	0.19	0.23
Band limited	**4.00**	**1.75**	**11.04**	**2.35**	**9.99**	**5.26**
Band limited total		**11.87**			**11.53**	
(BS EN ISO 5349-1: 2001)						
Hand-arm weighted	**0.52**	**0.23**	**1.43**	**0.37**	**1.11**	**0.68**
Hand-arm weighted total		**1.54**			**1.36**	
(BS EN ISO 5349-1: 2001)						

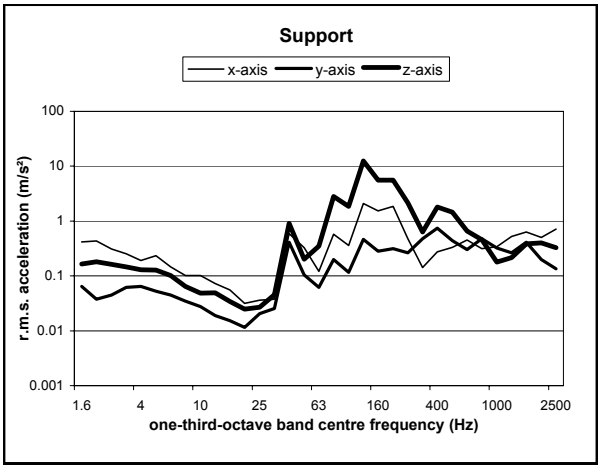


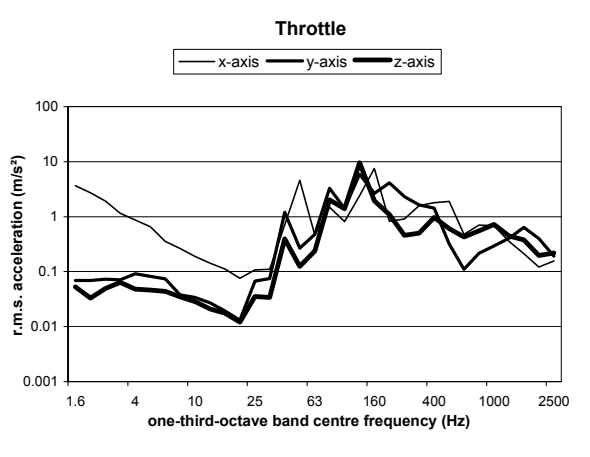




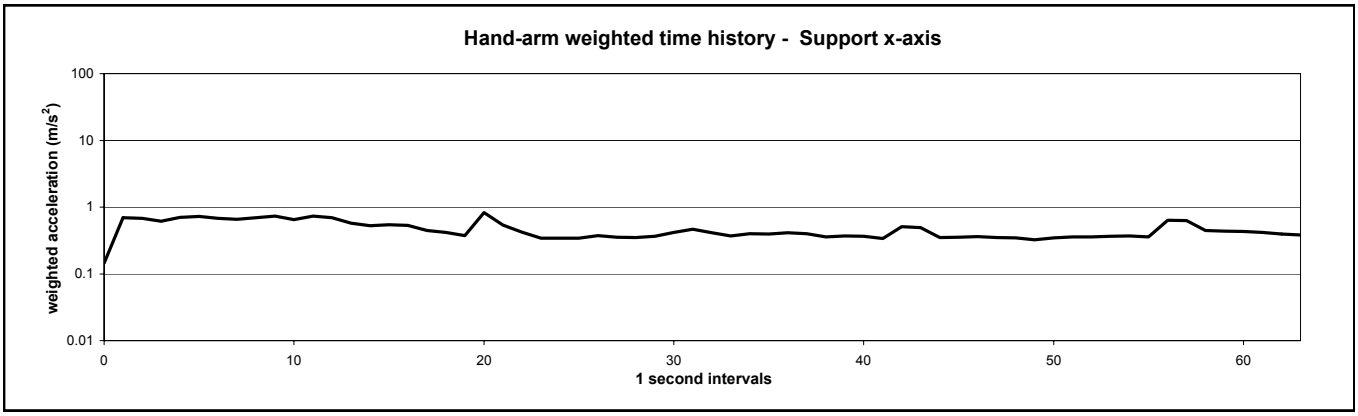
Results ID	JS2003826 200404 live tool2b op1
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	1
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-40 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.42	0.06	0.17	3.63 *	0.07	0.05
2	0.43	0.04	0.18	2.70 *	0.07	0.03
2.5	0.31	0.05	0.16	1.92	0.07	0.05
3.15	0.25	0.06	0.15	1.16	0.07	0.06
4	0.19	0.06	0.13	0.88	0.09	0.05
5	0.23	0.05	0.13	0.66	0.08	0.05
6.3	0.15	0.04	0.10	0.35	0.07	0.04
8	0.10	0.03	0.06	0.26	0.04	0.03
10	0.10	0.03	0.05	0.19	0.03	0.03
12.5	0.07	0.02	0.05	0.14	0.03	0.02
16	0.06	0.02	0.03	0.11	0.02	0.02
20	0.03	0.01	0.02	0.08	0.01	0.01
25	0.04	0.02	0.03	0.11	0.07	0.04
31.5	0.04	0.03	0.05	0.11	0.07	0.03
40	0.59	0.41	0.90	0.71	1.21	0.39
50	0.33	0.10	0.20	4.56	0.27	0.12
63	0.12	0.06	0.35	0.46	0.48	0.24
80	0.58	0.20	2.79	1.49	3.29	2.01
100	0.36	0.12	1.85	0.82	1.40	1.40
125	2.10	0.47	12.48	2.41	5.95	9.55
160	1.53	0.28	5.58	7.52	2.63	1.95
200	1.86	0.31	5.56	0.83	4.11	1.09
250	0.48	0.27	2.13	0.90	2.32	0.46
315	0.14	0.48	0.63	1.59	1.63	0.50
400	0.27	0.74	1.79	1.79	1.43	0.97
500	0.33	0.44	1.45	1.89	0.32	0.61
630	0.45	0.30	0.65	0.48	0.11	0.43
800	0.32	0.48	0.46	0.70	0.22	0.55
1000	0.34	0.32	0.18	0.68	0.29	0.72
1250	0.52	0.26	0.22	0.35	0.41	0.45
1600	0.63	0.41	0.38	0.21	0.64	0.38
2000	0.50	0.20	0.40	0.12	0.40	0.20
2500	0.71	0.13	0.33	0.16	0.19	0.22
Band limited	**3.48**	**1.43**	**15.52**	**9.93**	**9.17**	**10.25**
Band limited total (BS EN ISO 5349-1: 2001)		**15.97**			**16.97**	
Hand-arm weighted	**0.49**	**0.21**	**1.90**	**1.81**	**1.25**	**1.33**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.98**			**2.57**	



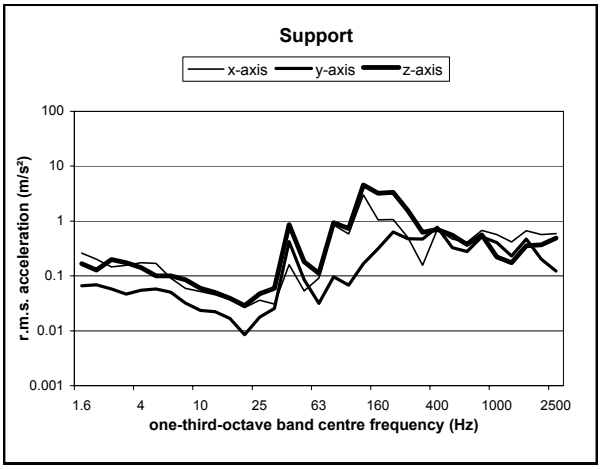


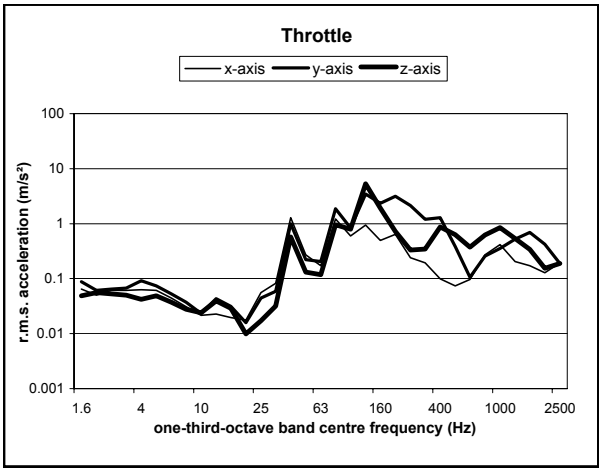
* estimated displacement > 10 mm

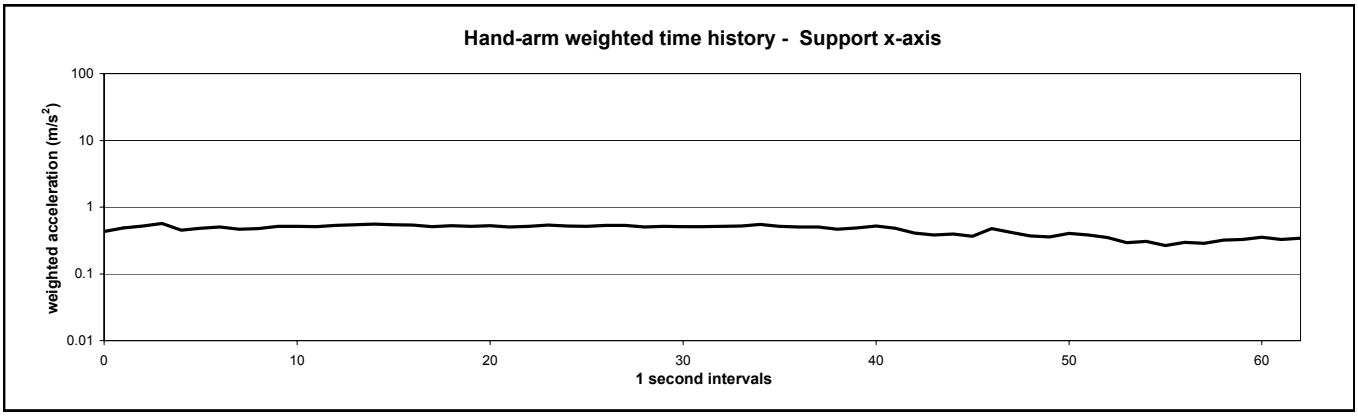


Results ID	JS2003826 200404 live tool2b op2
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2100 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	2
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 30-40 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.26	0.07	0.17	0.06	0.09	0.05
2	0.20	0.07	0.13	0.05	0.06	0.06
2.5	0.15	0.06	0.20	0.06	0.06	0.05
3.15	0.16	0.05	0.17	0.06	0.07	0.05
4	0.17	0.05	0.14	0.06	0.09	0.04
5	0.17	0.06	0.10	0.06	0.07	0.05
6.3	0.09	0.05	0.10	0.04	0.05	0.04
8	0.06	0.03	0.08	0.03	0.04	0.03
10	0.05	0.02	0.06	0.02	0.02	0.02
12.5	0.05	0.02	0.05	0.02	0.04	0.04
16	0.04	0.02	0.04	0.02	0.03	0.03
20	0.03	0.01	0.03	0.02	0.02	0.01
25	0.04	0.02	0.05	0.06	0.04	0.02
31.5	0.03	0.03	0.06	0.08	0.06	0.03
40	0.16	0.42	0.87	1.28	1.00	0.57
50	0.05	0.08	0.18	0.27	0.22	0.13
63	0.09	0.03	0.11	0.17	0.20	0.12
80	0.85	0.10	0.93	1.21	1.86	0.96
100	0.58	0.07	0.73	0.60	0.84	0.79
125	2.99	0.17	4.58	0.95	3.45	5.34
160	1.06	0.31	3.22	0.50	2.33	1.91
200	1.06	0.63	3.35	0.64	3.15	0.72
250	0.50	0.48	1.55	0.24	2.13	0.33
315	0.16	0.47	0.63	0.19	1.19	0.35
400	0.70	0.77	0.70	0.10	1.28	0.87
500	0.47	0.33	0.55	0.07	0.38	0.63
630	0.41	0.28	0.37	0.10	0.11	0.38
800	0.67	0.51	0.56	0.27	0.26	0.62
1000	0.57	0.41	0.22	0.42	0.36	0.85
1250	0.42	0.23	0.17	0.20	0.52	0.53
1600	0.67	0.47	0.36	0.17	0.69	0.34
2000	0.57	0.20	0.37	0.13	0.42	0.15
2500	0.59	0.12	0.49	0.19	0.19	0.19
Band limited	**3.76**	**1.52**	**6.98**	**2.33**	**6.37**	**6.09**
Band limited total (BS EN ISO 5349-1: 2001)		**8.08**			**9.11**	
Hand-arm weighted	**0.47**	**0.20**	**0.85**	**0.62**	**0.82**	**0.79**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.00**			**1.29**	

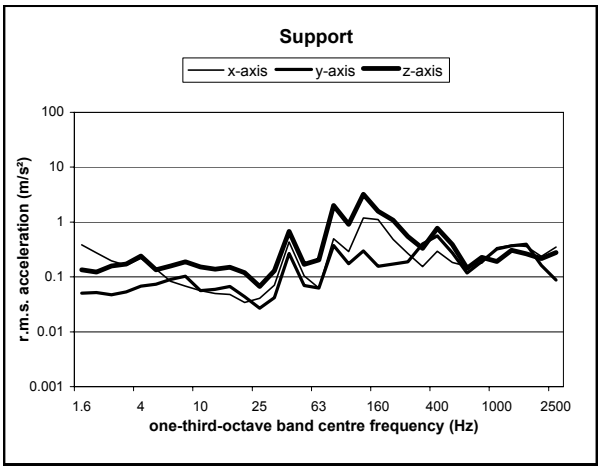


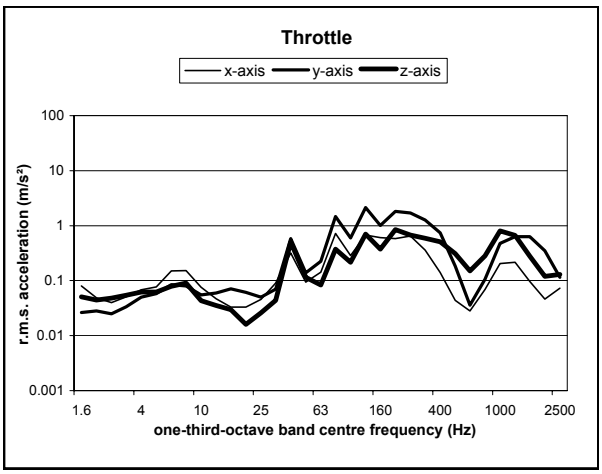


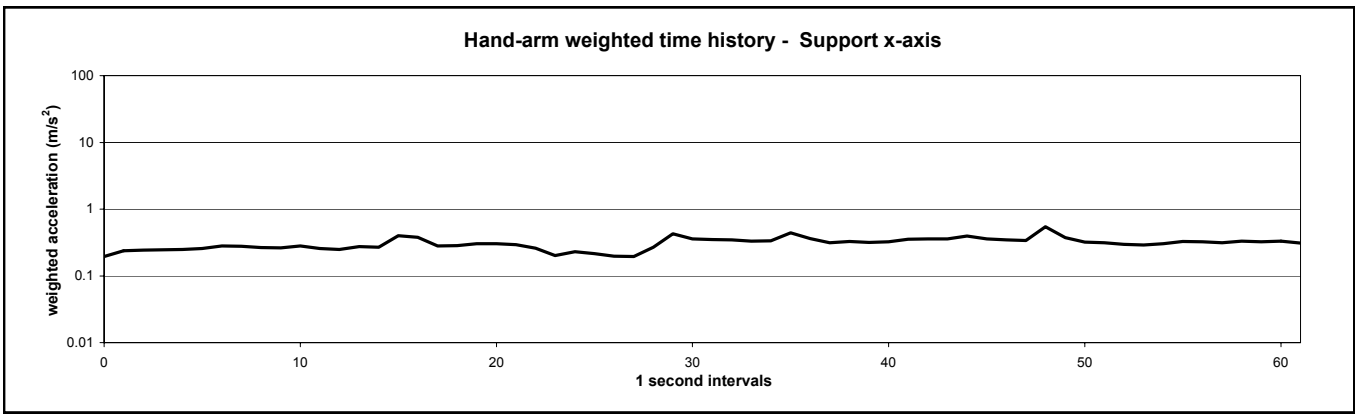


Results ID	JS2003826 200404 live tool2b op3
Equipment reference	A2
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HP 2500-VDG dump gun
Nozzle type	Straight jet
Operator	3
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle less than 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.38	0.05	0.13	0.08	0.03	0.05
2	0.27	0.05	0.12	0.05	0.03	0.04
2.5	0.20	0.05	0.16	0.04	0.02	0.05
3.15	0.16	0.05	0.17	0.05	0.03	0.05
4	0.22	0.07	0.24	0.07	0.05	0.06
5	0.14	0.07	0.13	0.08	0.06	0.06
6.3	0.08	0.09	0.16	0.15	0.08	0.08
8	0.07	0.10	0.19	0.15	0.08	0.09
10	0.06	0.06	0.15	0.08	0.06	0.04
12.5	0.05	0.06	0.14	0.05	0.06	0.04
16	0.05	0.07	0.15	0.03	0.07	0.03
20	0.03	0.04	0.12	0.03	0.06	0.02
25	0.04	0.03	0.07	0.05	0.05	0.03
31.5	0.07	0.04	0.13	0.09	0.07	0.04
40	0.44	0.27	0.68	0.32	0.58	0.50
50	0.10	0.07	0.17	0.09	0.14	0.12
63	0.06	0.06	0.20	0.14	0.22	0.08
80	0.50	0.38	2.00	0.72	1.47	0.37
100	0.29	0.17	0.91	0.28	0.60	0.22
125	1.19	0.30	3.20	0.67	2.14	0.71
160	1.12	0.16	1.58	0.61	1.01	0.38
200	0.48	0.17	1.08	0.58	1.83	0.85
250	0.27	0.19	0.55	0.65	1.69	0.67
315	0.15	0.40	0.33	0.36	1.26	0.59
400	0.29	0.56	0.77	0.14	0.74	0.51
500	0.18	0.27	0.39	0.04	0.18	0.31
630	0.16	0.12	0.14	0.03	0.04	0.15
800	0.18	0.19	0.23	0.07	0.11	0.28
1000	0.34	0.32	0.19	0.21	0.48	0.80
1250	0.38	0.37	0.31	0.22	0.63	0.66
1600	0.36	0.40	0.26	0.10	0.63	0.28
2000	0.24	0.16	0.22	0.05	0.35	0.12
2500	0.35	0.09	0.28	0.07	0.11	0.13
Band limited	**1.97**	**1.09**	**4.55**	**1.60**	**4.16**	**1.94**
Band limited total (BS EN ISO 5349-1: 2001)		**5.07**			**4.86**	
Hand-arm weighted	**0.32**	**0.22**	**0.76**	**0.32**	**0.55**	**0.29**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**0.85**			**0.70**	

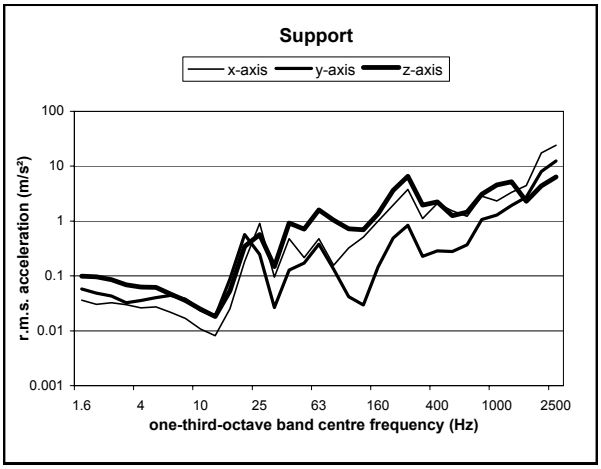


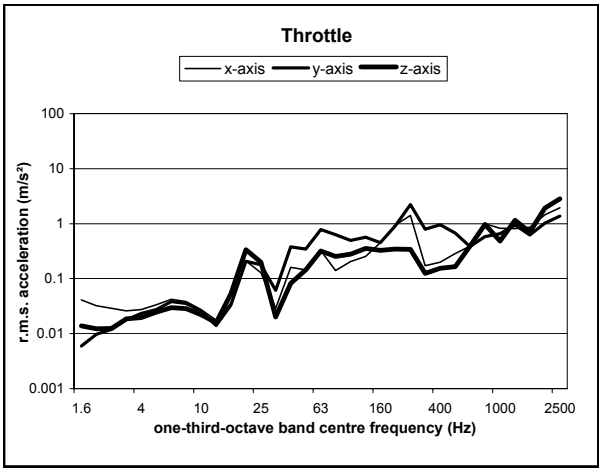


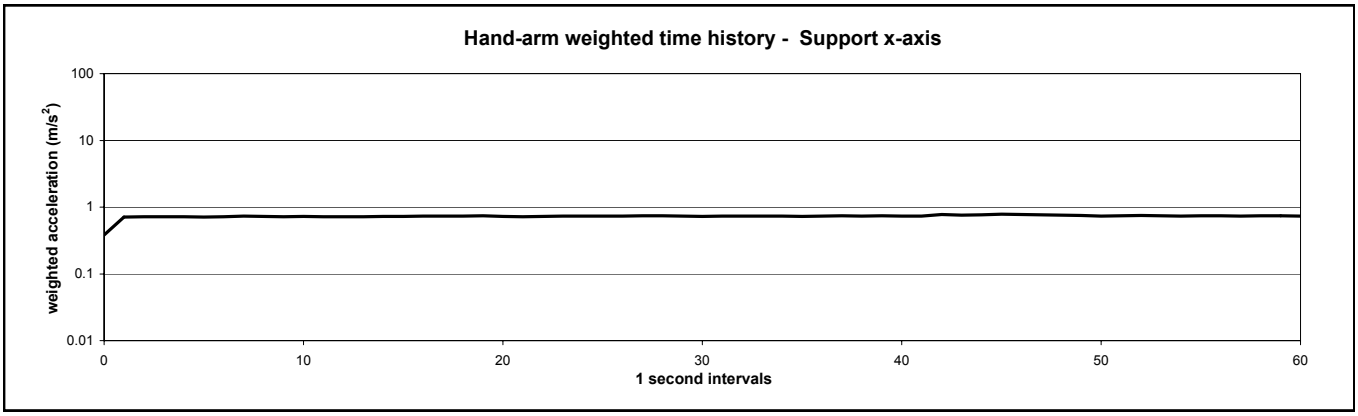


Results ID	JS2003826 200404 live tool3a op3
Equipment reference	A3
Jetting unit	Fully enclosed system producing 20 litres/min at 2000 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 6 rotating jets
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.04	0.06	0.10	0.04	0.01	0.01
2	0.03	0.05	0.10	0.03	0.01	0.01
2.5	0.03	0.04	0.09	0.03	0.01	0.01
3.15	0.03	0.03	0.07	0.03	0.02	0.02
4	0.03	0.04	0.06	0.03	0.02	0.02
5	0.03	0.04	0.06	0.03	0.03	0.02
6.3	0.02	0.04	0.05	0.04	0.04	0.03
8	0.02	0.04	0.04	0.04	0.04	0.03
10	0.01	0.02	0.02	0.03	0.03	0.02
12.5	0.01	0.02	0.02	0.02	0.01	0.02
16	0.03	0.09	0.05	0.04	0.03	0.05
20	0.18	0.56	0.35	0.21	0.21	0.34
25	0.90	0.25	0.57	0.13	0.18	0.20
31.5	0.09	0.03	0.15	0.03	0.06	0.02
40	0.48	0.13	0.91	0.16	0.38	0.08
50	0.22	0.17	0.71	0.15	0.35	0.14
63	0.48	0.38	1.60	0.32	0.78	0.32
80	0.16	0.13	1.03	0.14	0.63	0.25
100	0.32	0.04	0.72	0.21	0.50	0.28
125	0.51	0.03	0.69	0.25	0.56	0.35
160	0.99	0.15	1.36	0.45	0.45	0.33
200	1.96	0.49	3.62	0.94	0.92	0.34
250	3.79	0.84	6.53	1.41	2.22	0.34
315	1.11	0.23	1.94	0.17	0.79	0.12
400	2.09	0.29	2.24	0.20	0.96	0.15
500	1.53	0.28	1.26	0.29	0.68	0.16
630	1.22	0.37	1.45	0.39	0.38	0.39
800	2.84	1.06	3.06	0.99	0.58	0.97
1000	2.31	1.28	4.54	0.83	0.65	0.48
1250	3.32	1.93	5.21	0.82	0.95	1.15
1600	4.43	2.74	2.28	0.86	0.62	0.70
2000	17.51	8.04	4.38	1.45	1.03	1.92
2500	24.15	12.46	6.40	1.93	1.37	2.81
Band limited	**6.82**	**2.44**	**10.62**	**2.32**	**3.33**	**1.66**
Band limited total (BS EN ISO 5349-1: 2001)		**12.85**			**4.38**	
Hand-arm weighted	**0.74**	**0.50**	**0.97**	**0.27**	**0.42**	**0.33**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.32**			**0.60**	

