

HAND-ARM VIBRATION IN FOUNDRIES



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First published 2001

ISBN 0 7176 1798 X

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This booklet was prepared by the Foundries Industry Advisory Committee and has been agreed by the Health and Safety Commission. It contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

**Foundries
Industry
Advisory
Committee**

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Hand-arm vibration in foundries

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HSE BOOKS





Introduction

This booklet was produced by The Health and Safety Executive's (HSE) Metals and Minerals Sector in collaboration with the Castings Development Centre. The Foundries Industry Advisory Committee (FIAC) and its Noise and Vibration Subcommittee were consulted during its production. It is aimed at all levels of management, safety officers, safety representatives and others within the foundry industry who may require guidance on how to reduce the risks of hand-arm vibration syndrome (HAVS). Sources of guidance on other aspects of HAVS management which could also be of relevance to your foundry are listed in the Further reading section.

What is hand-arm vibration syndrome?

Vibration experienced in many foundry processes can cause a range of disabling health complaints that are known collectively as 'hand-arm vibration syndrome' (HAVS). The best known of these is 'vibration white finger' (VWF) which is caused by the effects of vibration on the body's blood circulation.

Other damage may be caused to the nerves and muscles of the fingers and hands causing numbness and tingling, reduced grip strength and sensitivity. HAVS is a reportable disease under the Reporting of Injuries, Diseases and Dangerous Occurrences (RIDDOR) Regulations 1995.¹

Studies indicate that around half of all foundry workers exposed to hand-arm vibration show symptoms of VWF.² Often, symptoms take several years to develop, but they may appear after only a few months in susceptible people. A 1996 HSE study³ found VWF in 25% of a group of fettlers; a further 11% showed other symptoms of HAVS.

What are the risks?

The risk of suffering from HAVS depends on both:

- the level of vibration to which the individual is exposed; and
- the time of exposure (both in terms of hours per day and years of work).

Hand-transmitted vibration is expressed in terms of the acceleration of the equipment in contact with the hand. The figure given is normally given in metres per second squared (m/s^2), eg $2.8m/s^2$.

An employee's daily vibration exposure depends upon the size of this figure as well as the length of time that the employee is exposed to the vibration.

The aim should be to reduce the amount of exposure of each employee to as low as is reasonably practicable. The HSE action level is 2.8m/s^2 averaged over an eight-hour day. Even if exposure to vibration can be reduced to the level of 2.8m/s^2 , wherever it is reasonably practicable to reduce exposure further, then this should be done.

The table below shows the relationship between vibration and time.

Table 1

Average vibration levels over the working day which cause an average over an 8-hour working day (often expressed as A(8)) of 2.8m/s^2