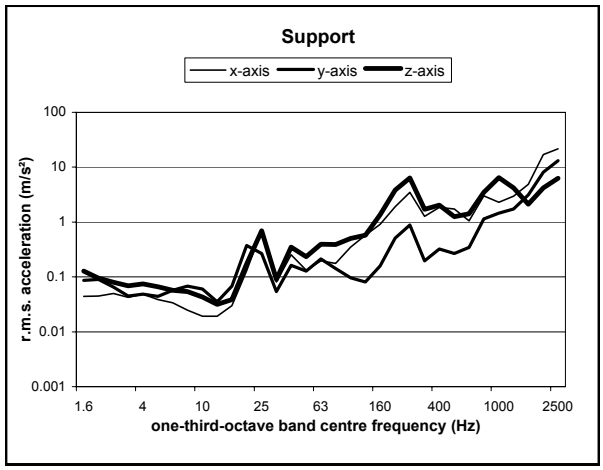


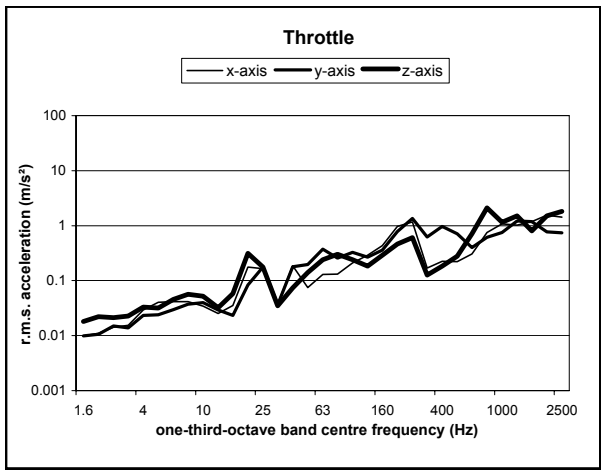


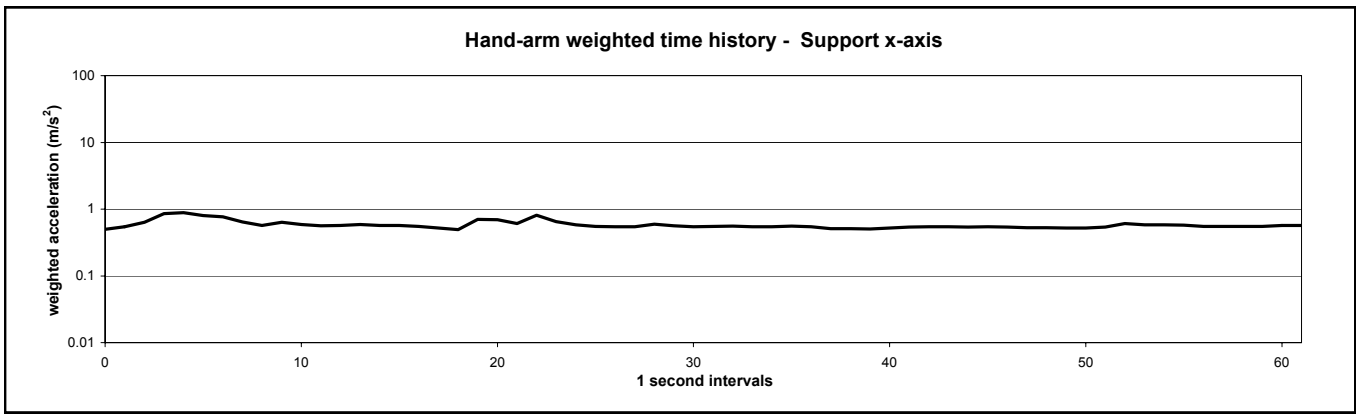


Results ID	JS2003826 200404 live tool3b op3
Field visit location	A3
Pump unit	Fully enclosed system producing 20 litres/min at 2000 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 6 rotating jets
Operator	3
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle less than 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.04	0.09	0.13	0.01	0.01	0.02
2	0.04	0.09	0.09	0.01	0.01	0.02
2.5	0.05	0.06	0.08	0.01	0.01	0.02
3.15	0.04	0.04	0.07	0.02	0.01	0.02
4	0.05	0.05	0.07	0.03	0.02	0.03
5	0.04	0.04	0.07	0.04	0.02	0.03
6.3	0.03	0.06	0.06	0.04	0.03	0.05
8	0.02	0.07	0.05	0.04	0.04	0.06
10	0.02	0.06	0.04	0.03	0.04	0.05
12.5	0.02	0.03	0.03	0.03	0.03	0.03
16	0.03	0.07	0.04	0.04	0.02	0.06
20	0.13	0.38	0.17	0.18	0.08	0.31
25	0.71	0.27	0.70	0.16	0.18	0.18
31.5	0.08	0.05	0.09	0.04	0.04	0.03
40	0.25	0.16	0.35	0.19	0.18	0.07
50	0.13	0.13	0.23	0.07	0.20	0.14
63	0.20	0.21	0.39	0.13	0.37	0.24
80	0.18	0.14	0.39	0.13	0.26	0.30
100	0.35	0.10	0.50	0.21	0.33	0.24
125	0.58	0.08	0.57	0.29	0.27	0.18
160	0.91	0.16	1.36	0.44	0.36	0.29
200	1.90	0.51	3.85	0.97	0.78	0.46
250	3.46	0.88	6.39	1.16	1.35	0.60
315	1.27	0.20	1.71	0.17	0.62	0.13
400	1.84	0.32	2.04	0.22	0.97	0.18
500	1.72	0.27	1.26	0.22	0.71	0.28
630	1.05	0.34	1.42	0.31	0.40	0.71
800	3.01	1.14	3.47	0.75	0.62	2.11
1000	2.30	1.45	6.47	1.08	0.75	1.16
1250	2.97	1.73	4.17	1.02	1.21	1.51
1600	4.85	3.13	2.13	1.18	1.19	0.80
2000	17.05	8.08	4.22	1.54	0.77	1.50
2500	21.49	13.12	6.29	1.44	0.74	1.81
Band limited	**6.52**	**2.42**	**10.89**	**2.19**	**2.54**	**2.76**
Band limited total (BS EN ISO 5349-1: 2001)		**12.92**			**4.35**	
Hand-arm weighted	**0.59**	**0.38**	**0.77**	**0.25**	**0.25**	**0.32**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.04**			**0.47**	

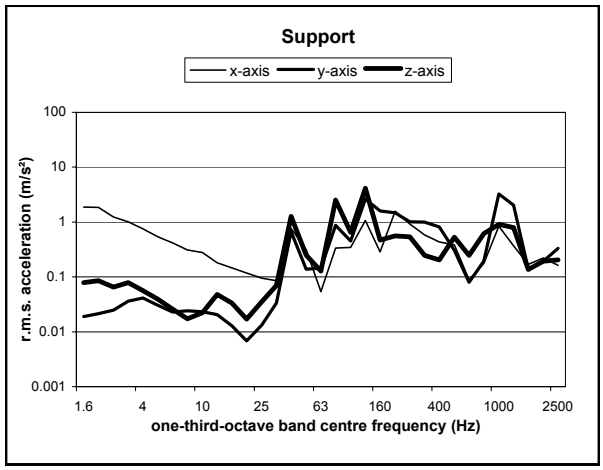


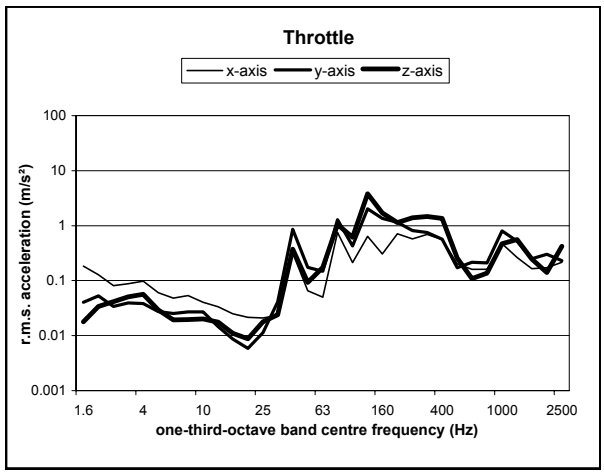




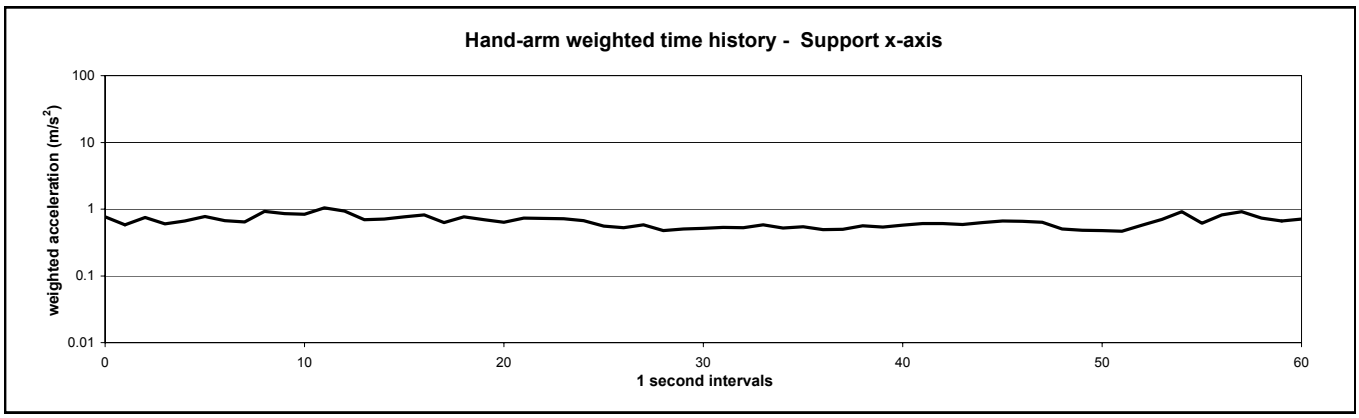
Results ID	JS2003826 200404 live tool4a op3
Equipment reference	A4
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HGLT dump gun
Nozzle type	Straight jet
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis	Throttle r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis
1.6	1.87 *	0.02	0.08	0.18	0.04	0.02
2	1.85 *	0.02	0.09	0.13	0.05	0.03
2.5	1.24	0.02	0.06	0.08	0.03	0.04
3.15	1.01	0.04	0.08	0.09	0.04	0.05
4	0.75	0.04	0.06	0.10	0.04	0.06
5	0.54	0.03	0.04	0.06	0.03	0.03
6.3	0.42	0.02	0.03	0.05	0.03	0.02
8	0.31	0.02	0.02	0.05	0.03	0.02
10	0.28	0.02	0.02	0.04	0.03	0.02
12.5	0.18	0.02	0.05	0.03	0.01	0.02
16	0.15	0.01	0.03	0.02	0.01	0.01
20	0.12	0.01	0.02	0.02	0.01	0.01
25	0.10	0.01	0.04	0.02	0.01	0.02
31.5	0.08	0.03	0.07	0.02	0.04	0.02
40	0.76	0.66	1.27	0.32	0.86	0.38
50	0.31	0.14	0.25	0.07	0.18	0.09
63	0.05	0.14	0.13	0.05	0.15	0.18
80	0.33	0.87	2.52	0.75	1.28	1.05
100	0.34	0.45	0.65	0.21	0.43	0.61
125	1.07	2.61	4.16	0.64	2.03	3.79
160	0.29	1.60	0.47	0.30	1.35	1.70
200	1.58	1.47	0.56	0.71	1.15	1.14
250	0.93	1.01	0.54	0.58	0.81	1.39
315	0.59	1.00	0.25	0.69	0.75	1.46
400	0.43	0.81	0.20	0.56	0.57	1.35
500	0.38	0.30	0.53	0.20	0.17	0.26
630	0.09	0.08	0.25	0.16	0.22	0.11
800	0.18	0.19	0.62	0.16	0.21	0.14
1000	0.84	3.26	0.90	0.47	0.80	0.47
1250	0.37	2.03	0.80	0.26	0.52	0.56
1600	0.17	0.14	0.14	0.16	0.25	0.25
2000	0.22	0.19	0.19	0.17	0.30	0.14
2500	0.16	0.33	0.20	0.22	0.23	0.42
Band limited	**2.66**	**5.04**	**5.32**	**1.77**	**3.48**	**5.14**
Band limited total (BS EN ISO 5349-1: 2001)		**7.80**			**6.46**	
Hand-arm weighted	**0.67**	**0.53**	**0.92**	**0.25**	**0.55**	**0.61**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.25**			**0.86**	



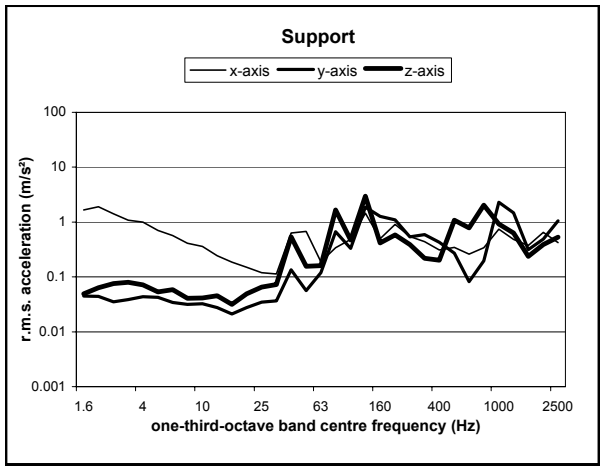


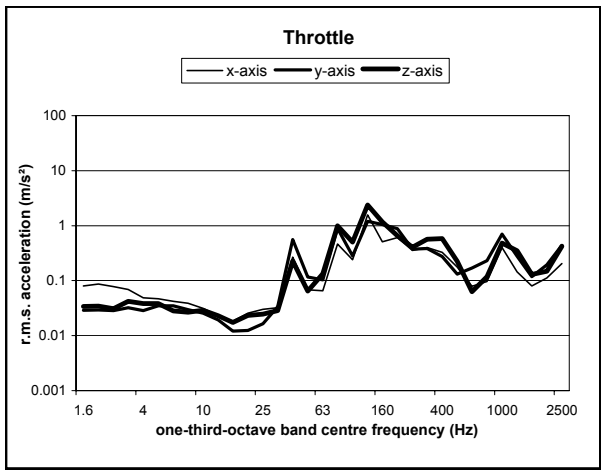
* estimated displacement > 10 mm



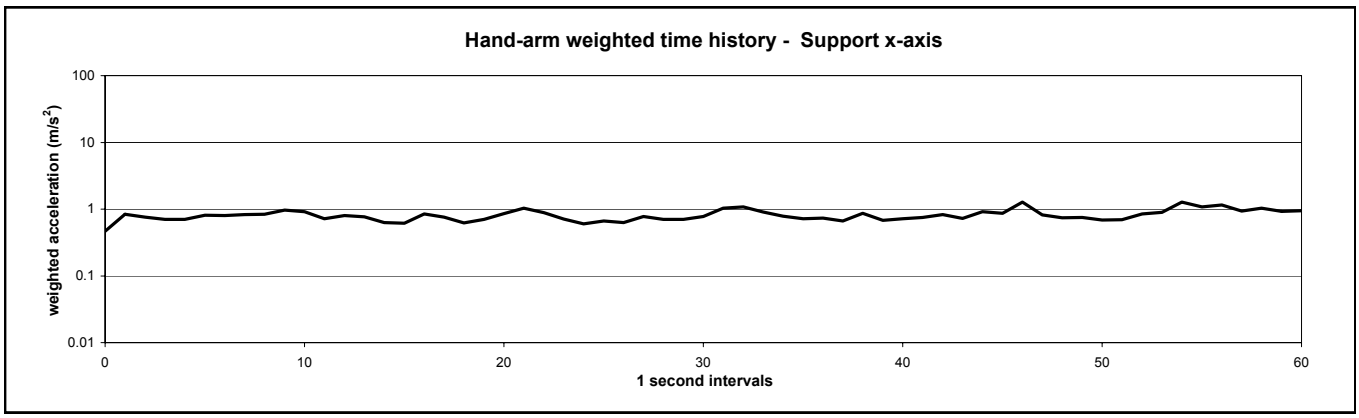
Results ID	JS2003826 200404 live tool4b op3
Equipment reference	A4
Jetting unit	Fully enclosed system producing 11 litres/min at 2200 bar
Water jetting gun	HGLT dump gun
Nozzle type	Straight jet
Operator	3
Operation	Water jet directed at 5 mm thick rusty metal plate against a wall
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle less than 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis	Throttle r.m.s. acceleration (m/s²) x-axis	y-axis	z-axis
1.6	1.66 *	0.04	0.05	0.08	0.03	0.03
2	1.91 *	0.04	0.06	0.09	0.03	0.03
2.5	1.41	0.04	0.08	0.08	0.03	0.03
3.15	1.08	0.04	0.08	0.07	0.03	0.04
4	1.00	0.04	0.07	0.05	0.03	0.04
5	0.70	0.04	0.05	0.05	0.03	0.04
6.3	0.57	0.03	0.06	0.04	0.03	0.03
8	0.41	0.03	0.04	0.04	0.03	0.03
10	0.36	0.03	0.04	0.03	0.03	0.03
12.5	0.24	0.03	0.05	0.02	0.02	0.02
16	0.19	0.02	0.03	0.02	0.01	0.02
20	0.15	0.03	0.05	0.03	0.01	0.02
25	0.12	0.03	0.07	0.03	0.02	0.02
31.5	0.11	0.04	0.07	0.03	0.03	0.03
40	0.63	0.13	0.54	0.27	0.56	0.23
50	0.67	0.06	0.16	0.07	0.12	0.06
63	0.19	0.12	0.16	0.07	0.10	0.13
80	0.34	0.67	1.67	0.46	0.89	0.99
100	0.48	0.33	0.47	0.24	0.28	0.50
125	1.45	1.87	2.97	1.57	1.19	2.37
160	0.50	1.27	0.41	0.51	1.05	1.18
200	0.90	1.09	0.58	0.60	0.88	0.65
250	0.54	0.54	0.39	0.36	0.37	0.40
315	0.44	0.59	0.22	0.40	0.38	0.56
400	0.31	0.43	0.20	0.33	0.28	0.58
500	0.34	0.27	1.08	0.18	0.13	0.23
630	0.26	0.08	0.79	0.08	0.17	0.06
800	0.34	0.20	2.03	0.10	0.23	0.12
1000	0.74	2.30	0.92	0.40	0.70	0.48
1250	0.48	1.47	0.64	0.14	0.28	0.35
1600	0.38	0.31	0.24	0.08	0.12	0.13
2000	0.65	0.49	0.39	0.11	0.19	0.15
2500	0.42	1.05	0.53	0.21	0.44	0.42
Band limited	**2.51**	**3.57**	**4.36**	**2.00**	**2.32**	**3.14**
Band limited total (BS EN ISO 5349-1: 2001)		**6.17**			**4.39**	
Hand-arm weighted	**0.83**	**0.34**	**0.58**	**0.27**	**0.36**	**0.41**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.07**			**0.61**	



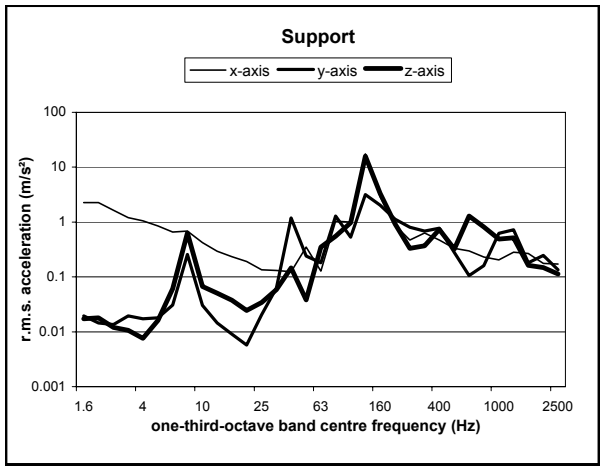


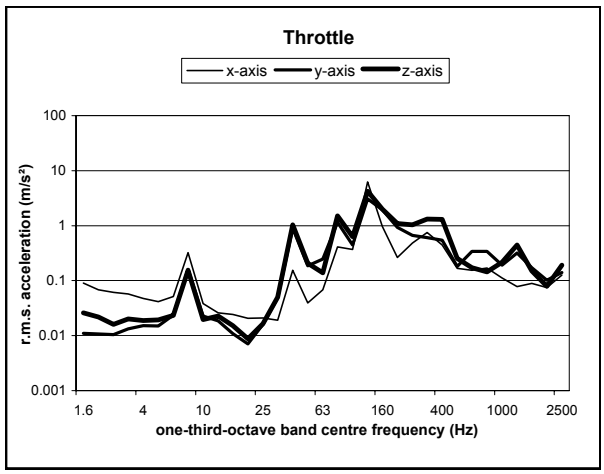
* estimated displacement > 10 mm



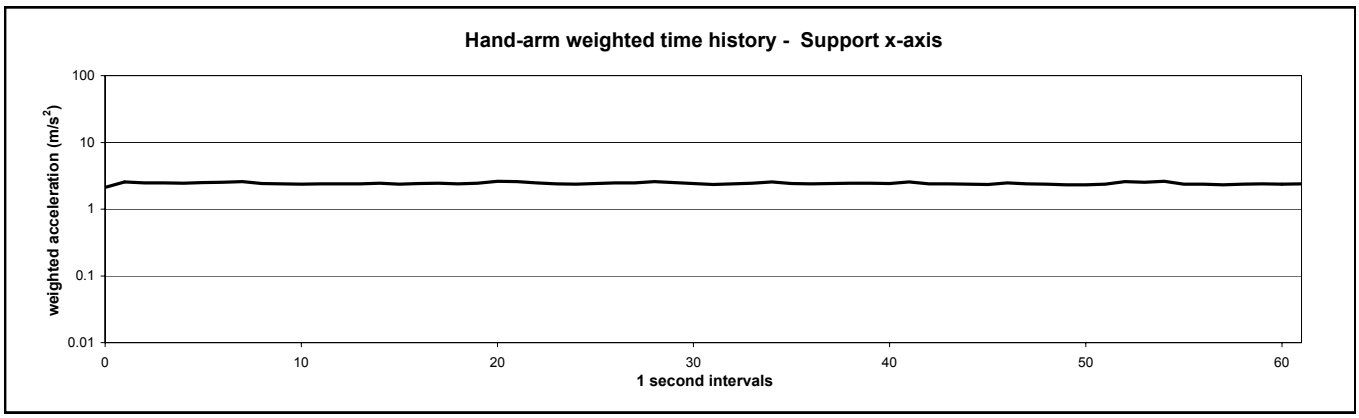
Results ID	JS2003826 200404 live tool5a op3
Equipment reference	A5
Jetting unit	Fully enclosed system producing 11 litres/min at 2500 bar
Water jetting gun	HGLT dump gun
Nozzle type	2500 bar orbital jet
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	2.27 *	0.02	0.02	0.09	0.01	0.03
2	2.27 *	0.01	0.02	0.07	0.01	0.02
2.5	1.64	0.01	0.01	0.06	0.01	0.02
3.15	1.20	0.02	0.01	0.06	0.01	0.02
4	1.06	0.02	0.01	0.05	0.02	0.02
5	0.85	0.02	0.02	0.04	0.02	0.02
6.3	0.66	0.03	0.06	0.05	0.02	0.02
8	0.69	0.26	0.63	0.32	0.16	0.15
10	0.42	0.03	0.07	0.04	0.02	0.02
12.5	0.29	0.01	0.05	0.03	0.02	0.02
16	0.23	0.01	0.04	0.02	0.01	0.02
20	0.19	0.01	0.02	0.02	0.01	0.01
25	0.13	0.02	0.03	0.02	0.02	0.02
31.5	0.13	0.06	0.06	0.02	0.05	0.05
40	0.12	1.19	0.15	0.15	0.90	1.04
50	0.35	0.24	0.04	0.04	0.19	0.21
63	0.13	0.18	0.35	0.07	0.25	0.14
80	1.04	1.29	0.55	0.41	1.16	1.51
100	1.00	0.53	0.97	0.37	0.45	0.63
125	17.36	3.17	15.93	6.23	3.08	4.20
160	2.93	2.02	3.35	0.97	1.95	1.99
200	0.87	1.12	0.92	0.26	0.93	1.10
250	0.47	0.80	0.33	0.48	0.67	1.03
315	0.64	0.68	0.37	0.75	0.60	1.31
400	0.47	0.78	0.74	0.45	0.54	1.31
500	0.33	0.28	0.32	0.17	0.18	0.25
630	0.30	0.11	1.28	0.15	0.34	0.17
800	0.23	0.16	0.81	0.17	0.34	0.14
1000	0.20	0.63	0.49	0.11	0.19	0.21
1250	0.28	0.72	0.52	0.08	0.32	0.44
1600	0.27	0.18	0.16	0.09	0.17	0.15
2000	0.18	0.25	0.15	0.08	0.10	0.08
2500	0.17	0.14	0.11	0.13	0.14	0.19
Band limited	**17.75**	**4.61**	**16.46**	**6.43**	**4.24**	**5.60**
Band limited total (BS EN ISO 5349-1: 2001)		**24.64**			**9.52**	
Hand-arm weighted	**2.44**	**0.77**	**2.14**	**0.86**	**0.65**	**0.81**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.33**			**1.35**	





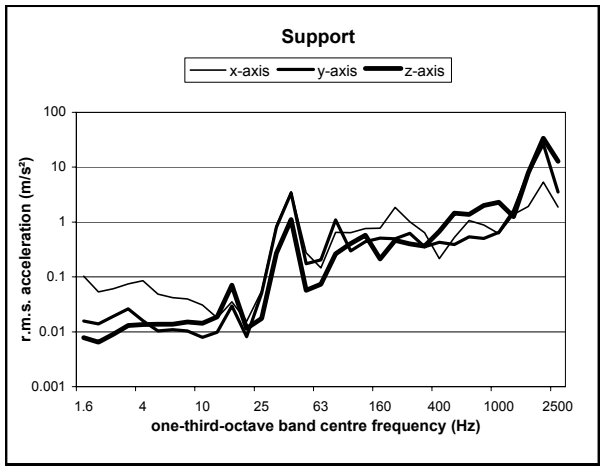
* estimated displacement > 10 mm

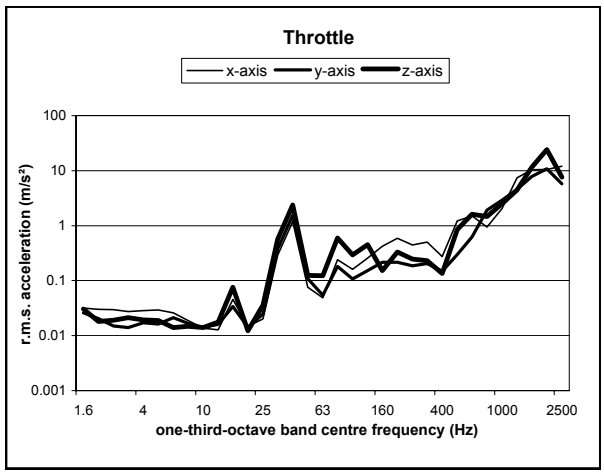


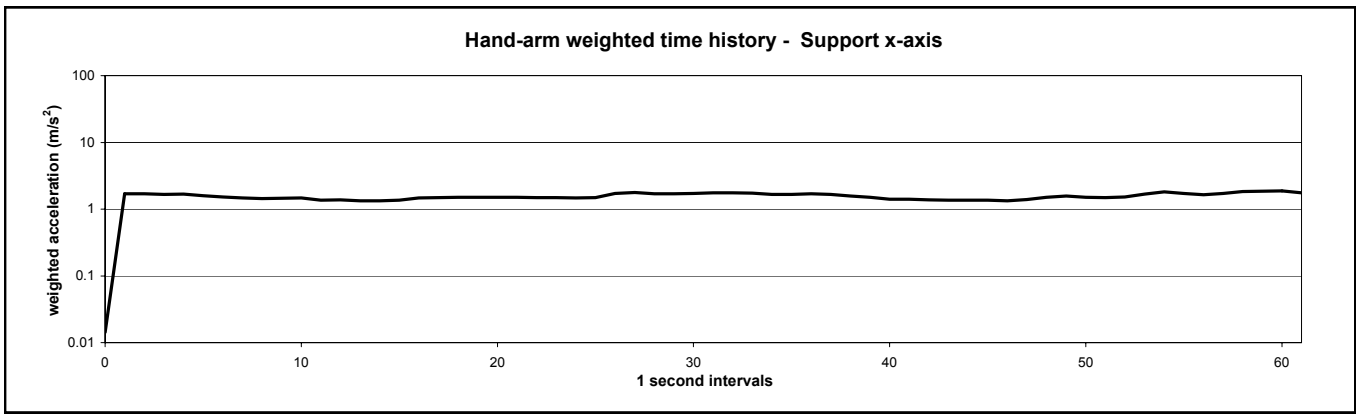
APPENDIX F SITE B HAV MEASUREMENT RESULTS

Results ID	JS2003826 210504 live tool1a op1
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	1
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.10	0.02	0.01	0.03	0.03	0.03
2	0.05	0.01	0.01	0.03	0.02	0.02
2.5	0.06	0.02	0.01	0.03	0.02	0.02
3.15	0.07	0.03	0.01	0.03	0.01	0.02
4	0.09	0.02	0.01	0.03	0.02	0.02
5	0.05	0.01	0.01	0.03	0.02	0.02
6.3	0.04	0.01	0.01	0.03	0.02	0.01
8	0.04	0.01	0.02	0.02	0.02	0.01
10	0.03	0.01	0.01	0.01	0.01	0.01
12.5	0.02	0.01	0.02	0.01	0.02	0.02
16	0.04	0.03	0.07	0.05	0.03	0.08
20	0.02	0.01	0.01	0.01	0.01	0.01
25	0.06	0.05	0.02	0.02	0.02	0.04
31.5	0.88	0.80	0.27	0.29	0.37	0.57
40	3.58	3.38	1.11	1.18	1.54	2.39
50	0.28	0.17	0.06	0.08	0.11	0.12
63	0.15	0.21	0.07	0.05	0.05	0.12
80	0.65	1.10	0.26	0.24	0.18	0.60
100	0.64	0.30	0.40	0.16	0.11	0.29
125	0.76	0.44	0.58	0.26	0.15	0.45
160	0.77	0.51	0.21	0.42	0.22	0.15
200	1.85	0.49	0.47	0.59	0.22	0.33
250	1.01	0.62	0.40	0.45	0.19	0.25
315	0.64	0.36	0.36	0.50	0.20	0.23
400	0.22	0.43	0.67	0.27	0.15	0.14
500	0.52	0.39	1.45	1.21	0.30	0.84
630	1.07	0.53	1.38	1.51	0.62	1.61
800	0.88	0.50	2.00	0.94	1.91	1.46
1000	0.61	0.65	2.30	2.06	2.90	2.50
1250	1.39	1.63	1.25	7.40	4.56	4.44
1600	1.92	7.84	7.84	10.33	7.82	11.52
2000	5.36	26.47	33.64	10.58	10.86	24.08
2500	1.88	3.55	12.86	11.95	5.75	7.67
Band limited	**4.88**	**4.14**	**3.84**	**6.15**	**4.79**	**5.14**
Band limited total (BS EN ISO 5349-1: 2001)		**7.46**			**9.33**	
Hand-arm weighted	**1.57**	**1.48**	**0.50**	**0.53**	**0.67**	**1.04**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**2.21**			**1.35**	

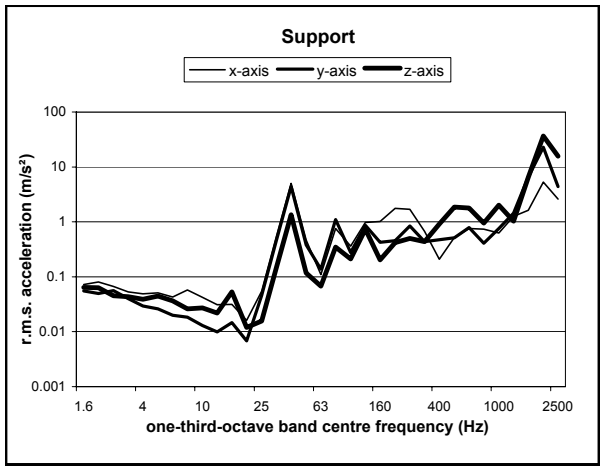


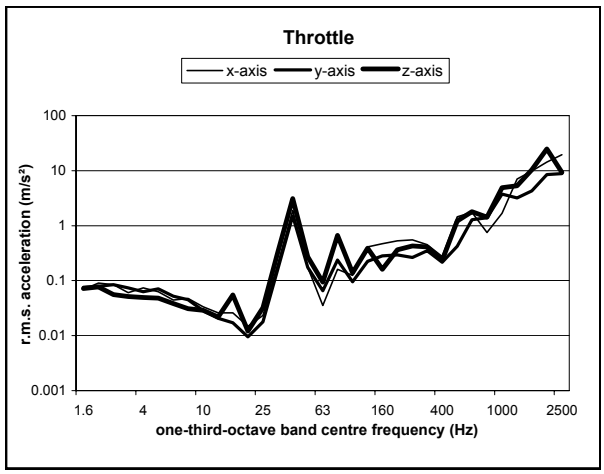


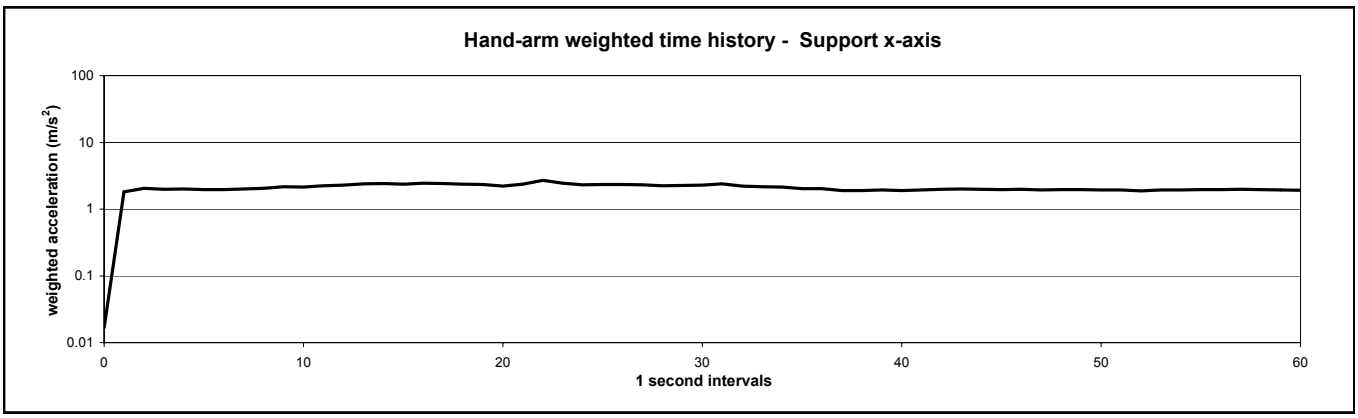


Results ID	JS2003826 210504 live tool1a op2
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.07	0.06	0.06	0.07	0.08	0.07
2	0.08	0.05	0.06	0.09	0.08	0.08
2.5	0.07	0.06	0.05	0.08	0.08	0.06
3.15	0.05	0.04	0.04	0.06	0.07	0.05
4	0.05	0.03	0.04	0.07	0.06	0.05
5	0.05	0.03	0.04	0.06	0.07	0.05
6.3	0.04	0.02	0.04	0.04	0.05	0.04
8	0.06	0.02	0.03	0.05	0.05	0.03
10	0.04	0.01	0.03	0.03	0.03	0.03
12.5	0.03	0.01	0.02	0.03	0.02	0.02
16	0.03	0.01	0.05	0.03	0.02	0.05
20	0.02	0.01	0.01	0.01	0.01	0.01
25	0.05	0.05	0.02	0.02	0.02	0.03
31.5	0.54	0.46	0.15	0.20	0.16	0.32
40	5.04	4.38	1.35	1.88	1.51	3.10
50	0.47	0.38	0.12	0.17	0.17	0.27
63	0.11	0.14	0.07	0.04	0.07	0.09
80	0.76	1.11	0.35	0.16	0.24	0.66
100	0.36	0.28	0.21	0.12	0.09	0.14
125	0.97	0.86	0.73	0.41	0.23	0.39
160	1.02	0.43	0.20	0.47	0.28	0.16
200	1.75	0.46	0.42	0.53	0.29	0.37
250	1.69	0.85	0.50	0.55	0.27	0.43
315	0.67	0.44	0.44	0.45	0.35	0.41
400	0.21	0.47	0.91	0.27	0.22	0.23
500	0.52	0.51	1.87	1.44	0.42	1.22
630	0.76	0.79	1.79	1.75	1.28	1.79
800	0.73	0.41	0.95	0.75	1.39	1.43
1000	0.62	0.75	2.02	1.67	3.77	4.92
1250	1.26	1.44	1.03	7.00	3.18	5.34
1600	1.62	6.53	6.46	9.79	4.28	10.37
2000	5.32	22.88	36.35	14.25	8.47	24.70
2500	2.58	4.39	15.64	19.45	8.88	9.32
Band limited	**6.11**	**5.06**	**3.84**	**6.09**	**4.64**	**7.00**
Band limited total (BS EN ISO 5349-1: 2001)		**8.81**			**10.37**	
Hand-arm weighted	**2.12**	**1.84**	**0.59**	**0.80**	**0.64**	**1.31**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**2.87**			**1.66**	

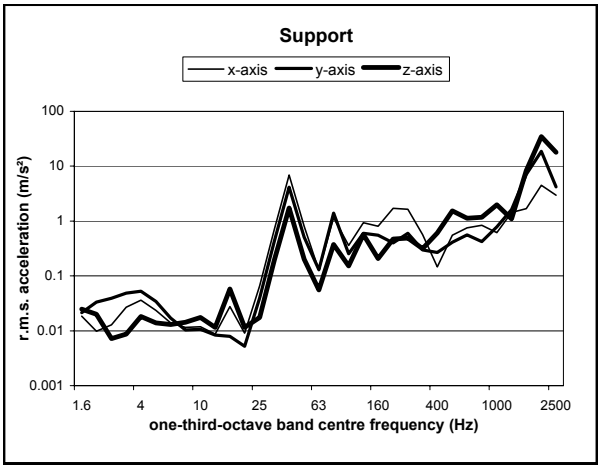


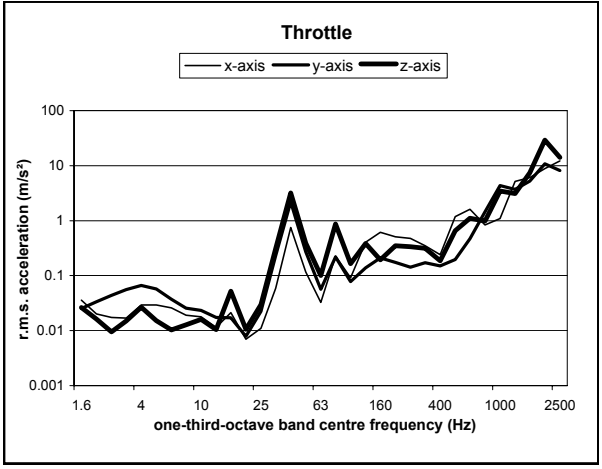


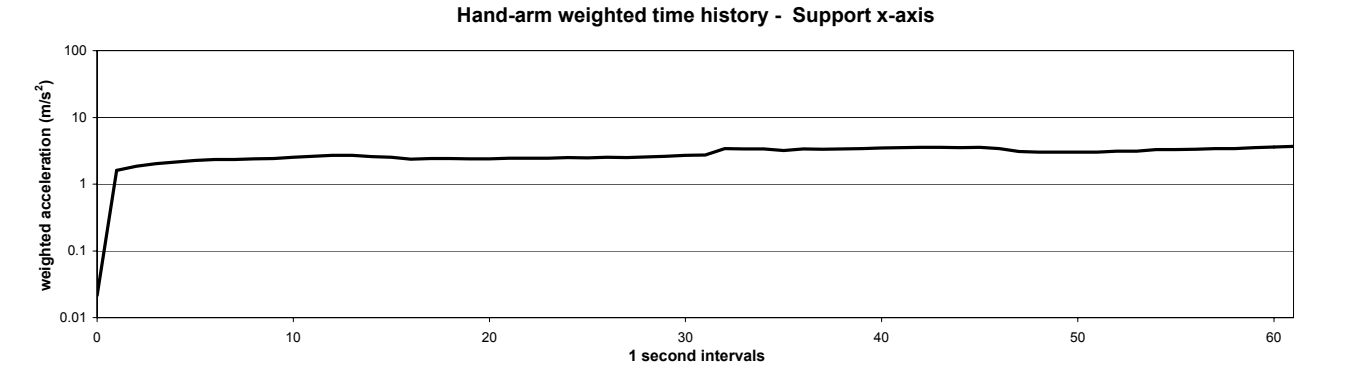


Results ID	JS2003826 210504 live tool1a op3
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.02	0.02	0.02	0.04	0.03	0.03
2	0.01	0.03	0.02	0.02	0.03	0.02
2.5	0.01	0.04	0.01	0.02	0.04	0.01
3.15	0.03	0.05	0.01	0.02	0.06	0.01
4	0.04	0.05	0.02	0.03	0.07	0.03
5	0.02	0.03	0.01	0.03	0.06	0.02
6.3	0.01	0.02	0.01	0.03	0.04	0.01
8	0.01	0.01	0.01	0.02	0.03	0.01
10	0.01	0.01	0.02	0.02	0.02	0.02
12.5	0.01	0.01	0.01	0.01	0.02	0.01
16	0.03	0.01	0.06	0.02	0.02	0.05
20	0.01	0.01	0.01	0.01	0.01	0.01
25	0.07	0.04	0.02	0.01	0.02	0.03
31.5	0.71	0.43	0.20	0.06	0.23	0.31
40	6.94	4.17	1.74	0.75	2.20	3.18
50	0.80	0.51	0.20	0.12	0.27	0.39
63	0.13	0.13	0.06	0.03	0.06	0.10
80	1.16	1.40	0.37	0.23	0.22	0.87
100	0.36	0.25	0.15	0.09	0.08	0.16
125	0.93	0.60	0.57	0.40	0.14	0.38
160	0.81	0.55	0.21	0.61	0.21	0.19
200	1.72	0.40	0.47	0.51	0.17	0.35
250	1.63	0.60	0.49	0.47	0.14	0.33
315	0.56	0.30	0.32	0.35	0.17	0.32
400	0.15	0.27	0.61	0.24	0.15	0.19
500	0.55	0.41	1.53	1.18	0.20	0.66
630	0.75	0.56	1.12	1.62	0.47	1.10
800	0.84	0.42	1.17	0.84	1.45	0.98
1000	0.61	0.79	1.97	1.09	4.33	3.48
1250	1.44	1.61	1.10	5.20	3.69	3.13
1600	1.69	7.08	8.31	6.09	5.21	7.39
2000	4.48	18.53	34.49	8.87	10.77	29.11
2500	2.97	4.20	18.01	12.21	8.19	14.09
Band limited	**7.81**	**4.85**	**3.55**	**4.56**	**5.25**	**5.26**
Band limited total (BS EN ISO 5349-1: 2001)		**9.86**			**8.72**	
Hand-arm weighted	**2.91**	**1.76**	**0.74**	**0.34**	**0.92**	**1.34**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.48**			**1.66**	

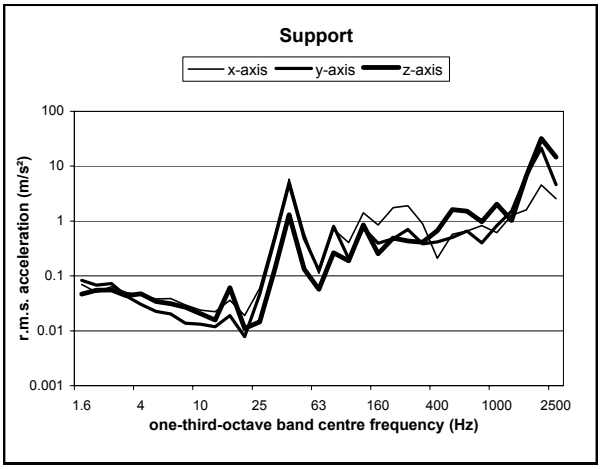


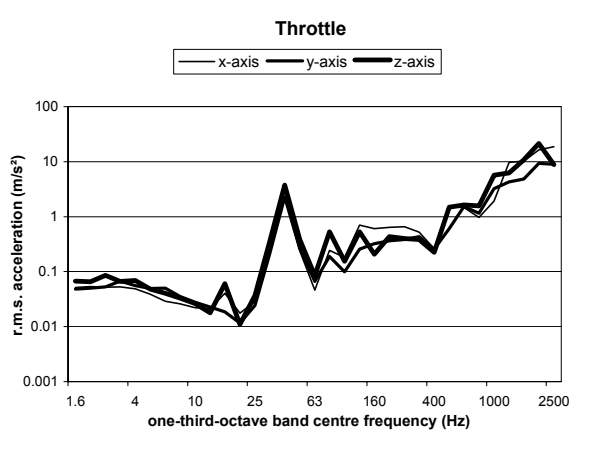


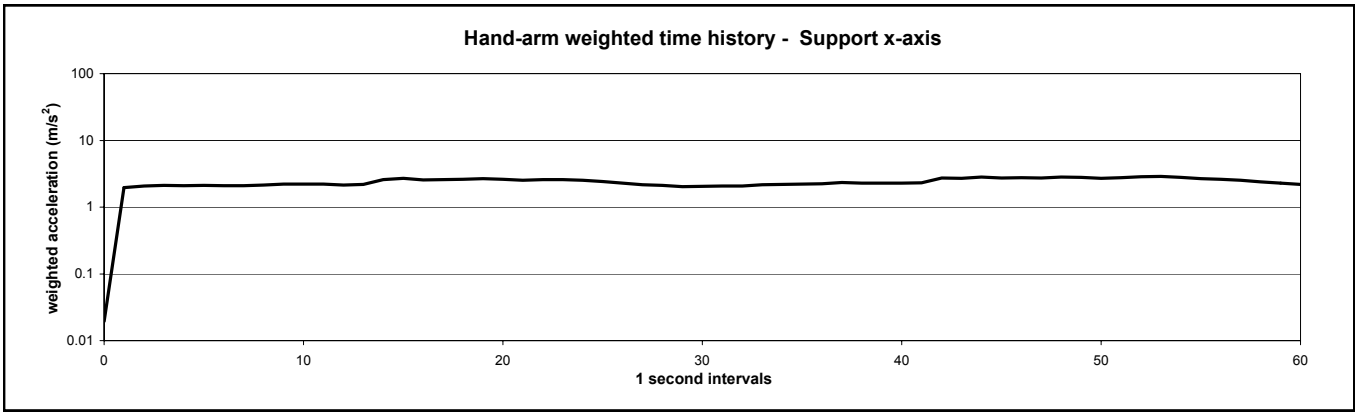


Results ID	JS2003826 210504 live tool1b op1
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	1
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.07	0.08	0.05	0.05	0.05	0.07
2	0.05	0.07	0.05	0.05	0.05	0.07
2.5	0.06	0.07	0.06	0.05	0.05	0.09
3.15	0.05	0.04	0.04	0.05	0.07	0.07
4	0.04	0.03	0.05	0.05	0.06	0.07
5	0.04	0.02	0.03	0.04	0.05	0.05
6.3	0.04	0.02	0.03	0.03	0.05	0.04
8	0.03	0.01	0.03	0.03	0.04	0.03
10	0.02	0.01	0.02	0.02	0.03	0.03
12.5	0.02	0.01	0.02	0.02	0.02	0.02
16	0.04	0.02	0.06	0.04	0.02	0.06
20	0.02	0.01	0.01	0.02	0.01	0.01
25	0.06	0.05	0.01	0.03	0.02	0.04
31.5	0.54	0.44	0.12	0.22	0.21	0.35
40	5.78	4.73	1.31	2.28	2.28	3.76
50	0.60	0.48	0.13	0.24	0.26	0.38
63	0.11	0.13	0.06	0.05	0.07	0.08
80	0.70	0.81	0.26	0.24	0.19	0.53
100	0.41	0.21	0.19	0.18	0.10	0.15
125	1.42	0.74	0.85	0.71	0.26	0.53
160	0.85	0.39	0.25	0.60	0.32	0.21
200	1.76	0.47	0.49	0.64	0.36	0.43
250	1.91	0.71	0.43	0.65	0.38	0.40
315	0.89	0.39	0.41	0.52	0.43	0.38
400	0.21	0.42	0.66	0.26	0.26	0.23
500	0.58	0.50	1.61	1.50	0.60	1.48
630	0.66	0.66	1.51	1.46	1.52	1.64
800	0.82	0.40	0.97	0.97	1.16	1.56
1000	0.61	0.82	2.02	1.92	3.22	5.70
1250	1.28	1.52	1.03	9.75	4.27	6.23
1600	1.59	6.76	6.65	10.23	4.83	10.80
2000	4.57	21.20	31.88	16.33	9.29	21.34
2500	2.54	4.60	14.64	18.61	9.00	8.80
Band limited	**6.89**	**5.26**	**3.55**	**7.96**	**5.14**	**8.08**
Band limited total (BS EN ISO 5349-1: 2001)		**9.37**			**12.45**	
Hand-arm weighted	**2.42**	**1.98**	**0.57**	**0.96**	**0.96**	**1.57**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.18**			**2.08**	

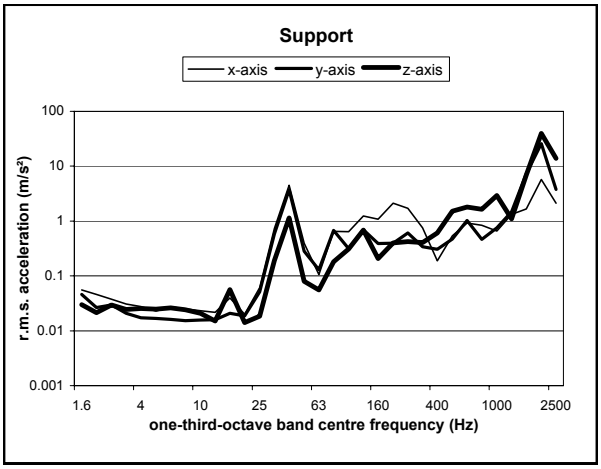


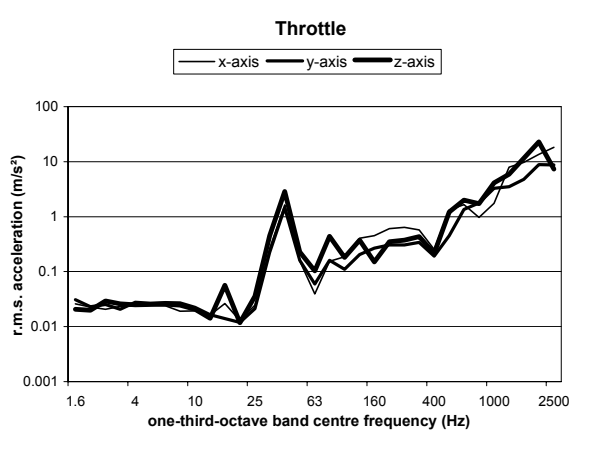


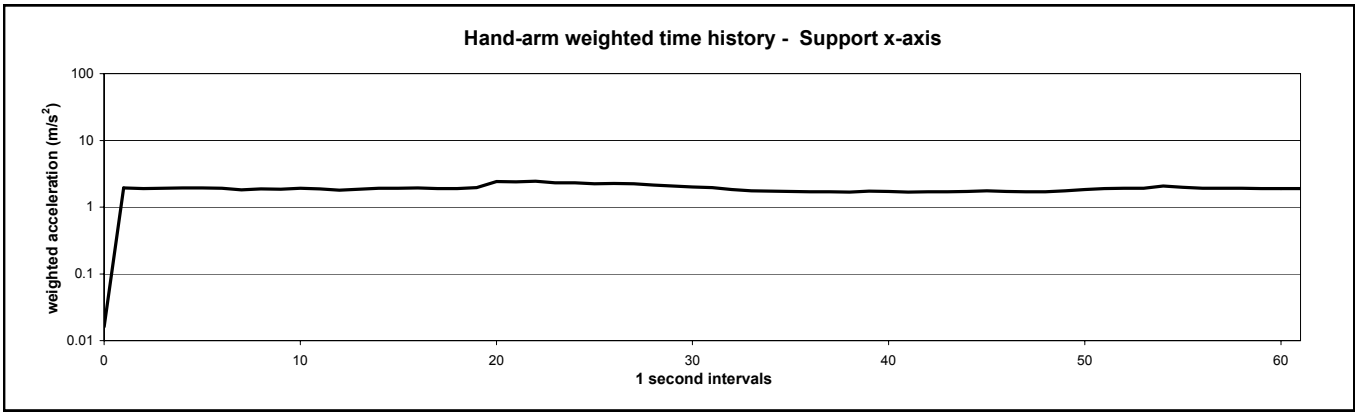


Results ID	JS2003826 210504 live tool1b op2
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	2
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.06	0.05	0.03	0.03	0.03	0.02
2	0.05	0.03	0.02	0.02	0.02	0.02
2.5	0.04	0.03	0.03	0.02	0.03	0.03
3.15	0.03	0.02	0.02	0.02	0.02	0.03
4	0.03	0.02	0.03	0.02	0.03	0.03
5	0.02	0.02	0.02	0.02	0.03	0.03
6.3	0.03	0.02	0.03	0.02	0.03	0.03
8	0.03	0.02	0.02	0.02	0.03	0.02
10	0.02	0.02	0.02	0.02	0.02	0.02
12.5	0.02	0.02	0.02	0.02	0.02	0.01
16	0.04	0.02	0.06	0.03	0.01	0.06
20	0.02	0.02	0.01	0.01	0.01	0.01
25	0.06	0.05	0.02	0.02	0.02	0.04
31.5	0.73	0.59	0.19	0.26	0.23	0.45
40	4.52	3.73	1.15	1.63	1.45	2.86
50	0.40	0.28	0.08	0.16	0.16	0.23
63	0.11	0.13	0.06	0.04	0.06	0.10
80	0.65	0.67	0.18	0.15	0.16	0.44
100	0.64	0.31	0.31	0.19	0.11	0.18
125	1.24	0.70	0.68	0.41	0.21	0.37
160	1.08	0.39	0.21	0.45	0.27	0.15
200	2.11	0.40	0.40	0.60	0.31	0.35
250	1.70	0.61	0.42	0.64	0.31	0.38
315	0.76	0.34	0.40	0.58	0.34	0.43
400	0.19	0.30	0.61	0.25	0.19	0.22
500	0.54	0.47	1.51	1.32	0.45	1.22
630	0.92	1.03	1.80	1.66	1.36	1.99
800	0.84	0.47	1.64	0.96	1.78	1.73
1000	0.66	0.75	2.90	1.75	3.27	4.13
1250	1.33	1.47	1.10	7.95	3.48	5.88
1600	1.66	7.29	6.92	9.77	4.80	11.52
2000	5.76	25.84	39.73	13.62	8.81	22.75
2500	2.11	3.76	13.89	18.30	8.71	7.37
Band limited	**5.96**	**4.38**	**4.13**	**6.61**	**4.59**	**6.84**
Band limited total (BS EN ISO 5349-1: 2001)		**8.47**			**10.56**	
Hand-arm weighted	**1.93**	**1.58**	**0.51**	**0.70**	**0.62**	**1.21**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**2.54**			**1.53**	

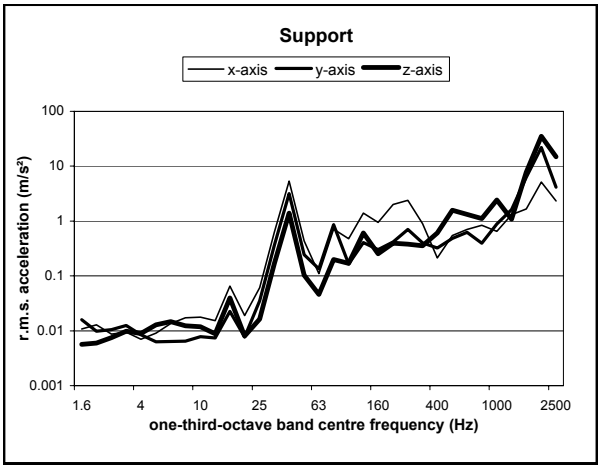


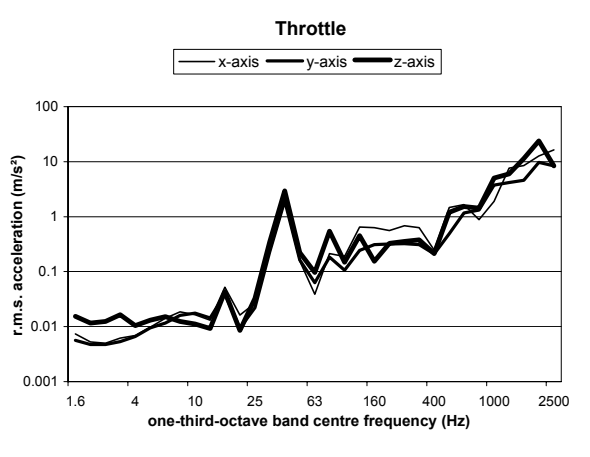


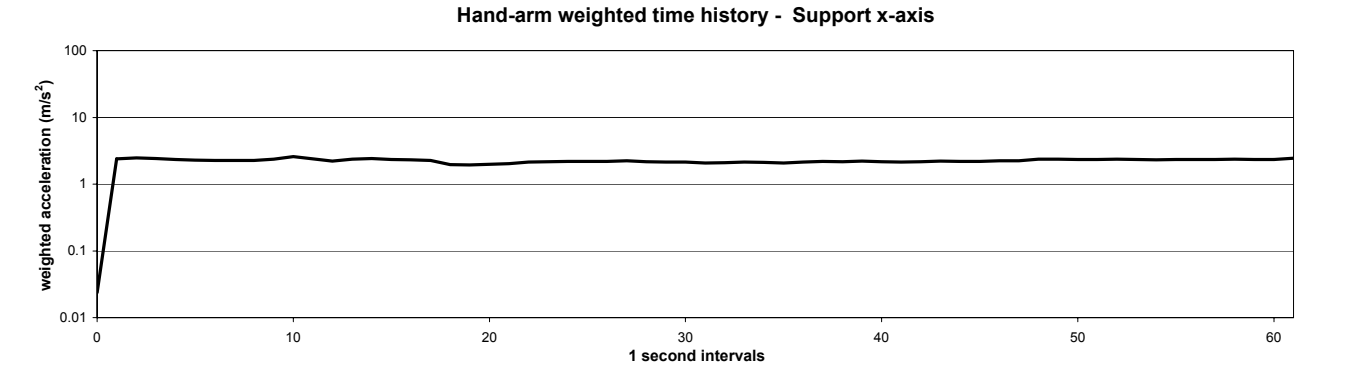


Results ID	JS2003826 210504 live tool1b op3
Equipment reference	B1
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	Air driven rotary gun
Nozzle type	Fixed nozzle with 5 rotating jets
Operator	3
Operation	Water jet directed at rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.01	0.02	0.01	0.01	0.01	0.02
2	0.01	0.01	0.01	0.01	0.00	0.01
2.5	0.01	0.01	0.01	0.01	0.00	0.01
3.15	0.01	0.01	0.01	0.01	0.01	0.02
4	0.01	0.01	0.01	0.01	0.01	0.01
5	0.01	0.01	0.01	0.01	0.01	0.01
6.3	0.01	0.01	0.01	0.01	0.01	0.02
8	0.02	0.01	0.01	0.02	0.02	0.01
10	0.02	0.01	0.01	0.02	0.02	0.01
12.5	0.02	0.01	0.01	0.01	0.01	0.01
16	0.06	0.02	0.04	0.05	0.04	0.04
20	0.02	0.01	0.01	0.02	0.01	0.01
25	0.06	0.04	0.02	0.03	0.02	0.03
31.5	0.63	0.37	0.17	0.22	0.23	0.34
40	5.33	3.15	1.39	1.90	1.94	2.94
50	0.43	0.24	0.10	0.16	0.16	0.22
63	0.11	0.13	0.05	0.04	0.06	0.10
80	0.71	0.86	0.20	0.21	0.18	0.54
100	0.48	0.17	0.17	0.19	0.11	0.15
125	1.39	0.40	0.61	0.65	0.24	0.45
160	0.94	0.30	0.25	0.63	0.31	0.16
200	1.99	0.42	0.40	0.56	0.32	0.33
250	2.38	0.70	0.38	0.68	0.32	0.36
315	0.90	0.40	0.36	0.63	0.31	0.38
400	0.21	0.32	0.61	0.25	0.21	0.21
500	0.55	0.48	1.57	1.46	0.49	1.21
630	0.71	0.63	1.32	1.64	1.17	1.53
800	0.84	0.39	1.11	0.88	1.32	1.44
1000	0.65	0.88	2.43	1.89	3.77	5.02
1250	1.30	1.62	1.08	7.67	4.19	6.03
1600	1.66	6.32	7.82	8.51	4.57	11.38
2000	5.12	21.90	34.85	12.69	9.66	23.75
2500	2.31	4.12	14.88	16.38	8.43	8.33
Band limited	**6.74**	**3.83**	**3.63**	**6.60**	**5.15**	**7.18**
Band limited total (BS EN ISO 5349-1: 2001)		**8.56**			**11.03**	
Hand-arm weighted	**2.25**	**1.33**	**0.60**	**0.81**	**0.82**	**1.24**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**2.68**			**1.69**	

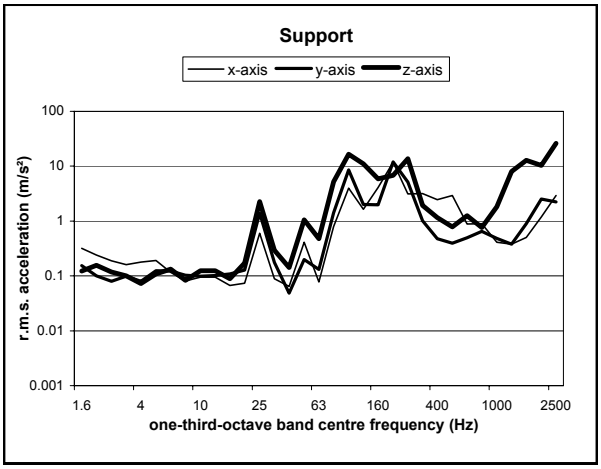


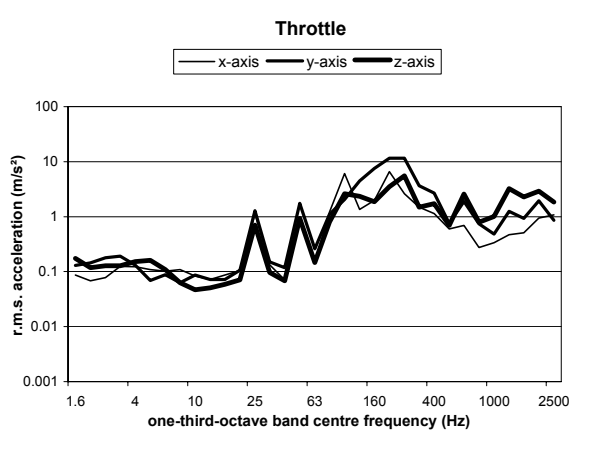


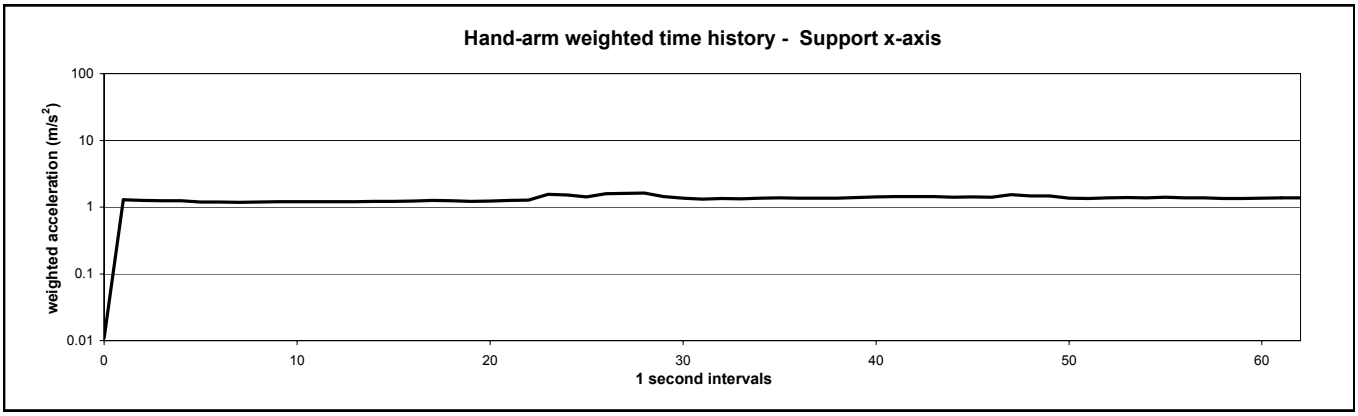


Results ID	JS2003826 210504 live tool2a op1
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	1
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.32	0.15	0.12	0.09	0.13	0.17
2	0.24	0.10	0.16	0.07	0.14	0.12
2.5	0.19	0.08	0.12	0.08	0.18	0.13
3.15	0.16	0.10	0.10	0.12	0.19	0.13
4	0.18	0.08	0.07	0.12	0.13	0.15
5	0.19	0.12	0.11	0.11	0.07	0.16
6.3	0.12	0.12	0.13	0.10	0.09	0.11
8	0.08	0.10	0.08	0.11	0.06	0.06
10	0.09	0.10	0.12	0.08	0.09	0.05
12.5	0.09	0.10	0.12	0.07	0.07	0.05
16	0.07	0.11	0.09	0.09	0.07	0.06
20	0.07	0.13	0.17	0.10	0.11	0.07
25	0.60	1.40	2.26	1.14	1.29	0.70
31.5	0.09	0.18	0.29	0.13	0.15	0.10
40	0.06	0.05	0.14	0.07	0.12	0.07
50	0.41	0.20	1.05	0.99	1.74	0.93
63	0.08	0.13	0.48	0.15	0.26	0.15
80	0.79	1.42	5.23	1.22	1.11	0.80
100	3.99	8.55	16.48	6.10	2.06	2.62
125	1.64	2.01	11.00	1.35	4.48	2.36
160	4.07	1.98	5.91	1.97	7.48	1.86
200	11.84	11.94	6.83	6.61	11.57	3.53
250	3.11	5.13	13.72	2.62	11.62	5.53
315	3.18	1.01	1.92	1.48	3.64	1.48
400	2.46	0.48	1.16	1.14	2.67	1.72
500	2.94	0.39	0.78	0.60	0.75	0.69
630	0.88	0.50	1.26	0.69	1.90	2.57
800	0.90	0.65	0.76	0.28	0.74	0.79
1000	0.41	0.48	1.82	0.33	0.48	1.01
1250	0.38	0.38	8.00	0.47	1.25	3.25
1600	0.50	0.89	12.76	0.51	0.93	2.28
2000	1.19	2.52	10.39	0.94	1.95	2.90
2500	2.91	2.25	26.08	1.08	0.86	1.85
Band limited	**14.56**	**16.00**	**27.17**	**10.09**	**19.51**	**8.90**
Band limited total (BS EN ISO 5349-1: 2001)		**34.73**			**23.70**	
Hand-arm weighted	**1.35**	**1.99**	**3.72**	**1.45**	**1.88**	**0.93**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**4.43**			**2.55**	

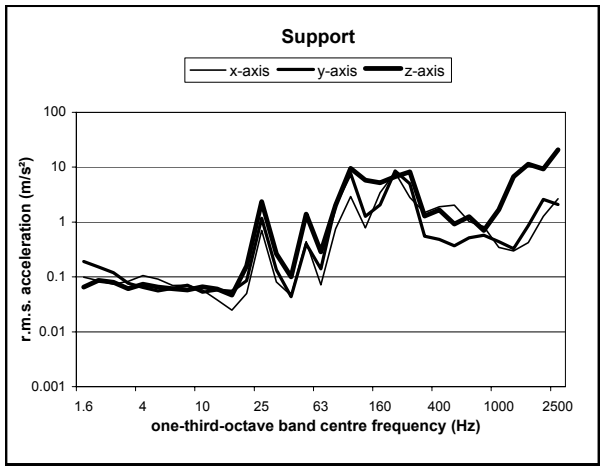


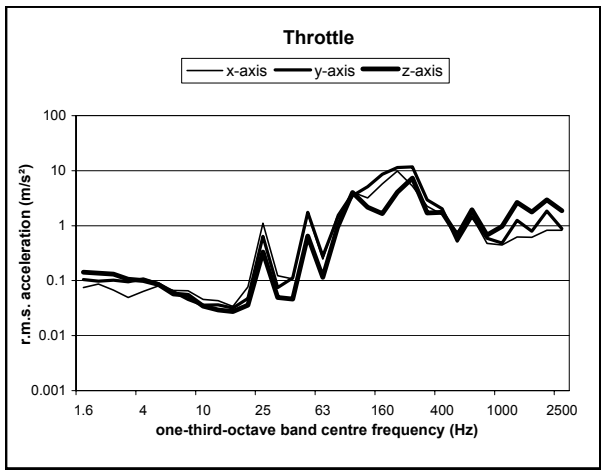


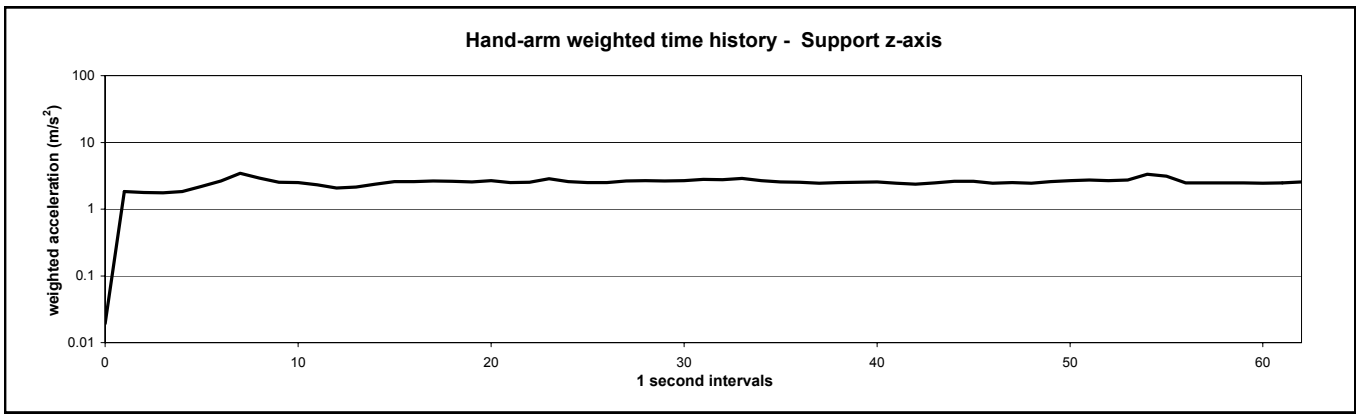


Results ID	JS2003826 210504 live tool2a op2
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.10	0.19	0.07	0.07	0.11	0.14
2	0.09	0.15	0.09	0.09	0.10	0.14
2.5	0.07	0.12	0.08	0.07	0.10	0.13
3.15	0.08	0.08	0.06	0.05	0.10	0.11
4	0.11	0.06	0.07	0.06	0.11	0.10
5	0.09	0.06	0.07	0.08	0.09	0.09
6.3	0.07	0.06	0.06	0.07	0.06	0.06
8	0.07	0.07	0.06	0.07	0.05	0.05
10	0.06	0.05	0.07	0.05	0.04	0.03
12.5	0.04	0.06	0.06	0.04	0.04	0.03
16	0.02	0.06	0.05	0.03	0.03	0.03
20	0.05	0.09	0.16	0.08	0.05	0.04
25	0.70	1.17	2.36	1.10	0.64	0.33
31.5	0.08	0.13	0.26	0.12	0.08	0.05
40	0.05	0.04	0.10	0.11	0.11	0.05
50	0.44	0.40	1.40	1.67	1.74	0.64
63	0.07	0.14	0.28	0.25	0.28	0.11
80	0.75	2.09	2.03	1.57	1.38	0.92
100	2.92	7.66	9.56	4.08	3.51	3.99
125	0.79	1.27	5.79	3.19	5.09	2.15
160	3.44	2.07	5.24	5.77	8.65	1.65
200	7.95	8.51	6.72	9.79	11.35	4.05
250	2.82	5.01	8.20	5.21	11.77	7.31
315	1.48	0.55	1.30	2.24	2.93	1.70
400	1.89	0.48	1.66	1.59	2.04	1.75
500	2.04	0.37	0.92	0.77	0.52	0.66
630	1.03	0.52	1.25	1.49	1.47	1.93
800	0.83	0.58	0.71	0.47	0.59	0.68
1000	0.35	0.44	1.68	0.45	0.48	0.96
1250	0.30	0.33	6.72	0.62	1.24	2.65
1600	0.42	0.86	11.32	0.62	0.79	1.77
2000	1.27	2.61	9.29	0.82	1.85	2.95
2500	2.67	2.10	20.72	0.82	0.88	1.87
Band limited	**10.24**	**13.01**	**17.56**	**14.15**	**20.04**	**10.44**
Band limited total (BS EN ISO 5349-1: 2001)		**24.14**			**26.66**	
Hand-arm weighted	**1.03**	**1.71**	**2.55**	**1.61**	**1.87**	**0.99**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.24**			**2.66**	

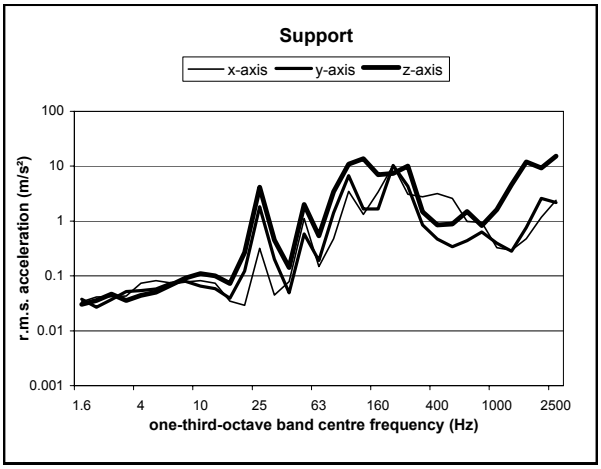


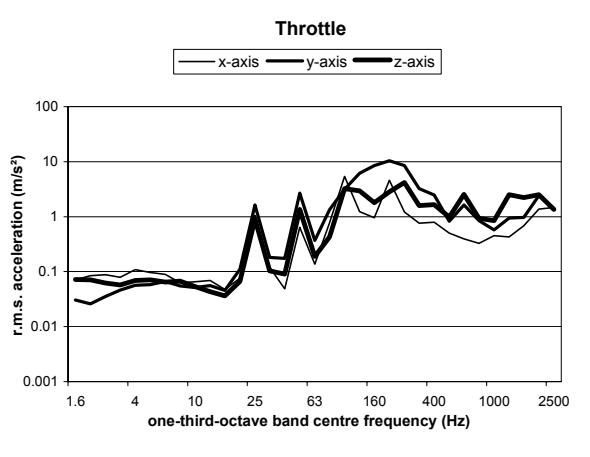


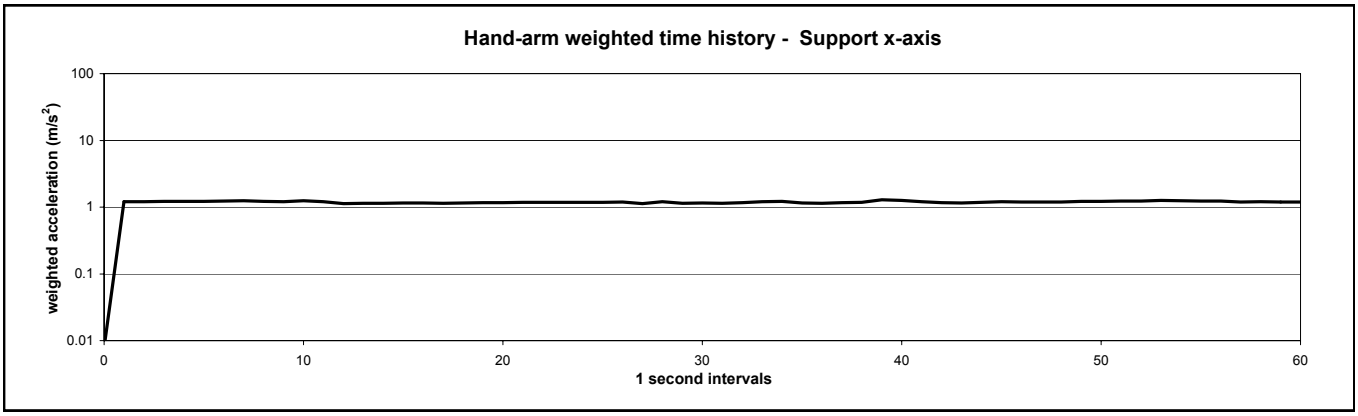


Results ID	JS2003826 210504 live tool2a op3
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	3
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.03	0.04	0.03	0.07	0.03	0.07
2	0.04	0.03	0.04	0.08	0.03	0.07
2.5	0.04	0.04	0.05	0.09	0.04	0.06
3.15	0.04	0.05	0.04	0.08	0.05	0.06
4	0.07	0.05	0.04	0.11	0.06	0.07
5	0.08	0.06	0.05	0.10	0.06	0.07
6.3	0.07	0.07	0.07	0.09	0.07	0.06
8	0.08	0.08	0.09	0.06	0.06	0.07
10	0.08	0.07	0.11	0.07	0.05	0.05
12.5	0.07	0.06	0.10	0.07	0.06	0.04
16	0.03	0.04	0.07	0.05	0.05	0.04
20	0.03	0.12	0.27	0.08	0.11	0.07
25	0.32	1.82	4.14	1.06	1.64	0.90
31.5	0.04	0.20	0.45	0.12	0.18	0.10
40	0.08	0.05	0.14	0.05	0.17	0.09
50	1.11	0.59	2.01	0.64	2.67	1.35
63	0.15	0.19	0.54	0.14	0.37	0.19
80	0.48	1.41	3.44	0.77	1.34	0.43
100	3.48	6.72	10.93	5.42	3.14	3.23
125	1.33	1.66	13.76	1.24	6.12	2.93
160	3.37	1.66	7.02	0.95	8.49	1.79
200	10.36	10.33	7.38	4.61	10.34	2.83
250	3.08	4.33	10.08	1.21	8.47	4.16
315	2.77	0.85	1.46	0.76	3.23	1.59
400	3.18	0.47	0.85	0.79	2.47	1.66
500	2.60	0.34	0.88	0.50	0.82	0.98
630	0.98	0.44	1.49	0.39	1.63	2.55
800	0.94	0.63	0.83	0.33	0.85	0.93
1000	0.33	0.39	1.61	0.45	0.58	0.85
1250	0.30	0.28	4.63	0.43	0.95	2.51
1600	0.48	0.76	11.98	0.68	0.97	2.24
2000	1.17	2.59	9.33	1.37	2.42	2.52
2500	2.40	2.18	15.19	1.47	1.41	1.36
Band limited	**13.02**	**13.54**	**23.80**	**7.65**	**18.18**	**8.19**
Band limited total (BS EN ISO 5349-1: 2001)		**30.32**			**21.36**	
Hand-arm weighted	**1.19**	**1.88**	**3.95**	**1.22**	**2.14**	**1.06**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**4.54**			**2.69**	

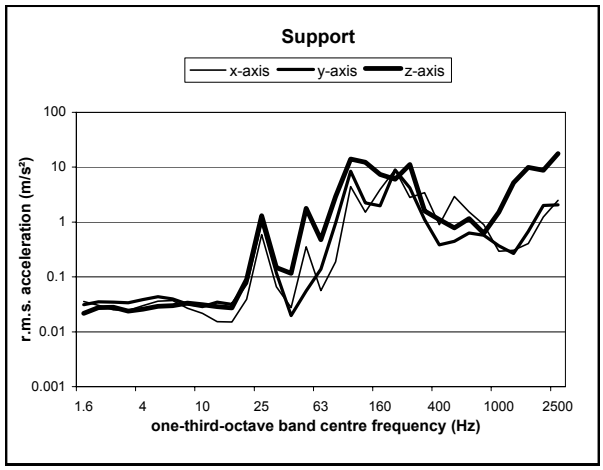


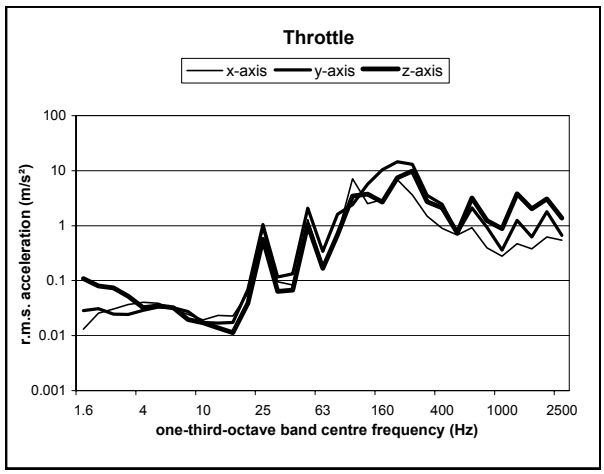


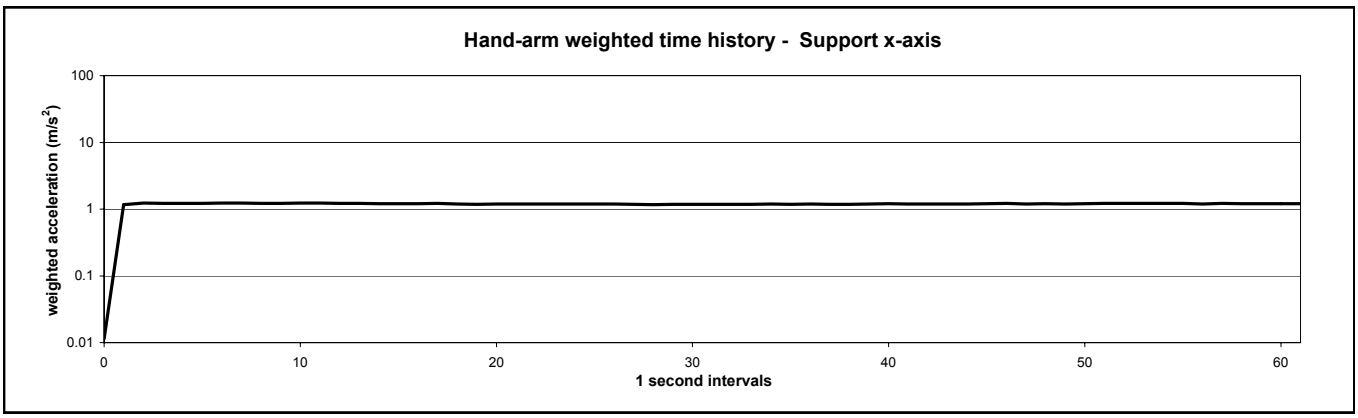


Results ID	JS2003826 210504 live tool2b op1
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	1
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-30 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.04	0.03	0.02	0.01	0.03	0.11
2	0.03	0.04	0.03	0.03	0.03	0.08
2.5	0.03	0.03	0.03	0.03	0.02	0.07
3.15	0.02	0.03	0.02	0.04	0.02	0.05
4	0.03	0.04	0.03	0.04	0.03	0.03
5	0.04	0.04	0.03	0.04	0.03	0.04
6.3	0.04	0.04	0.03	0.03	0.03	0.03
8	0.03	0.03	0.03	0.02	0.03	0.02
10	0.02	0.03	0.03	0.02	0.02	0.02
12.5	0.02	0.03	0.03	0.02	0.02	0.01
16	0.02	0.03	0.03	0.02	0.02	0.01
20	0.04	0.08	0.09	0.06	0.07	0.04
25	0.59	1.06	1.31	0.85	1.05	0.57
31.5	0.07	0.12	0.15	0.09	0.12	0.06
40	0.03	0.02	0.12	0.08	0.13	0.07
50	0.35	0.06	1.77	1.29	2.07	1.04
63	0.06	0.14	0.48	0.19	0.34	0.17
80	0.19	0.96	2.91	0.67	1.60	0.68
100	4.43	8.42	14.16	7.18	2.41	3.45
125	1.51	2.24	12.30	2.51	5.65	3.73
160	3.90	1.97	7.43	2.97	10.43	2.68
200	8.98	8.91	6.05	6.84	14.56	7.40
250	2.81	4.20	11.17	3.62	13.06	9.90
315	3.45	1.11	1.59	1.48	3.57	2.73
400	0.89	0.38	1.11	0.89	2.43	2.10
500	2.94	0.45	0.79	0.68	0.73	0.74
630	1.53	0.63	1.15	0.92	2.10	3.21
800	0.90	0.57	0.62	0.39	0.94	1.23
1000	0.29	0.37	1.51	0.28	0.36	0.88
1250	0.31	0.27	5.21	0.47	1.25	3.79
1600	0.40	0.67	9.92	0.38	0.62	2.03
2000	1.23	2.00	8.74	0.63	1.79	3.07
2500	2.50	2.05	17.61	0.55	0.66	1.36
Band limited	**12.26**	**13.46**	**24.55**	**11.57**	**23.70**	**14.79**
Band limited total (BS EN ISO 5349-1: 2001)		**30.56**			**30.24**	
Hand-arm weighted	**1.20**	**1.74**	**3.21**	**1.54**	**2.21**	**1.29**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.85**			**2.99**	

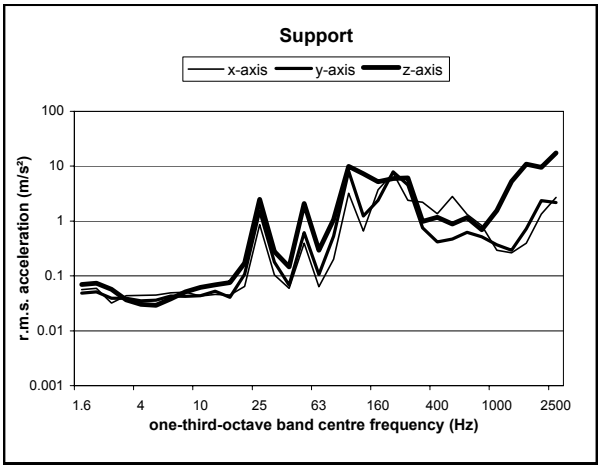


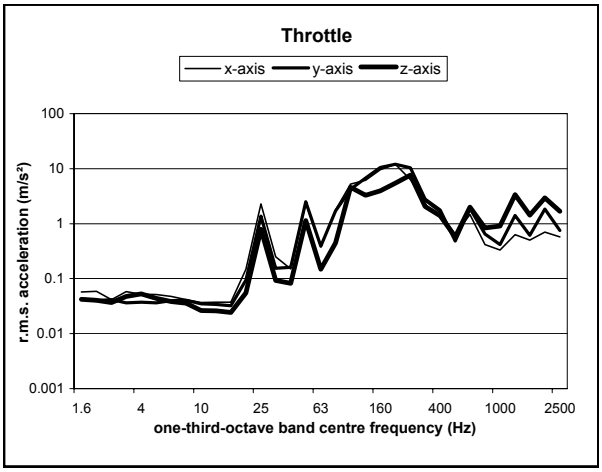


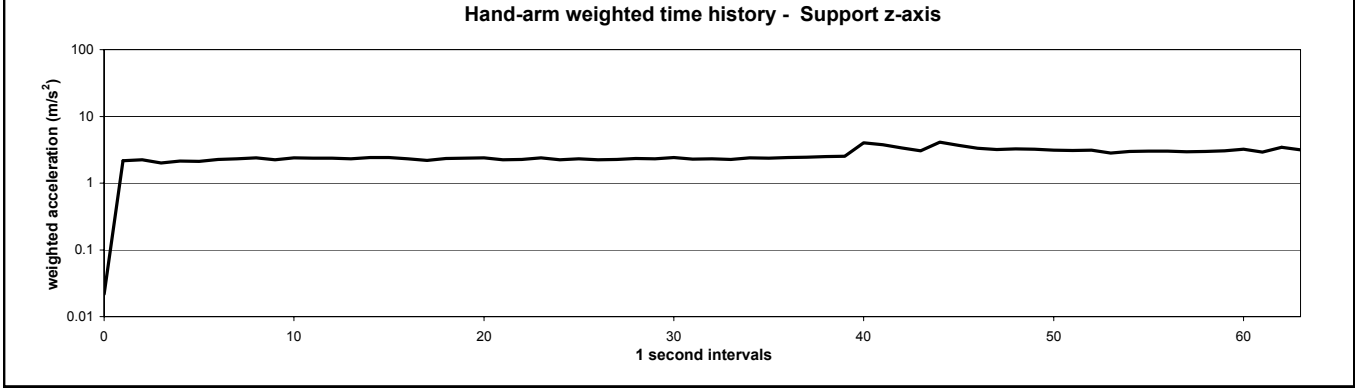


Results ID	JS2003826 210504 live tool2b op2
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	2
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.06	0.05	0.07	0.06	0.04	0.04
2	0.06	0.05	0.07	0.06	0.04	0.04
2.5	0.03	0.04	0.06	0.04	0.04	0.04
3.15	0.04	0.04	0.04	0.06	0.04	0.05
4	0.04	0.04	0.03	0.05	0.04	0.05
5	0.04	0.04	0.03	0.05	0.04	0.04
6.3	0.05	0.04	0.04	0.05	0.04	0.04
8	0.05	0.04	0.05	0.04	0.04	0.04
10	0.04	0.04	0.06	0.04	0.04	0.03
12.5	0.05	0.05	0.07	0.04	0.03	0.03
16	0.04	0.04	0.08	0.04	0.03	0.02
20	0.06	0.11	0.17	0.15	0.09	0.05
25	0.86	1.53	2.50	2.28	1.38	0.79
31.5	0.10	0.18	0.28	0.25	0.15	0.09
40	0.06	0.07	0.15	0.15	0.16	0.08
50	0.40	0.62	2.08	2.34	2.52	1.13
63	0.06	0.11	0.29	0.38	0.39	0.15
80	0.20	0.53	1.07	1.77	1.71	0.44
100	3.23	8.14	9.93	5.24	4.22	4.58
125	0.66	1.23	7.30	6.16	6.80	3.26
160	3.71	2.38	5.21	9.60	10.53	3.94
200	7.46	7.88	5.93	12.07	11.99	5.44
250	2.39	4.57	6.09	6.32	10.35	7.61
315	2.22	0.75	0.98	2.57	2.79	2.06
400	1.35	0.42	1.18	1.58	1.77	1.40
500	2.81	0.47	0.88	0.64	0.48	0.57
630	1.31	0.62	1.16	1.47	1.89	1.99
800	0.83	0.51	0.70	0.42	0.64	0.83
1000	0.29	0.37	1.55	0.33	0.42	0.91
1250	0.26	0.29	5.25	0.63	1.42	3.36
1600	0.40	0.72	10.92	0.50	0.61	1.42
2000	1.35	2.35	9.52	0.70	1.85	2.95
2500	2.68	2.17	17.53	0.57	0.75	1.67
Band limited	**10.18**	**12.69**	**16.84**	**19.21**	**21.28**	**12.40**
Band limited total (BS EN ISO 5349-1: 2001)		**23.41**			**31.24**	
Hand-arm weighted	**1.08**	**1.82**	**2.69**	**2.51**	**2.31**	**1.31**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**3.42**			**3.65**	

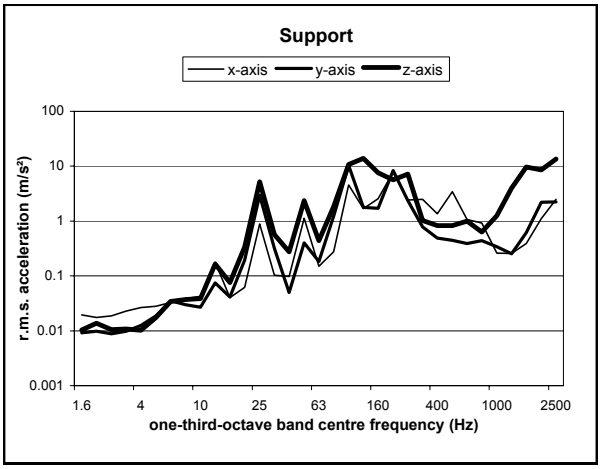


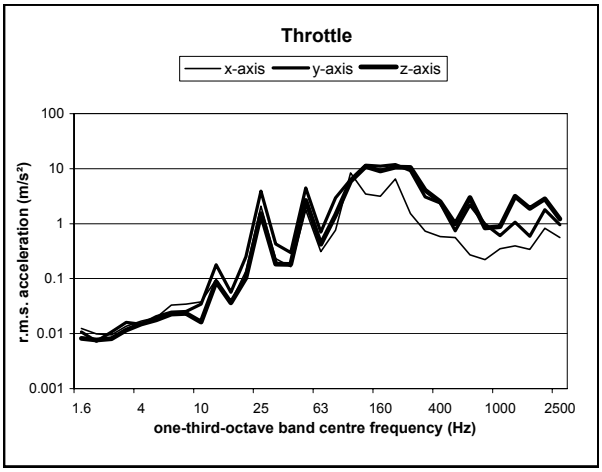


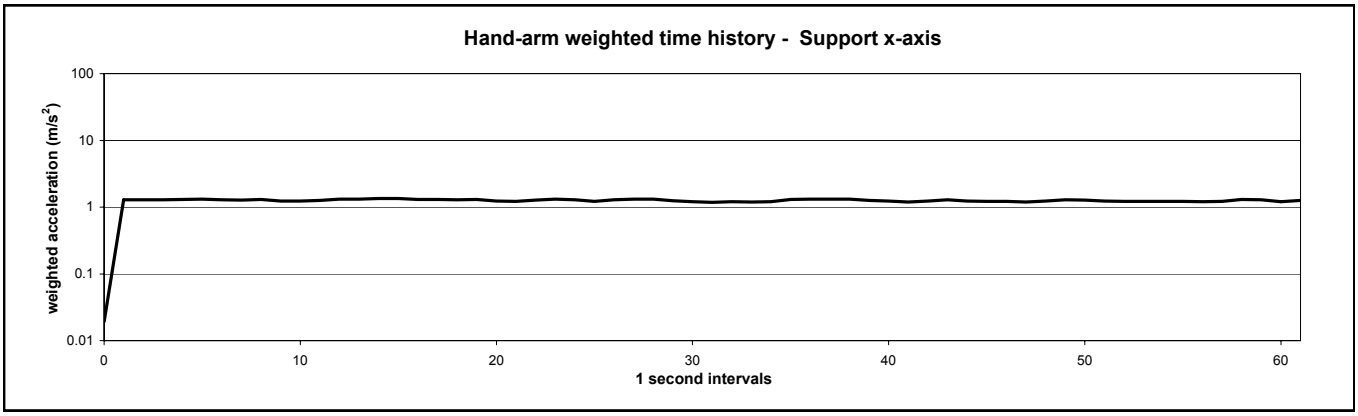


Results ID	JS2003826 210504 live tool2b op3
Equipment reference	B2
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Rotary nozzle with 3 rotating jets
Operator	3
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.02	0.01	0.01	0.01	0.01	0.01
2	0.02	0.01	0.01	0.01	0.01	0.01
2.5	0.02	0.01	0.01	0.01	0.01	0.01
3.15	0.02	0.01	0.01	0.01	0.02	0.01
4	0.03	0.01	0.01	0.02	0.01	0.02
5	0.03	0.02	0.02	0.02	0.02	0.02
6.3	0.03	0.04	0.03	0.03	0.02	0.02
8	0.04	0.03	0.04	0.03	0.03	0.02
10	0.04	0.03	0.04	0.04	0.03	0.02
12.5	0.18	0.07	0.16	0.10	0.18	0.09
16	0.04	0.04	0.08	0.04	0.06	0.04
20	0.06	0.19	0.34	0.14	0.25	0.10
25	0.89	2.95	5.21	2.09	3.90	1.53
31.5	0.10	0.32	0.57	0.23	0.43	0.18
40	0.10	0.05	0.28	0.17	0.30	0.18
50	1.13	0.40	2.35	1.77	4.44	2.66
63	0.15	0.18	0.44	0.31	0.70	0.42
80	0.28	1.22	1.82	0.76	2.95	1.43
100	4.57	10.31	10.71	8.36	6.29	5.92
125	1.68	1.78	13.90	3.46	11.60	11.00
160	2.56	1.70	7.61	3.15	11.05	9.12
200	7.79	8.33	5.64	6.53	11.91	10.72
250	2.42	2.36	7.14	1.53	9.18	10.47
315	2.49	0.78	1.02	0.73	3.07	4.08
400	1.36	0.49	0.83	0.58	2.39	2.51
500	3.44	0.44	0.83	0.56	0.74	0.98
630	1.07	0.39	1.00	0.27	2.19	3.00
800	0.92	0.44	0.63	0.22	0.98	0.83
1000	0.26	0.34	1.25	0.35	0.61	0.88
1250	0.26	0.25	3.96	0.39	1.06	3.14
1600	0.39	0.62	9.66	0.34	0.59	1.90
2000	1.11	2.20	8.51	0.82	1.80	2.83
2500	2.49	2.22	13.48	0.56	0.95	1.22
Band limited	**10.97**	**14.12**	**22.31**	**12.10**	**24.25**	**22.66**
Band limited total (BS EN ISO 5349-1: 2001)		**28.59**			**35.33**	
Hand-arm weighted	**1.26**	**2.66**	**4.40**	**2.14**	**3.83**	**2.60**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**5.29**			**5.10**	

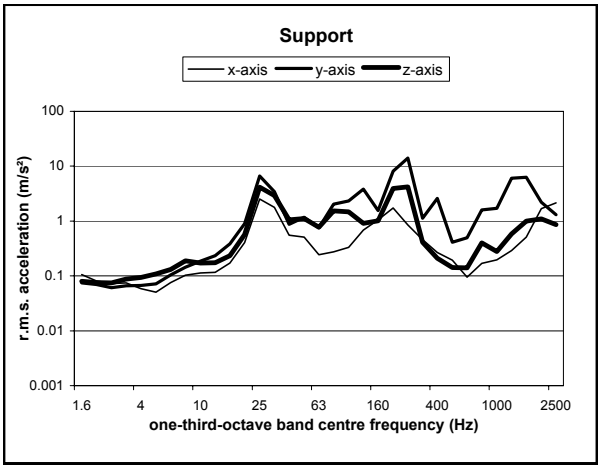


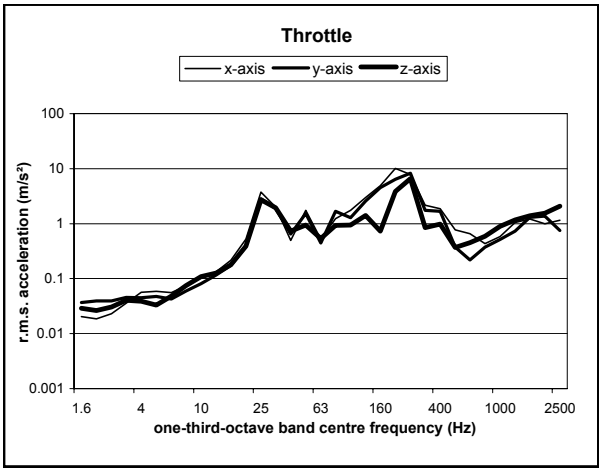


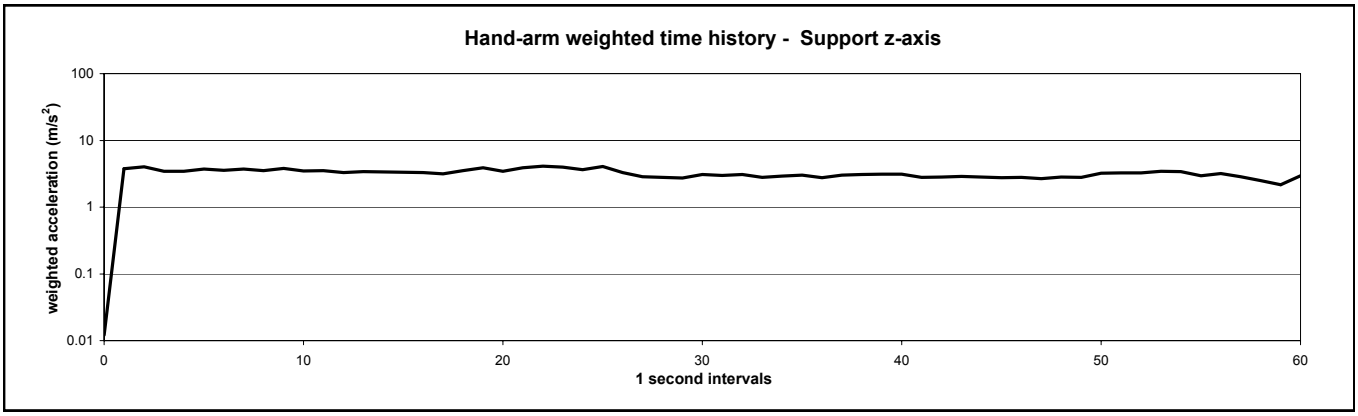


Results ID	JS2003826 210504 live tool3a op1
Equipment reference	B3
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	2500 bar orbital jet
Operator	1
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.11	0.07	0.08	0.02	0.04	0.03
2	0.08	0.07	0.08	0.02	0.04	0.03
2.5	0.07	0.06	0.07	0.02	0.04	0.03
3.15	0.07	0.07	0.09	0.04	0.05	0.04
4	0.06	0.07	0.09	0.06	0.04	0.04
5	0.05	0.07	0.11	0.06	0.05	0.03
6.3	0.08	0.10	0.13	0.06	0.04	0.05
8	0.10	0.14	0.19	0.07	0.06	0.08
10	0.11	0.19	0.17	0.10	0.08	0.11
12.5	0.12	0.23	0.17	0.13	0.12	0.13
16	0.17	0.38	0.23	0.22	0.17	0.18
20	0.40	0.90	0.57	0.52	0.39	0.39
25	2.53	6.66	4.15	3.73	2.82	2.73
31.5	1.78	3.45	2.91	2.01	1.90	1.95
40	0.55	0.88	1.05	0.50	0.65	0.73
50	0.51	1.17	1.12	1.74	1.53	0.95
63	0.24	0.75	0.78	0.52	0.45	0.53
80	0.27	2.03	1.54	1.22	1.68	0.94
100	0.33	2.34	1.47	1.75	1.28	0.95
125	0.68	3.84	0.91	3.00	2.57	1.41
160	1.05	1.56	1.01	4.92	4.53	0.73
200	1.72	8.07	3.92	10.06	6.43	3.83
250	0.85	14.06	4.18	7.88	8.26	6.58
315	0.46	1.12	0.41	2.17	1.75	0.84
400	0.27	2.59	0.21	1.87	1.68	0.98
500	0.19	0.41	0.14	0.77	0.38	0.37
630	0.10	0.49	0.14	0.65	0.22	0.45
800	0.17	1.60	0.40	0.43	0.37	0.59
1000	0.20	1.71	0.28	0.59	0.51	0.89
1250	0.29	6.07	0.59	1.04	0.73	1.17
1600	0.51	6.27	1.00	1.21	1.30	1.40
2000	1.69	2.20	1.10	0.99	1.37	1.54
2500	2.15	1.31	0.86	1.15	0.75	2.08
Band limited	**4.03**	**19.50**	**8.30**	**15.26**	**12.74**	**8.88**
Band limited total (BS EN ISO 5349-1: 2001)		**21.57**			**21.77**	
Hand-arm weighted	**1.96**	**4.96**	**3.25**	**3.00**	**2.41**	**2.21**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**6.24**			**4.43**	

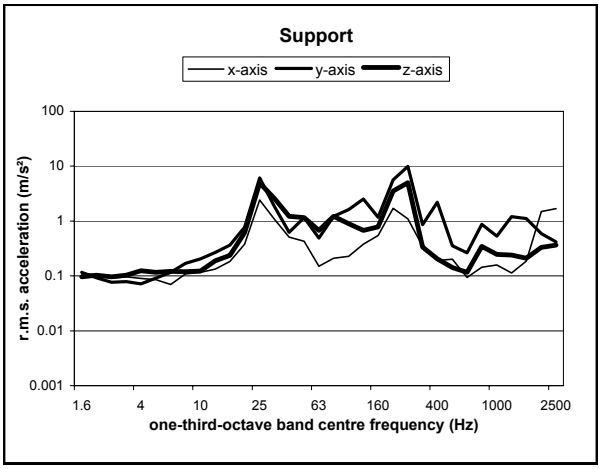


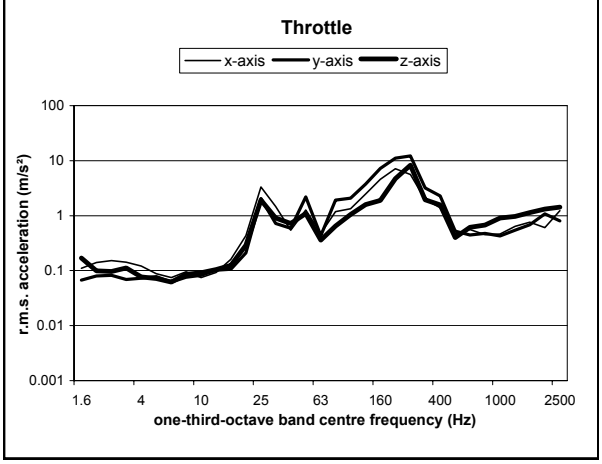


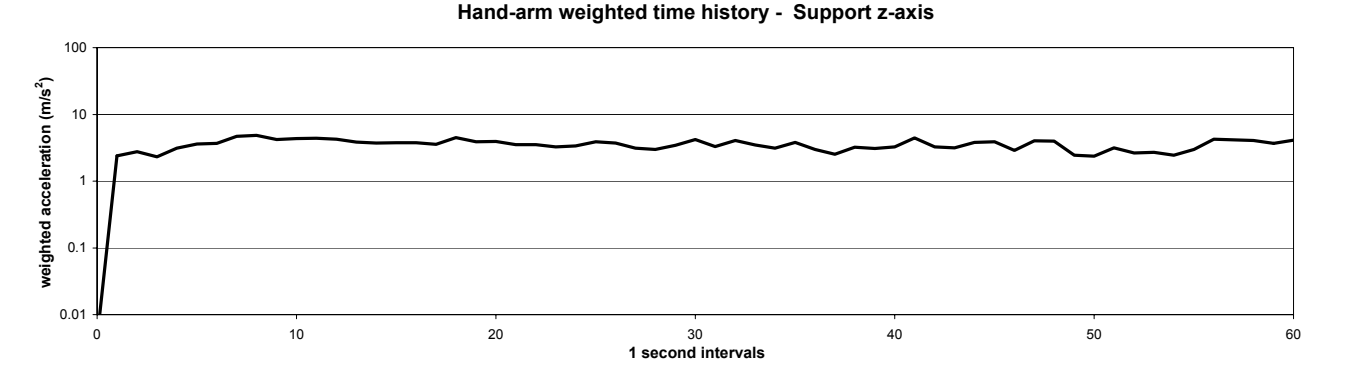


Results ID	JS2003826 210504 live tool3a op2
Equipment reference	B3
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	2500 bar orbital jet
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.11	0.12	0.10	0.11	0.07	0.17
2	0.11	0.09	0.10	0.14	0.08	0.10
2.5	0.09	0.08	0.10	0.15	0.08	0.10
3.15	0.10	0.08	0.10	0.14	0.07	0.11
4	0.09	0.07	0.12	0.12	0.07	0.08
5	0.09	0.09	0.12	0.09	0.08	0.07
6.3	0.07	0.12	0.12	0.07	0.06	0.06
8	0.11	0.17	0.12	0.10	0.08	0.09
10	0.12	0.20	0.12	0.07	0.08	0.09
12.5	0.13	0.27	0.19	0.09	0.10	0.10
16	0.18	0.36	0.24	0.16	0.11	0.13
20	0.38	0.77	0.61	0.43	0.21	0.29
25	2.42	6.09	4.95	3.32	2.06	1.92
31.5	1.08	1.86	2.59	1.46	0.72	0.91
40	0.51	0.62	1.22	0.54	0.59	0.72
50	0.43	1.16	1.16	1.27	2.20	1.10
63	0.15	0.49	0.67	0.48	0.43	0.36
80	0.21	1.23	1.22	1.18	1.91	0.65
100	0.23	1.61	0.90	1.33	2.07	1.05
125	0.38	2.53	0.67	2.49	3.73	1.60
160	0.55	1.18	0.78	4.56	7.26	1.90
200	1.70	5.62	3.54	7.15	11.16	4.69
250	1.10	9.86	4.99	5.58	12.19	8.29
315	0.35	0.86	0.34	1.97	3.20	1.94
400	0.19	2.20	0.20	1.38	2.29	1.58
500	0.20	0.35	0.14	0.46	0.52	0.40
630	0.09	0.27	0.12	0.56	0.44	0.61
800	0.14	0.87	0.35	0.45	0.47	0.67
1000	0.16	0.53	0.25	0.47	0.43	0.91
1250	0.11	1.20	0.24	0.64	0.54	0.97
1600	0.19	1.12	0.21	0.76	0.68	1.14
2000	1.50	0.59	0.33	0.61	1.08	1.33
2500	1.69	0.41	0.36	1.23	0.81	1.42
Band limited	**3.54**	**13.82**	**8.71**	**11.60**	**19.34**	**10.63**
Band limited total (BS EN ISO 5349-1: 2001)		**16.71**			**24.93**	
Hand-arm weighted	**1.73**	**4.26**	**3.62**	**2.54**	**2.24**	**1.62**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**5.85**			**3.75**	

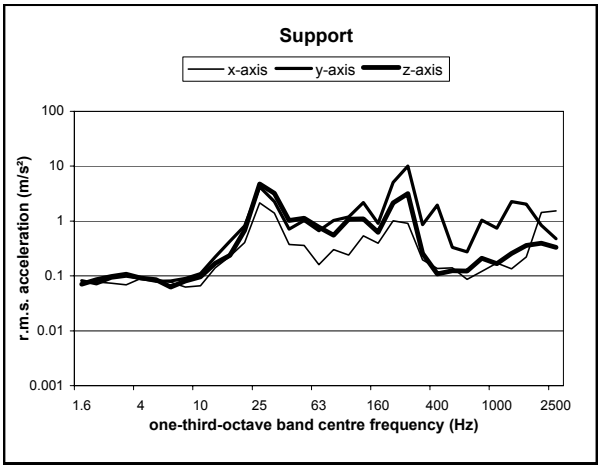


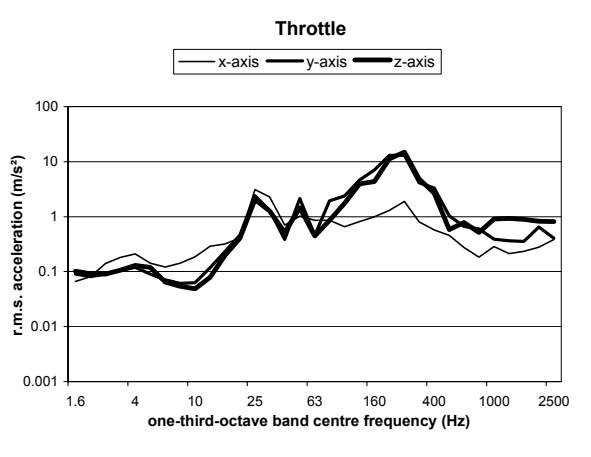


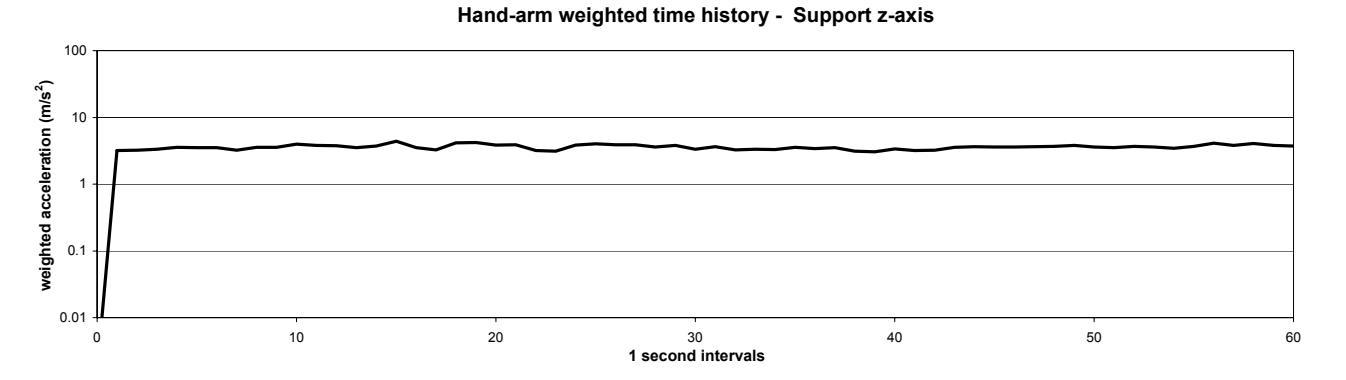


Results ID	JS2003826 210504 live tool3b op1
Equipment reference	B3
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	2500 bar orbital jet
Operator	1
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 20-40 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.07	0.08	0.07	0.07	0.09	0.10
2	0.08	0.07	0.09	0.08	0.08	0.09
2.5	0.07	0.09	0.10	0.14	0.09	0.09
3.15	0.07	0.10	0.11	0.18	0.10	0.11
4	0.09	0.09	0.09	0.21	0.12	0.13
5	0.09	0.08	0.08	0.14	0.09	0.12
6.3	0.08	0.08	0.06	0.12	0.07	0.06
8	0.06	0.09	0.08	0.14	0.06	0.05
10	0.07	0.11	0.10	0.19	0.06	0.05
12.5	0.14	0.22	0.17	0.29	0.12	0.08
16	0.23	0.43	0.24	0.32	0.23	0.20
20	0.40	0.82	0.67	0.41	0.46	0.40
25	2.14	4.19	4.77	3.11	2.39	2.05
31.5	1.39	2.26	3.22	2.28	1.30	1.26
40	0.37	0.72	1.02	0.71	0.38	0.51
50	0.36	1.02	1.13	1.02	2.14	1.45
63	0.16	0.66	0.77	0.86	0.45	0.44
80	0.30	1.02	0.55	0.86	1.94	0.86
100	0.24	1.19	1.08	0.65	2.38	1.74
125	0.54	2.18	1.09	0.81	4.62	3.93
160	0.39	0.91	0.62	1.00	7.09	4.36
200	1.01	5.05	2.14	1.31	13.11	11.22
250	0.91	10.00	3.18	1.89	12.97	14.90
315	0.20	0.86	0.26	0.80	4.09	4.84
400	0.14	1.95	0.11	0.58	3.34	2.67
500	0.14	0.33	0.12	0.45	1.03	0.58
630	0.09	0.27	0.12	0.27	0.67	0.79
800	0.12	1.03	0.21	0.18	0.60	0.51
1000	0.17	0.74	0.17	0.28	0.39	0.91
1250	0.13	2.26	0.26	0.21	0.36	0.93
1600	0.22	2.03	0.36	0.23	0.35	0.89
2000	1.44	0.84	0.40	0.28	0.65	0.82
2500	1.53	0.48	0.33	0.38	0.40	0.81
Band limited	**3.10**	**12.94**	**7.37**	**5.19**	**21.52**	**20.65**
Band limited total (BS EN ISO 5349-1: 2001)		**15.21**			**30.27**	
Hand-arm weighted	**1.63**	**3.21**	**3.63**	**2.47**	**2.56**	**2.22**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**5.11**			**4.19**	

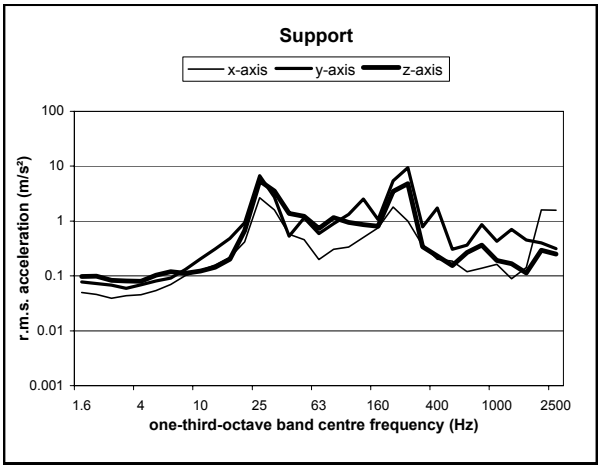


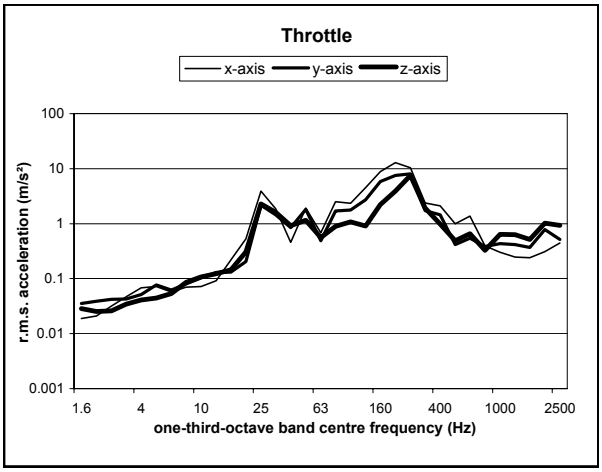


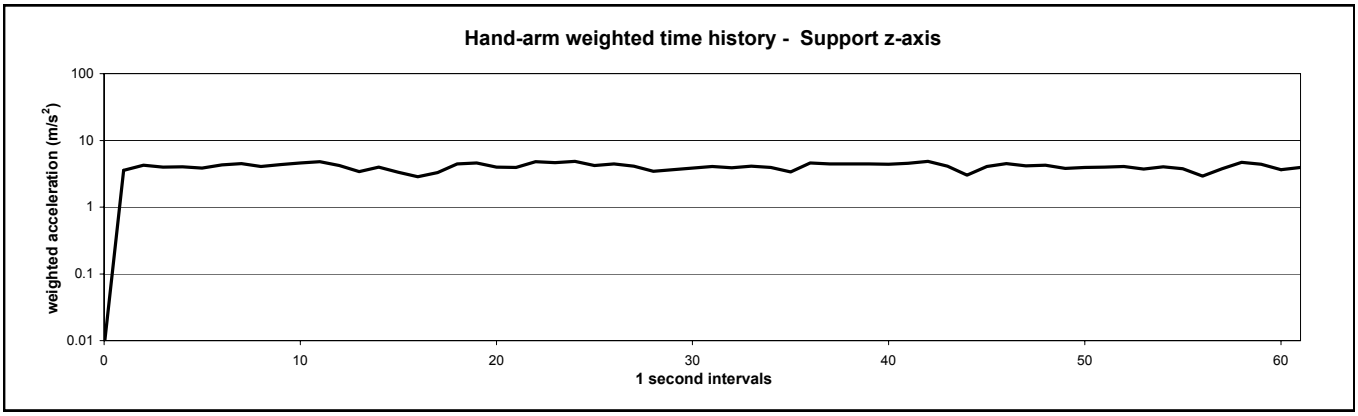


Results ID	JS2003826 210504 live tool3b op2
Field visit reference	B3
Pump unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	2500 bar orbital jet
Operator	2
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10-20 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.05	0.08	0.10	0.02	0.04	0.03
2	0.05	0.07	0.10	0.02	0.04	0.03
2.5	0.04	0.07	0.08	0.03	0.04	0.03
3.15	0.04	0.06	0.08	0.05	0.04	0.03
4	0.05	0.07	0.08	0.07	0.05	0.04
5	0.05	0.08	0.10	0.07	0.08	0.04
6.3	0.07	0.09	0.12	0.06	0.06	0.05
8	0.10	0.13	0.11	0.07	0.08	0.09
10	0.13	0.21	0.12	0.07	0.10	0.11
12.5	0.16	0.31	0.14	0.09	0.13	0.12
16	0.22	0.48	0.20	0.22	0.13	0.14
20	0.42	0.93	0.67	0.53	0.20	0.31
25	2.65	6.68	5.45	3.91	2.18	2.30
31.5	1.59	2.72	3.52	1.88	1.45	1.61
40	0.57	0.53	1.37	0.45	0.84	0.92
50	0.46	1.15	1.21	1.92	1.81	1.15
63	0.20	0.59	0.73	0.68	0.49	0.56
80	0.31	0.90	1.16	2.52	1.70	0.89
100	0.34	1.32	0.94	2.33	1.77	1.08
125	0.50	2.50	0.86	4.53	2.73	0.91
160	0.75	1.07	0.80	8.84	5.80	2.23
200	1.80	5.39	3.48	12.93	7.48	3.90
250	0.99	9.40	4.80	10.41	8.08	7.58
315	0.36	0.78	0.34	2.37	1.73	1.93
400	0.20	1.74	0.23	2.11	1.44	0.98
500	0.19	0.31	0.15	0.99	0.41	0.49
630	0.12	0.37	0.27	1.37	0.54	0.65
800	0.14	0.86	0.37	0.39	0.38	0.33
1000	0.16	0.43	0.19	0.30	0.43	0.64
1250	0.09	0.70	0.17	0.25	0.42	0.63
1600	0.14	0.45	0.11	0.24	0.37	0.51
2000	1.59	0.40	0.29	0.31	0.79	1.02
2500	1.57	0.32	0.25	0.45	0.51	0.93
Band limited	**3.99**	**13.67**	**9.25**	**20.54**	**13.61**	**9.83**
Band limited total (BS EN ISO 5349-1: 2001)		**16.98**			**26.53**	
Hand-arm weighted	**1.99**	**4.74**	**4.11**	**3.33**	**2.10**	**1.94**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**6.58**			**4.39**	

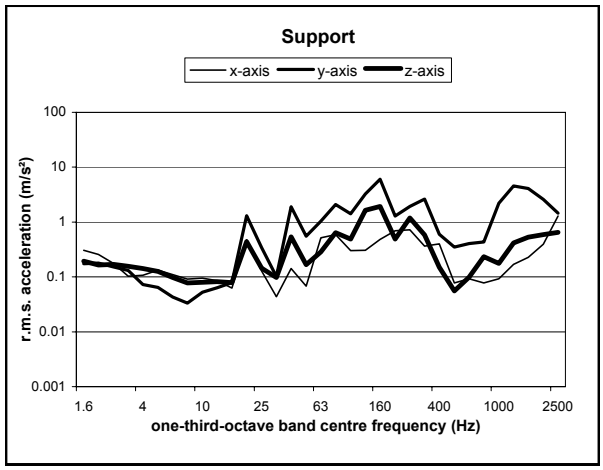


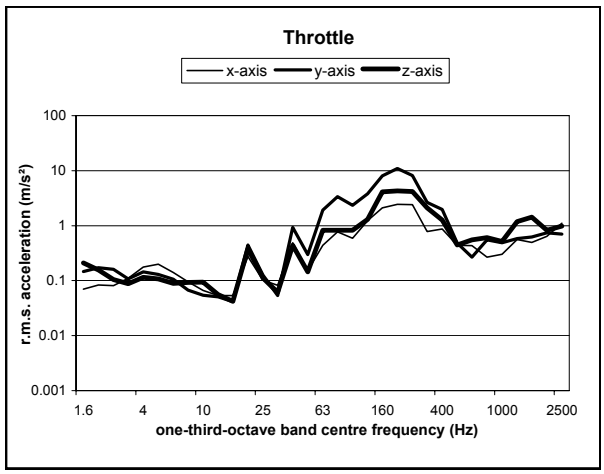


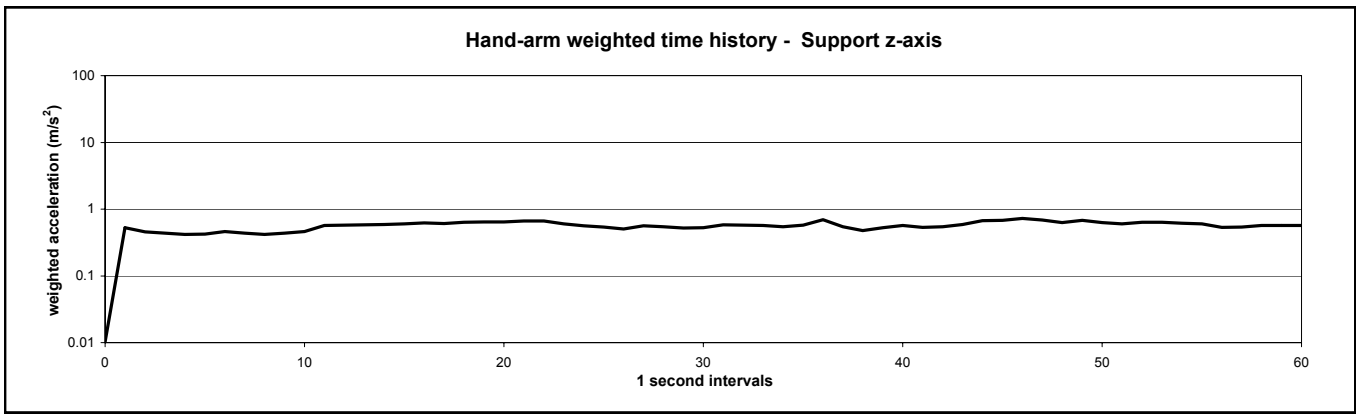


Results ID	JS2003826 210504 live tool4a op2
Equipment reference	B4
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Straight jet
Operator	2
Operation	Free air
Total sample duration	60 s from 1 sample
Measurement notes	Operator in a typical posture for water jetting towards a vertical target material. But no target material, so jet hitting ground.

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.30	0.17	0.19	0.07	0.15	0.21
2	0.26	0.18	0.16	0.08	0.17	0.16
2.5	0.18	0.15	0.17	0.08	0.16	0.11
3.15	0.10	0.13	0.16	0.11	0.11	0.09
4	0.11	0.07	0.14	0.18	0.14	0.11
5	0.13	0.06	0.13	0.20	0.13	0.11
6.3	0.11	0.04	0.10	0.14	0.11	0.09
8	0.09	0.03	0.08	0.09	0.07	0.09
10	0.10	0.05	0.08	0.07	0.05	0.09
12.5	0.09	0.06	0.08	0.05	0.05	0.06
16	0.06	0.08	0.08	0.05	0.04	0.04
20	0.47	1.30	0.44	0.28	0.44	0.38
25	0.13	0.34	0.14	0.10	0.13	0.11
31.5	0.04	0.10	0.10	0.08	0.05	0.06
40	0.14	1.91	0.54	0.49	0.93	0.44
50	0.07	0.55	0.17	0.15	0.30	0.14
63	0.51	1.04	0.28	0.44	1.93	0.82
80	0.59	2.09	0.64	0.77	3.37	0.82
100	0.30	1.42	0.49	0.59	2.33	0.82
125	0.31	3.27	1.64	1.23	3.81	1.29
160	0.48	6.04	1.93	2.10	8.03	4.10
200	0.70	1.29	0.49	2.45	10.97	4.29
250	0.72	1.92	1.18	2.42	8.15	4.18
315	0.36	2.63	0.58	0.78	2.64	2.10
400	0.40	0.60	0.15	0.87	1.97	1.27
500	0.08	0.35	0.06	0.44	0.48	0.44
630	0.09	0.40	0.10	0.43	0.27	0.55
800	0.08	0.43	0.23	0.27	0.55	0.60
1000	0.09	2.21	0.18	0.30	0.49	0.51
1250	0.17	4.54	0.42	0.56	0.58	1.18
1600	0.23	4.09	0.53	0.49	0.62	1.43
2000	0.39	2.60	0.59	0.64	0.74	0.83
2500	1.30	1.46	0.65	1.11	0.70	0.99
Band limited	**1.63**	**9.35**	**3.14**	**4.62**	**17.29**	**8.03**
Band limited total (BS EN ISO 5349-1: 2001)		**9.99**			**19.61**	
Hand-arm weighted	**0.47**	**1.62**	**0.57**	**0.55**	**1.76**	**0.80**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.79**			**2.01**	

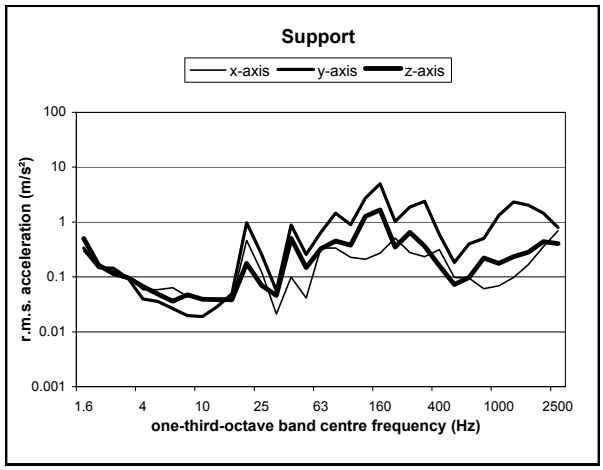


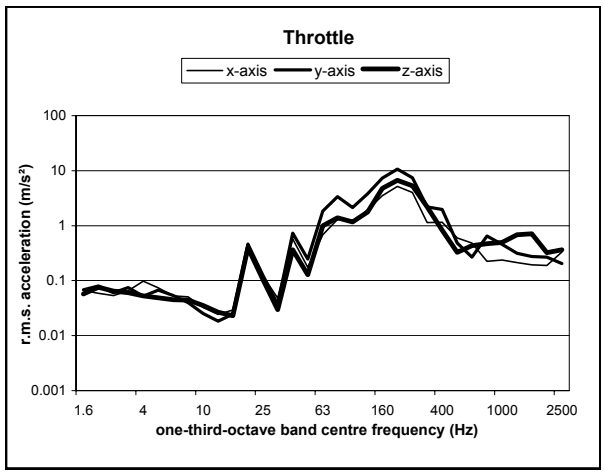


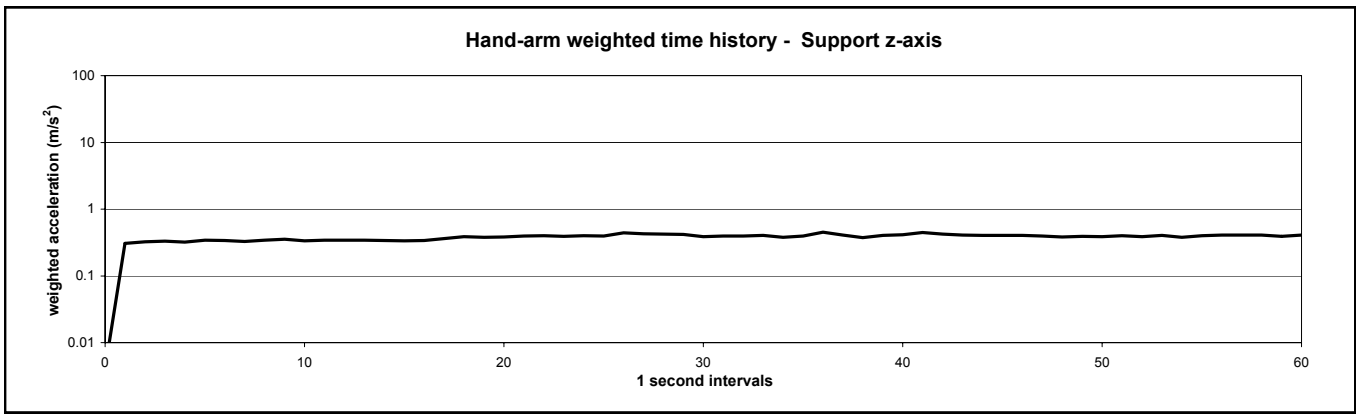


Results ID	JS2003826 210504 live tool4b op2
Equipment reference	B4
Jetting unit	Containerised pump unit producing 20 litres/min at 2200 bar
Water jetting gun	UHP dump gun
Nozzle type	Straight jet
Operator	2
Operation	Water jet directed at 20 mm thick rusty metal plate on ground
Total sample duration	60 s from 1 sample
Measurement notes	Nozzle approximately 10 cm from plate (in line with lance).

one-third-octave band centre frequency (Hz)	Support r.m.s. acceleration (m/s²)			Throttle r.m.s. acceleration (m/s²)		
	x-axis	y-axis	z-axis	x-axis	y-axis	z-axis
1.6	0.30	0.34	0.50	0.07	0.07	0.06
2	0.15	0.15	0.17	0.06	0.08	0.08
2.5	0.13	0.14	0.11	0.05	0.06	0.06
3.15	0.10	0.09	0.10	0.07	0.07	0.06
4	0.06	0.04	0.07	0.10	0.05	0.05
5	0.06	0.04	0.05	0.07	0.07	0.05
6.3	0.06	0.03	0.04	0.05	0.05	0.05
8	0.04	0.02	0.05	0.05	0.04	0.04
10	0.04	0.02	0.04	0.03	0.03	0.04
12.5	0.04	0.03	0.04	0.02	0.02	0.03
16	0.04	0.05	0.04	0.03	0.02	0.02
20	0.46	0.97	0.18	0.43	0.46	0.39
25	0.12	0.26	0.07	0.12	0.13	0.10
31.5	0.02	0.06	0.05	0.05	0.04	0.03
40	0.10	0.88	0.50	0.57	0.73	0.36
50	0.04	0.26	0.15	0.17	0.25	0.13
63	0.33	0.65	0.33	0.68	1.83	0.99
80	0.33	1.46	0.45	1.29	3.38	1.39
100	0.23	0.90	0.38	1.14	2.13	1.16
125	0.21	2.72	1.27	1.94	3.78	1.77
160	0.27	4.98	1.66	3.50	7.31	4.80
200	0.51	1.02	0.35	5.17	10.63	6.70
250	0.28	1.88	0.65	4.00	7.47	5.30
315	0.23	2.37	0.36	1.13	2.19	2.19
400	0.31	0.60	0.16	1.15	1.96	0.83
500	0.10	0.18	0.07	0.60	0.48	0.33
630	0.09	0.40	0.10	0.48	0.27	0.44
800	0.06	0.51	0.22	0.23	0.65	0.47
1000	0.07	1.32	0.18	0.24	0.46	0.49
1250	0.10	2.31	0.23	0.21	0.31	0.68
1600	0.17	2.03	0.28	0.19	0.28	0.71
2000	0.36	1.46	0.44	0.19	0.27	0.32
2500	0.69	0.80	0.40	0.33	0.21	0.36
Band limited	**1.08**	**7.23**	**2.44**	**8.12**	**16.30**	**10.48**
Band limited total (BS EN ISO 5349-1: 2001)		**7.71**			**21.02**	
Hand-arm weighted	**0.41**	**1.14**	**0.38**	**0.86**	**1.67**	**1.00**
Hand-arm weighted total (BS EN ISO 5349-1: 2001)		**1.27**			**2.13**	







APPENDIX G SITE A NOISE MEASUREMENT RESULTS

Table G1 Equipment A1

Operator and jet action	**Tripod mounted microphone**		**Dosemeter**		**Notes**
	L_{eq} dB(A)	**L_{Ceq}-L_{Aeq} dB**	**Max peak dB(C)**	**L_{eq} dB(A)**	
Op1 free air (1)	106.5	-0.2	121.5	Not available	-
Op1 work (1)	97.0	1.9	114.0	Not available	Jet length 10-20 cm from workpiece
Op1 free air (2)	107.5	-0.6	121.5	Not available	-
Op1 work (2)	103.0	1.7	120.0	Not available	Jet length 10-20 cm from workpiece
Op2 free air	104.0	-0.3	119.0	107.0	-
Op2 work	110.0	-0.5	125.0	115.0	Jet length 30-40 cm from workpiece
Op3 free air	104.5	-0.1	118.5	108.0	-
Op3 work	93.5	3.8	111.5	98.0	Jet length < 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2540 - 2570 bar.					

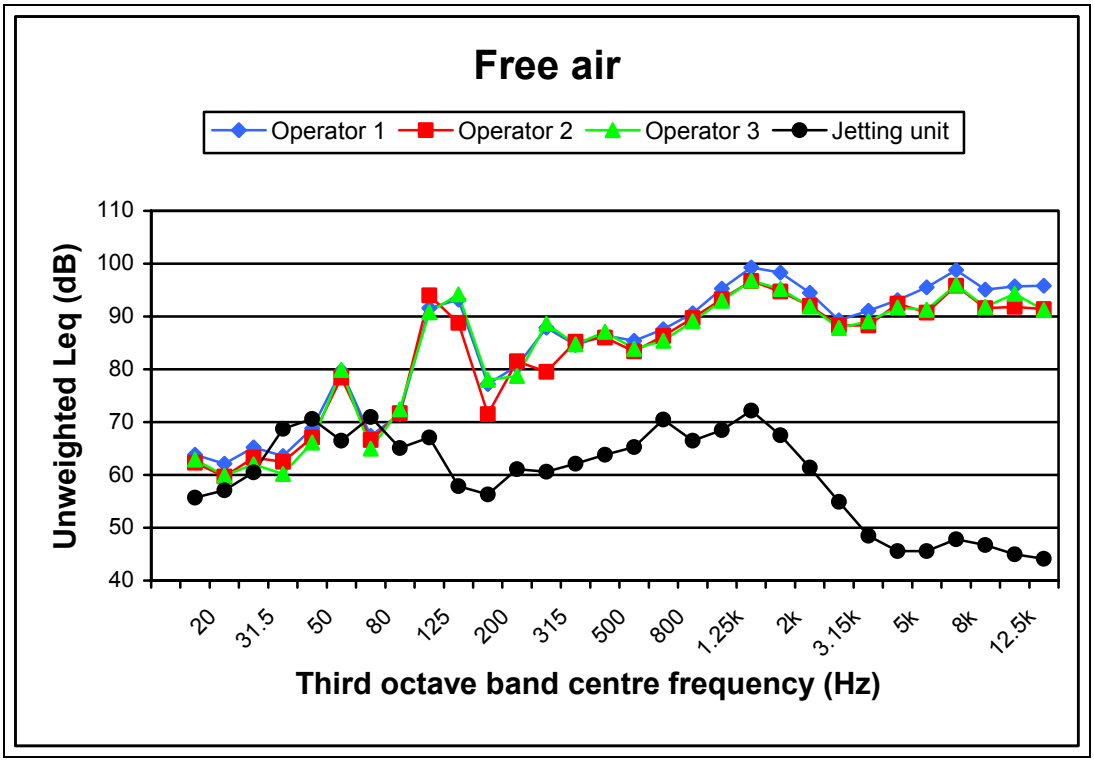


Figure G1 Equipment A1 (analyser files 3, 9, 11 and 21)

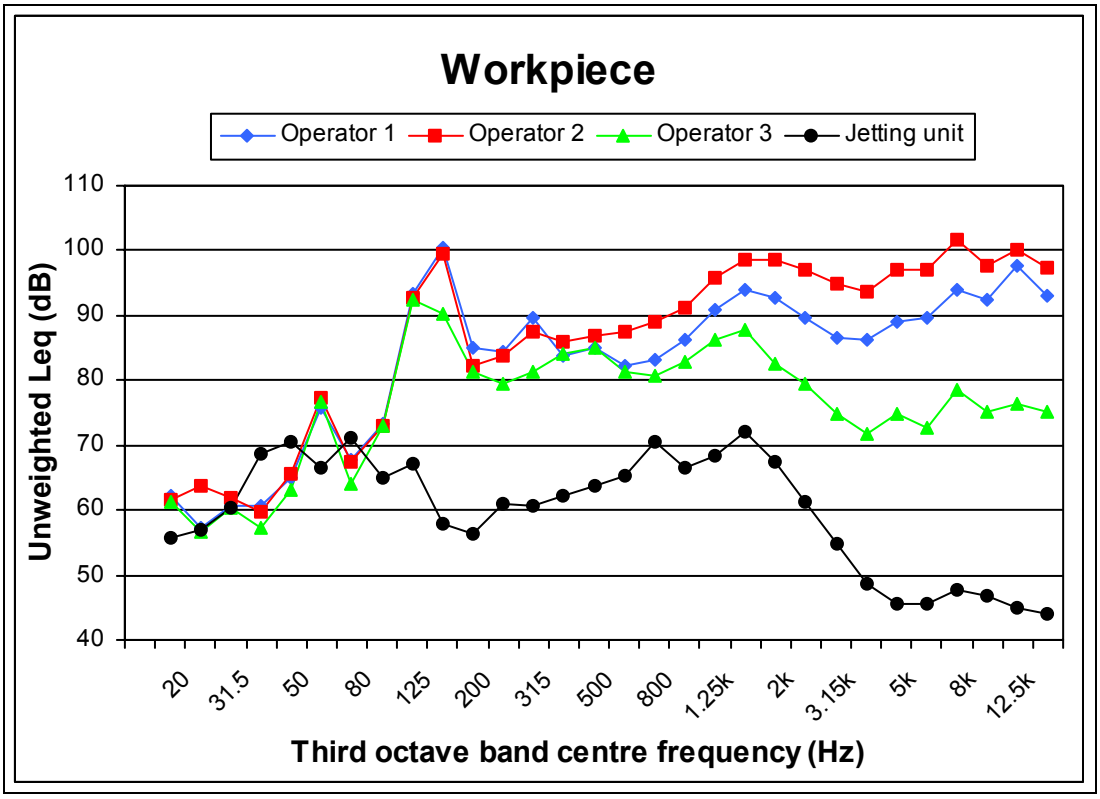


Figure G2 Equipment A1 (analyser files 2, 10, 12 and 21)

Table G2 Equipment A2

Operator and jet action	Tripod mounted microphone		Dosemeter		Notes
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB	Max peak dB(C)	L_{eq} dB(A)	
Op1 free air	112.5	-0.4	125.5	113.5	-
Op1 work	106.5	-0.9	124.0	112.0	Jet length 10-40 cm from workpiece
Op2 free air	112.5	-0.5	125.5	114.5	-
Op2 work	105.5	-0.5	120.0	115.0	Jet length 30-40 cm from workpiece
Op3 free air	114.5	-0.6	128.0	114.5	-
Op3 work	105.0	-0.8	118.0	110.5	Jet length < 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar.					

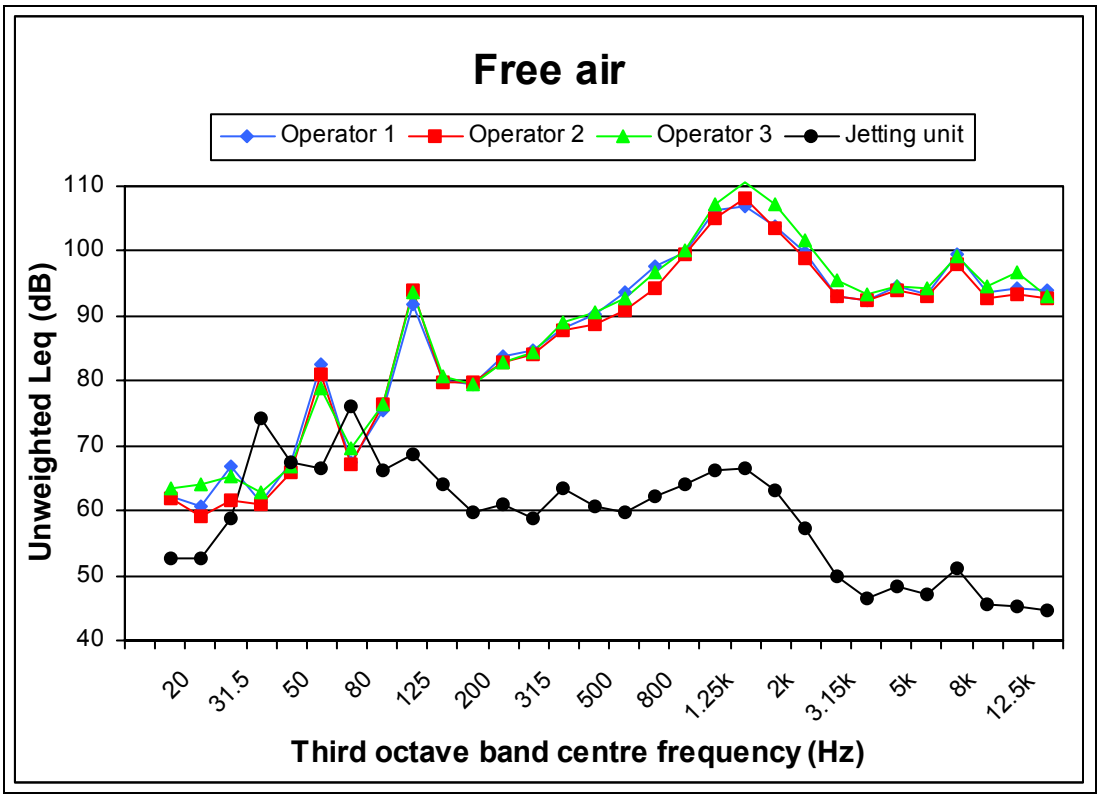


Figure G3 Equipment A2 (analyser files 5, 7, 13 and 23)

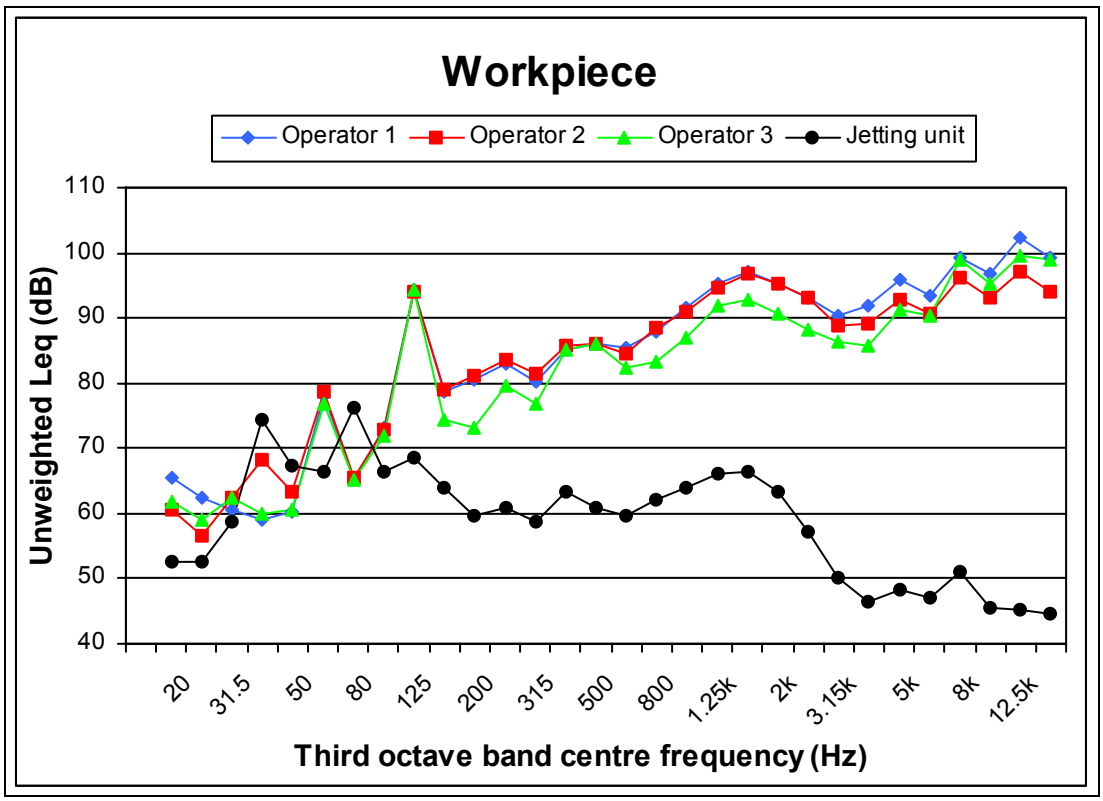


Figure G4 Equipment A2 (analyser files 6, 8, 14 and 23)

Table G3 Equipment A3

Operator and jet action	Tripod mounted microphone		Dosemeter		Notes
	L_{eq} dB(A)	**L_{Ceq}-L_{Aeq} dB**	**Max peak dB(C)**	**L_{eq} dB(A)**	
Op3 free air	108.0	-1.2	121.5	Not available	-
Op3 work	101.5	-0.5	116.0	108.5	Jet length < 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2000 bar.					

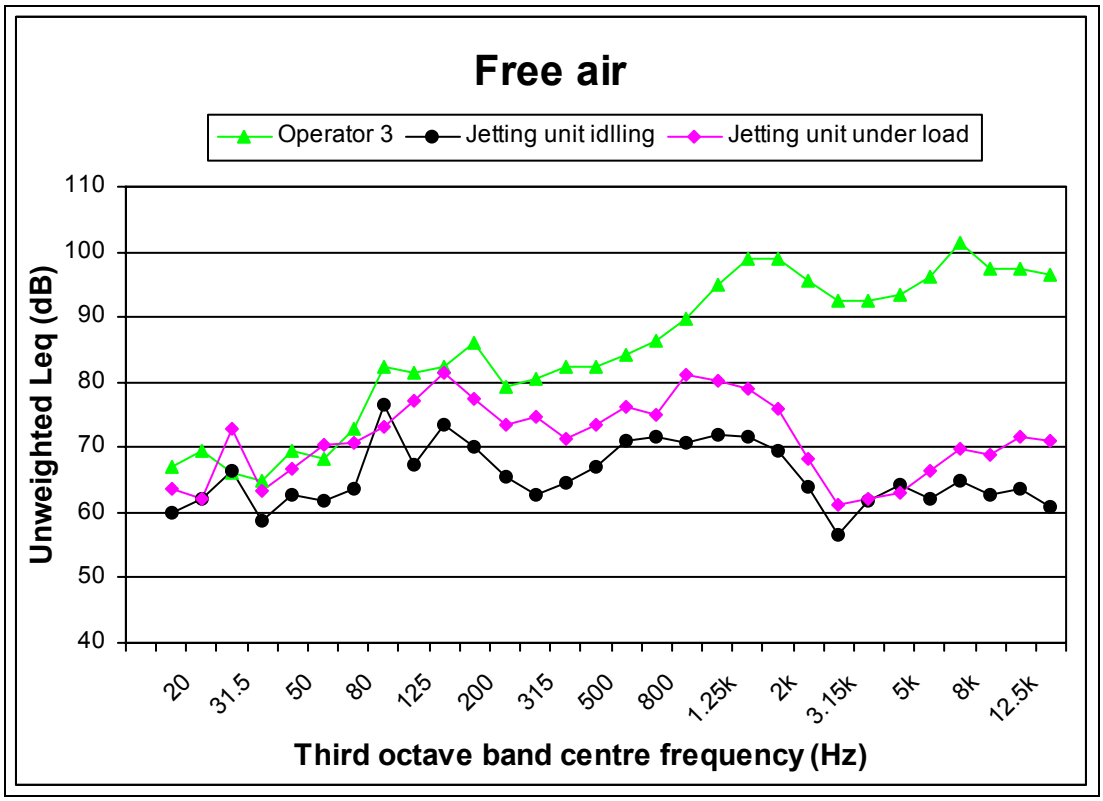


Figure G5 Equipment A3 (analyser files 15, 24 and 25)

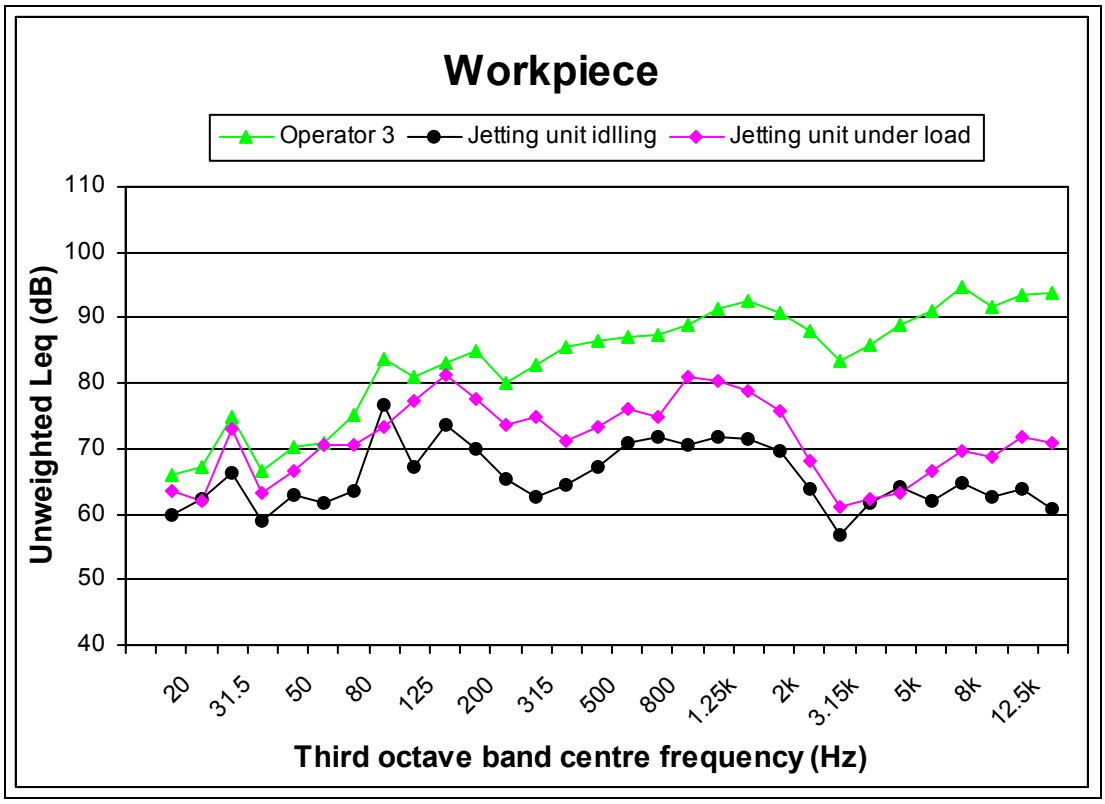


Figure G6 Equipment A3 (analyser files 16, 24 and 25)

Table G4 Equipment A4

Operator and jet action	Tripod mounted microphone		Dosemeter		Notes
	L_{eq} dB(A)	**L_{Ceq}-L_{Aeq} dB**	**Max peak dB(C)**	**L_{eq} dB(A)**	
Op3 free air	114.0	-0.6	128.0	114.5	-
Op3 work	111.5	-1.6	129.5	115.0	Jet length < 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar.					

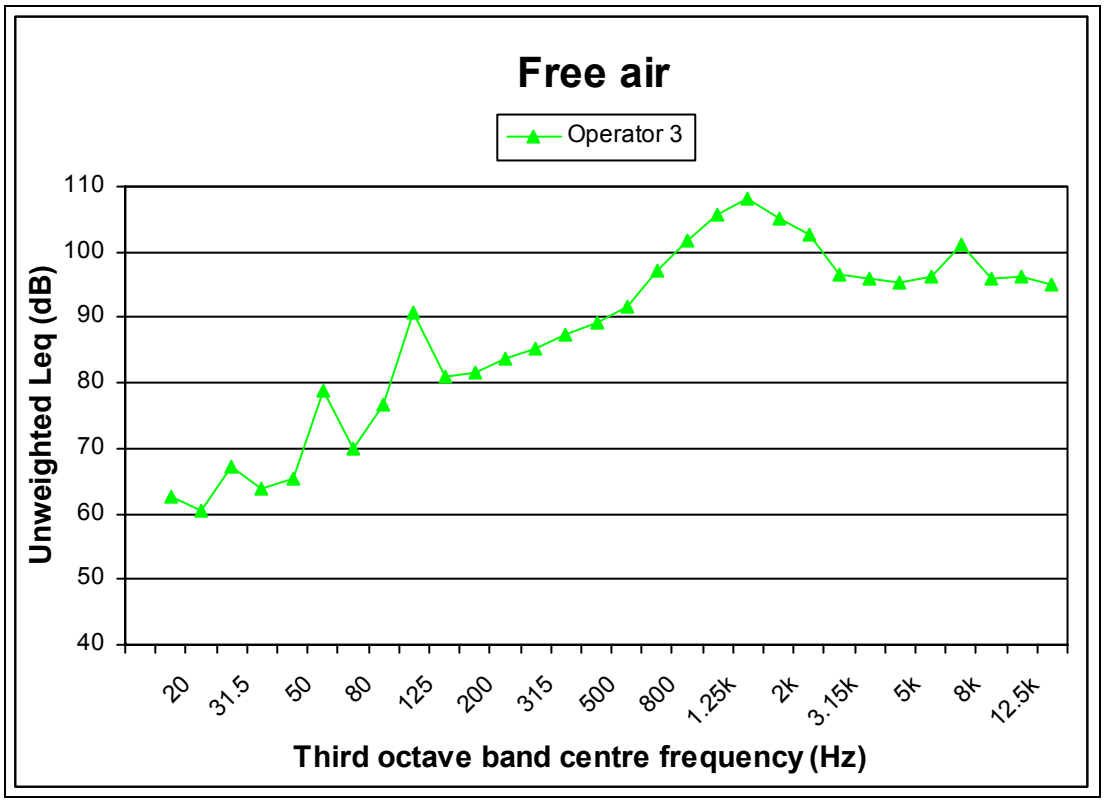


Figure G7 Equipment A4 (analyser file 17)

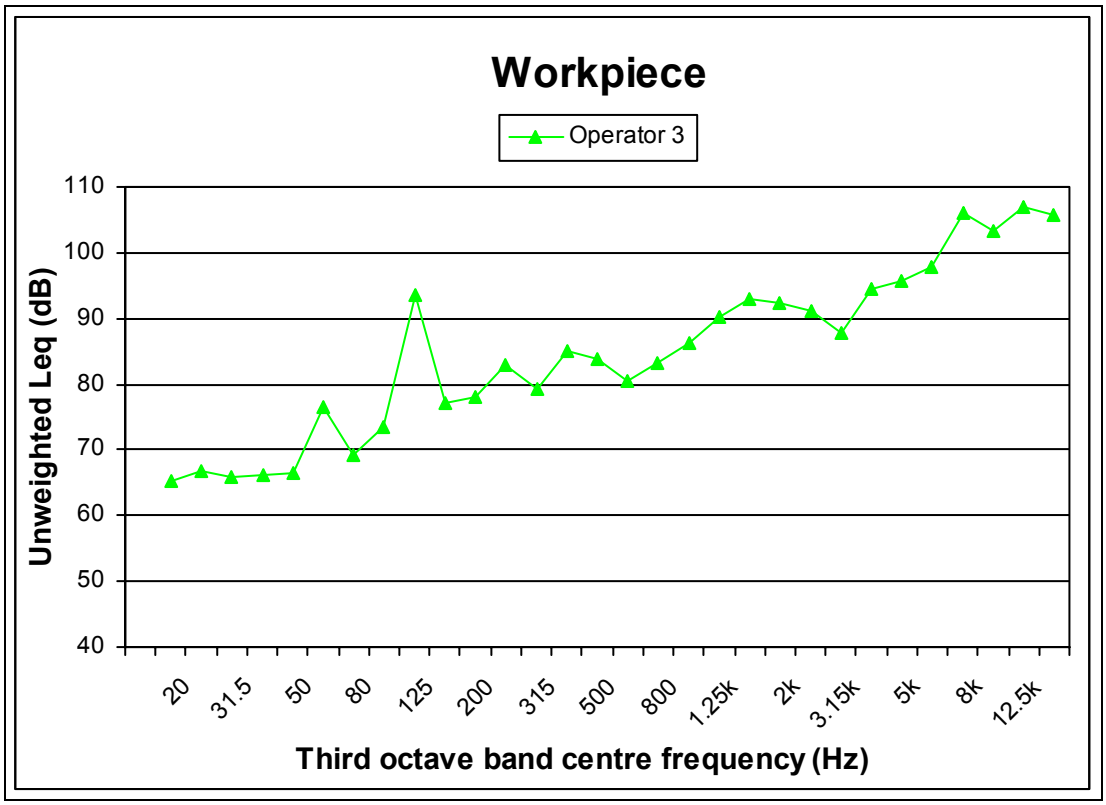


Figure G8 Equipment A4 (analyser file 18)

Table G5 Equipment A5

Operator and jet action	Tripod mounted microphone		Dosemeter		Notes
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB	Max peak dB(C)	L_{eq} dB(A)	
Op3 free air	104.5	-0.3	123.5	108.5	-
Op3 work*	95.5	4.1	113.5	95.0	Jet length of < 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2500 bar. * Internal mechanism out of balance towards end of measurement.					

Table G6 Compressor noise without water jetting noise

Operation	Tripod mounted microphone	
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB
A1-A2 jetting unit running before jet operation	77.0	2.6
A1-A2 jetting unit running before jet operation	72.5	7.0
A3-A5 jetting unit running before jet operation	79.5	3.2
A3-A5 jetting unit running under load with no jet	86.5	2.5
L_{Aeq} values rounded to nearest 0.5 dB.		

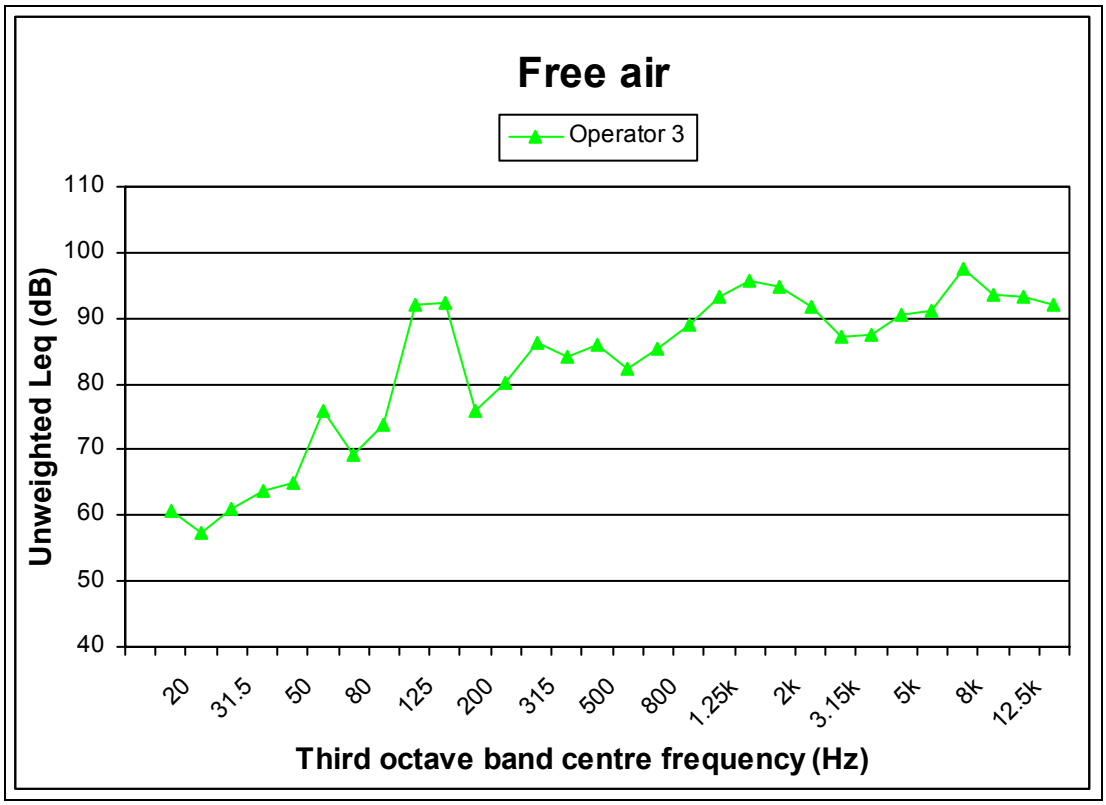


Figure G9 Equipment A5 (analyser file 19)

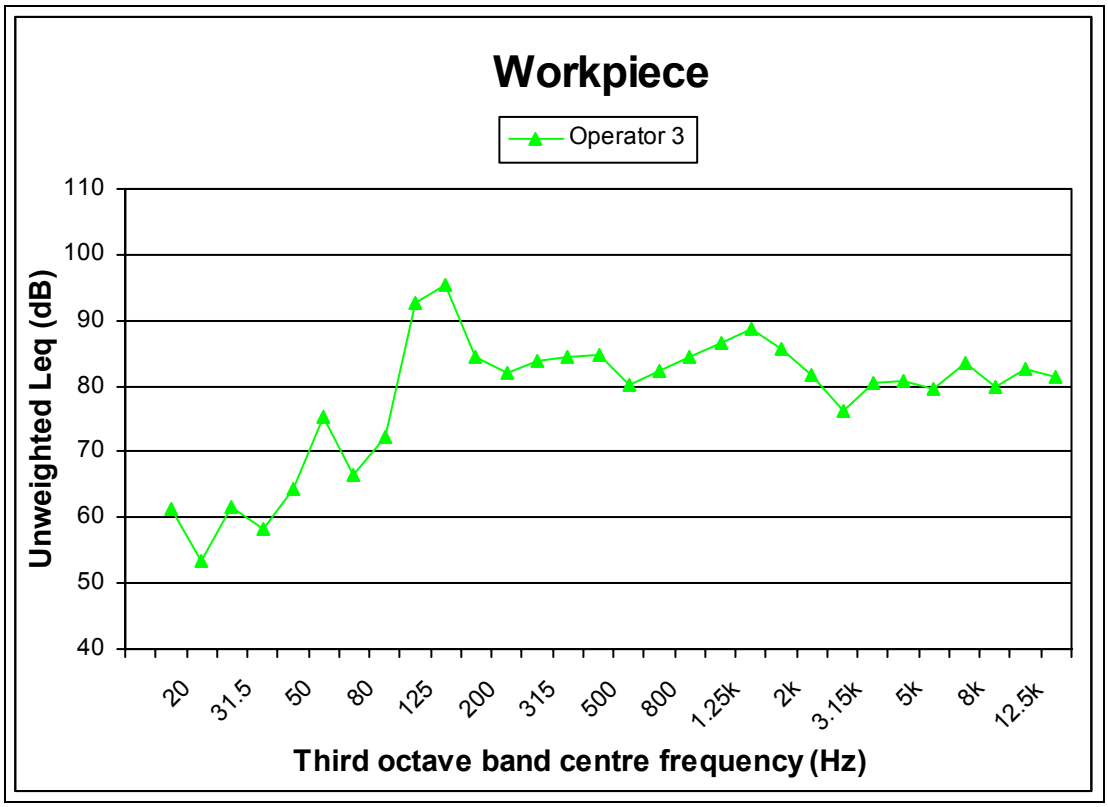


Figure G10 Equipment A5 (analyser file 20)

APPENDIX H SITE B NOISE MEASUREMENT RESULTS

Table H1 Equipment B1

Operator and jet action	Tripod mounted microphone			Dosemeter			Notes
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB	Max peak dB(C)	L_{eq} dB(A)	5s sample L_{eq} range dB(A)	Max peak dB(C)	
Op1 free air	119.5	-1.7	133.7	119.5	119.0 - 120.0	134.0	Jet angled at about 45º towards workpiece
Op1 work	108.5	-1.6	128.0	111.5	108.5 - 113.5	129.0	Jet length of 10-20 cm sometimes passing over workpiece edges
Op2 free air	117.5	-1.8	132.0	118.0	118.0	132.5	Jet angled at about 45º towards workpiece
Op2 work	106.5	-1.5	124.5	108.5	107.0 - 110.5	127.0	Jet length of 10-20 cm sometimes passing over workpiece edges
Op3 free air	121.0	-1.7	135.0	120.0	119.5 - 120.0	136.0	Long jet away from workpiece
Op3 work	105.5	-1.5	120.5	110.5	108.5 - 112.5	127.0	Jet length of 10-20 cm from workpiece
Op2 free air*	119.0	-1.7	133.0	118.5	117.5 - 119.0	133.5	Jet angled at about 45º towards workpiece
Op2 work*	107.5	-1.6	122.5	110.0	108.5 - 112.0	126.0	Jet length of 10-20 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar except * is 2500 bar.							

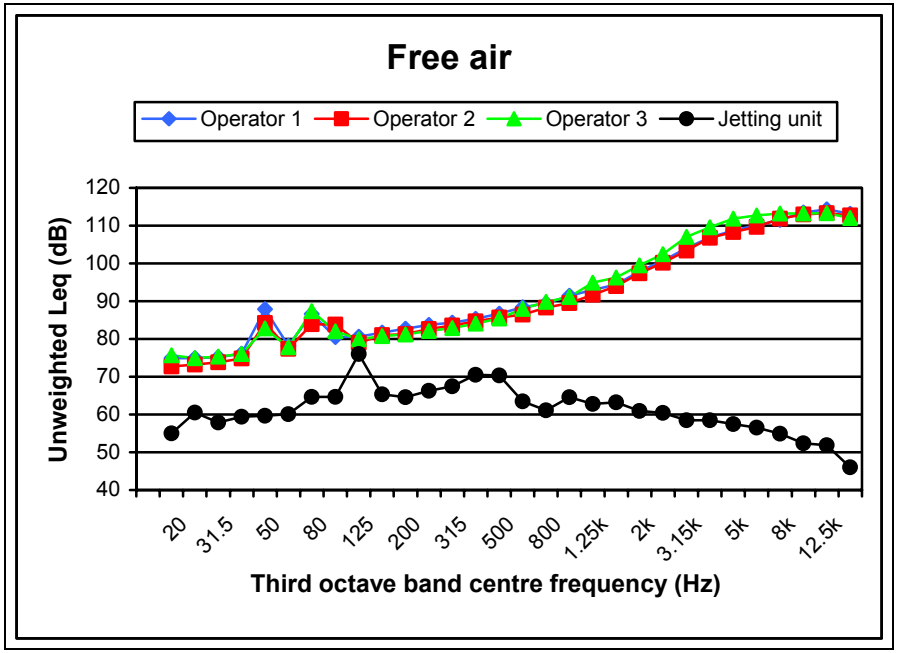


Figure H1 Equipment B1 (analyser files 5, 6, 8 and 28)

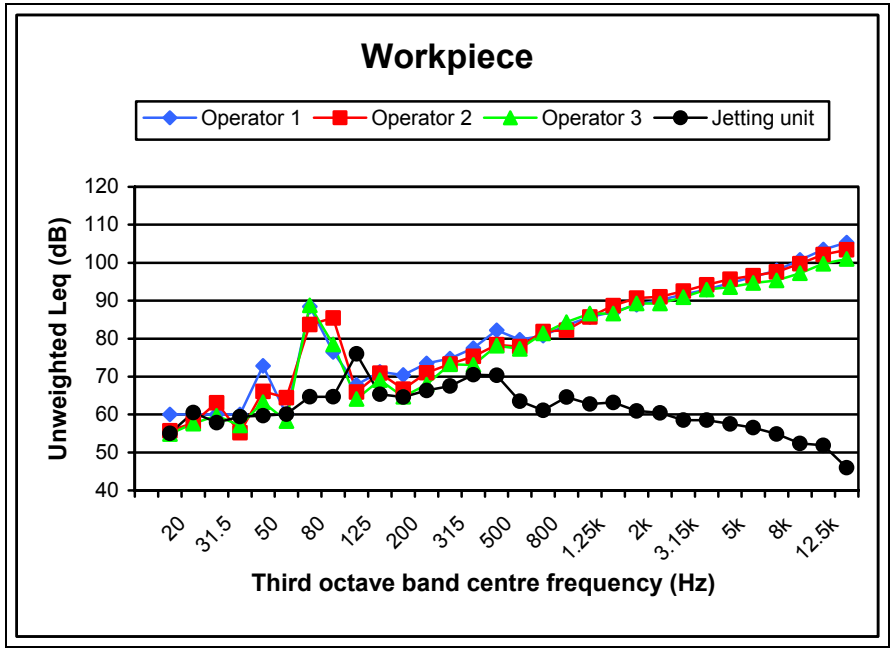


Figure H2 Equipment B1 (analyser files 30, 7, 9 and 28)

Table H2 Equipment B2

Operator and jet action	Tripod mounted microphone			Dosemeter			Notes
	L_{eq} dB(A)	**L_{Ceq}-L_{Aeq} dB**	**Max peak dB(C)**	**L_{eq} dB(A)**	**5s sample L_{eq} range dB(A)**	**Max peak dB(C)**	
Op1 free air	124.5	-1.7	138.5	125.5	124.5 - 126.5	142.0	Long jet away from workpiece
Op1 work	113.5	-1.7	128.5	113.5	110.0 - 115.5	130.0	Jet length of 10-30 cm from workpiece
Op2 free air	123.0	-1.7	139.0	123.0	122.5 - 123.9	138.5	Jet angled at about 45º towards workpiece
Op2 work	109.5	-1.5	127.0	110.5	109.5 - 110.5	131.0	Jet length of 10 cm from workpiece
Op3 free air	124.5	-1.6	139.5	Overload			Long jet away from workpiece
Op3 work	107.5	-1.5	124.0	112.0	112.0 - 112.5	129.0	Jet length of 10-20 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar.							

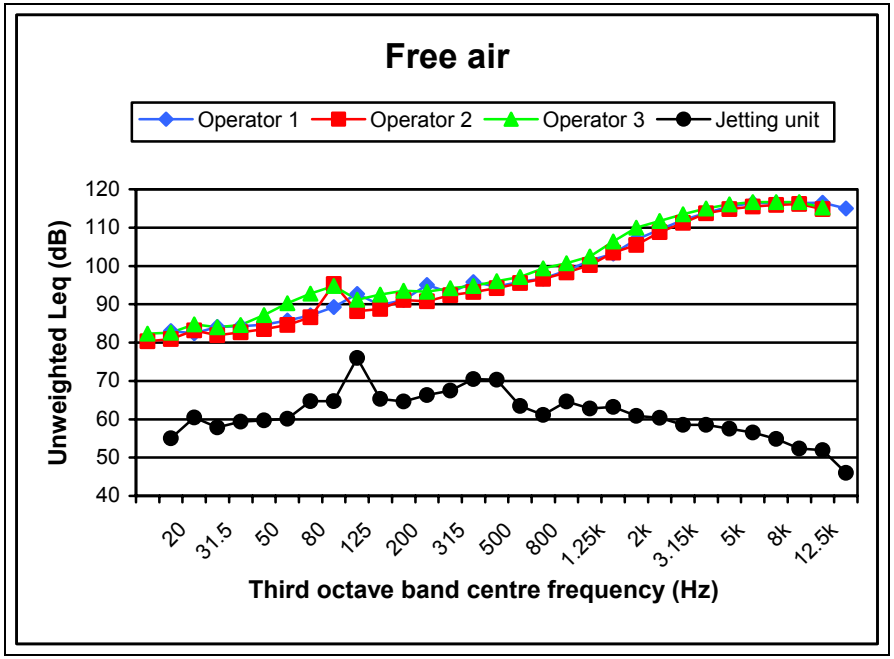


Figure H3 Equipment B2 (analyser files 14, 16, 12 and 28)

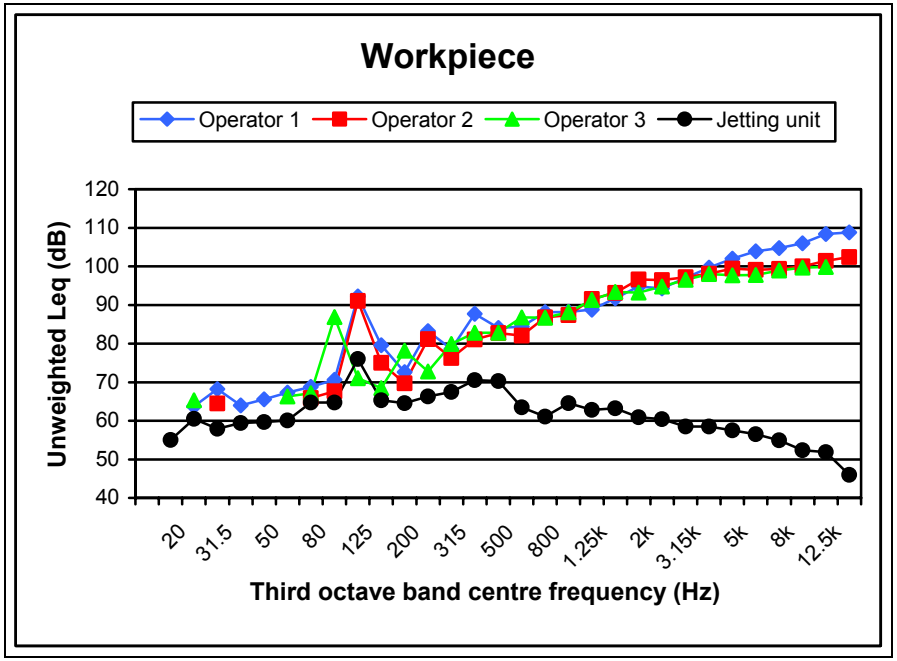


Figure H4 Equipment B2 (analyser files 15, 17, 13 and 28)

Table H3 Equipment B3

Operator and jet action	Tripod mounted microphone			Dosemeter			Notes
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB	Max peak dB(C)	L_{eq} dB(A)	5s sample L_{eq} range dB(A)	Max peak dB(C)	
Op1 free air	127.5	-1.5	141.5	Overload			Long jet away from workpiece
Op1 work	112.5	-1.5	131.0	113.5	112.5 - 116.5	134.5	Jet length of 20-40 cm from workpiece
Op2 free air	114.0	-1.6	129.0	115.0	113.5 - 116.0	131.0	Jet angled at about 45º towards workpiece
Op2 work (1)	112.5	-1.5	126.5	114.5	113.5 - 115.0	128.0	Jet length of 10-20 cm from workpiece
Op2 work (2)	111.5	-1.4	124.5	113.5	112.0 - 114.0	128.5	Jet length of 10-30 cm from workpiece
Op2 free air	121.5	-1.6	136.5	124.0	120.5 - 126.0	142.0	Long jet towards workpiece
Op2 work	112.0	-1.4	127.5	114.5	114.0 - 115.5	130.5	Jet length of 10-20 cm sometimes passing over workpiece edges
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar.							

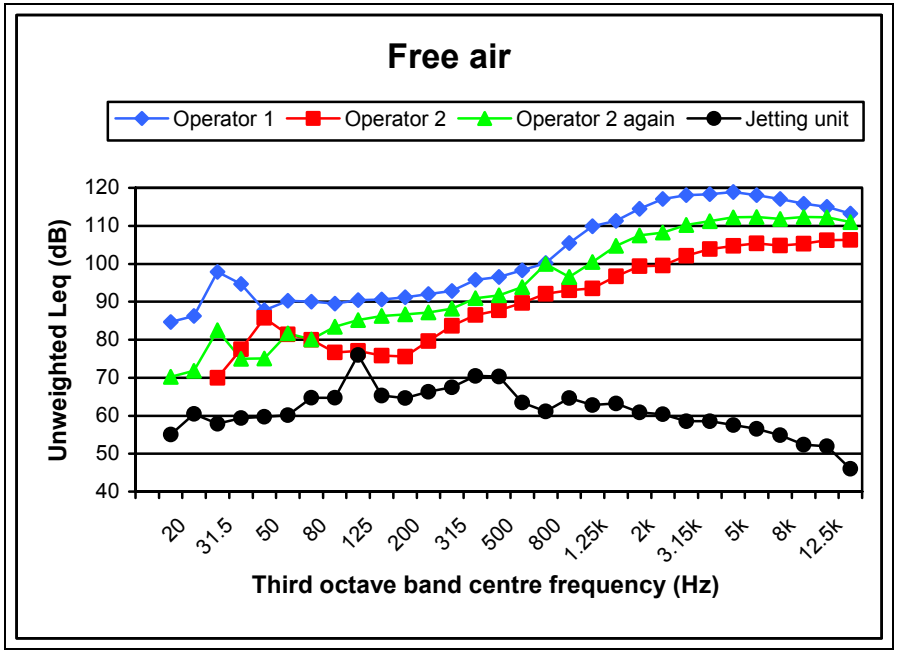


Figure H5 Equipment B3 (analyser files 22, 18, 24 and 28)

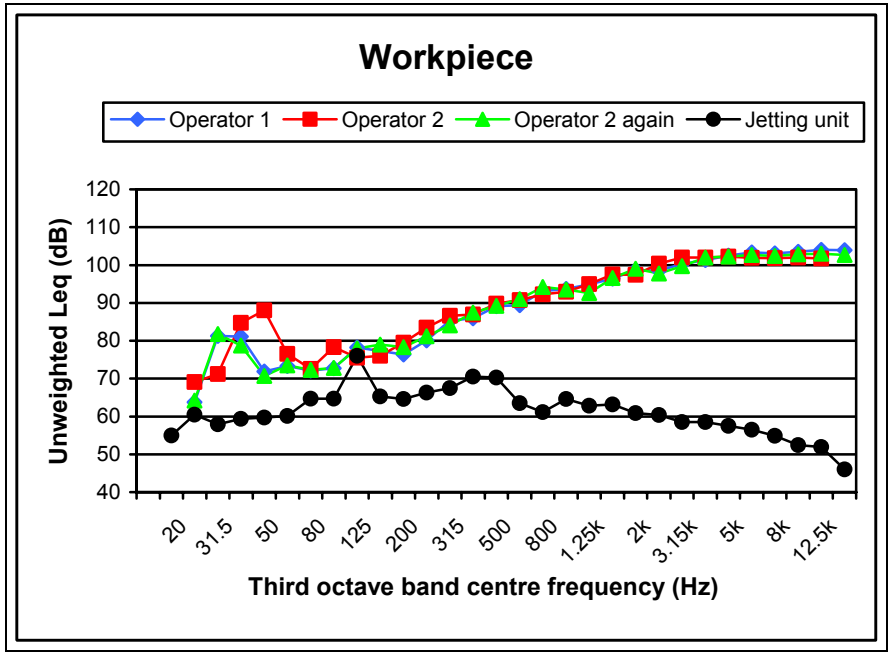


Figure H6 Equipment B3 (analyser files 23, 20, 25 and 28)

Table H4 Equipment B4

Operator and jet action	Tripod mounted microphone			Dosemeter			Notes
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB	Max peak dB(C)	L_{eq} dB(A)	5s sample L_{eq} range dB(A)	Max peak dB(C)	
Op2 free air	123.5	-1.5	137.0	Overload			Long jet towards workpiece
Op2 work	110.5	-1.7	124.0	113.0	112.5 - 114.0	129.5	Jet length of 10 cm from workpiece
Data rounded to nearest 0.5 dB (except for L_{Ceq}-L_{Aeq}). Operating pressure 2200 bar.							

Table H5 Compressor noise without water jetting noise

Operation	Tripod mounted microphone	
	L_{eq} dB(A)	L_{Ceq}-L_{Aeq} dB
Jetting unit running before jet operation	68.5	+8.0
Jetting unit running at full load (jet test valve)	73.5	+6.2
L_{Aeq} values rounded to nearest 0.5 dB. Operating pressure 2200 bar.		

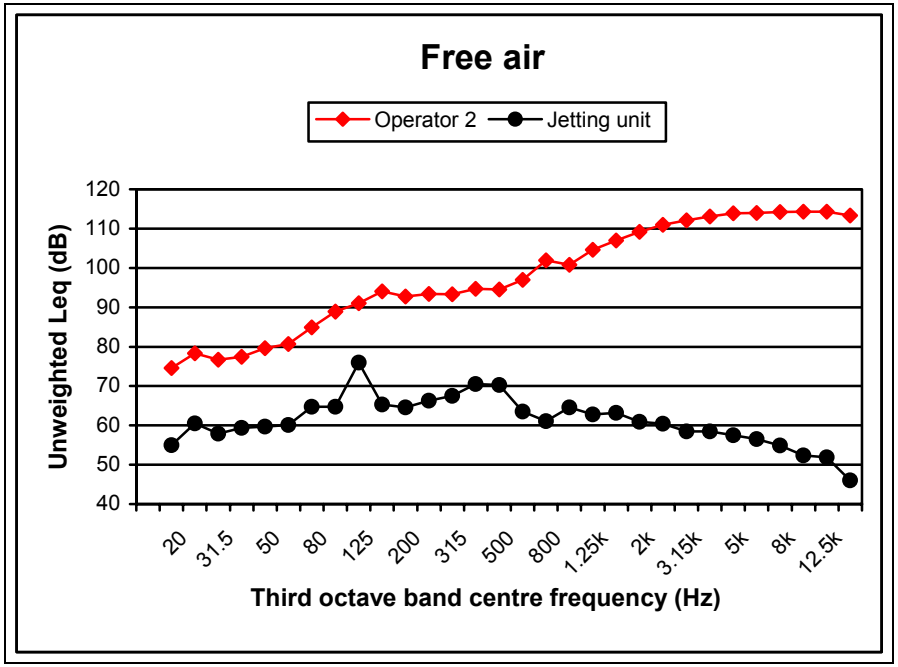


Figure H7 Equipment B4 (analyser files 26 and 28)

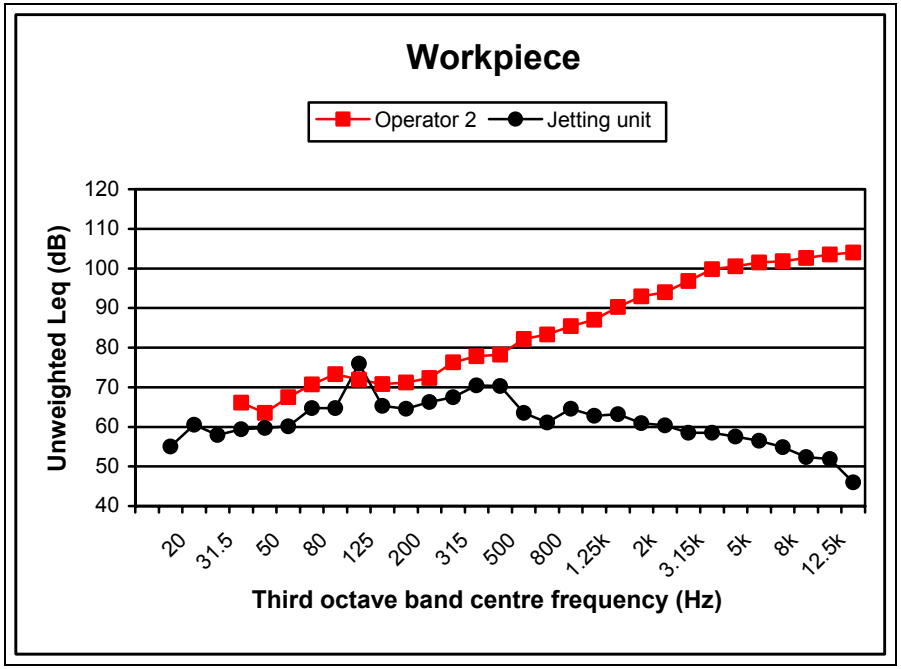


Figure H8 Equipment B4 (analyser files 27 and 28)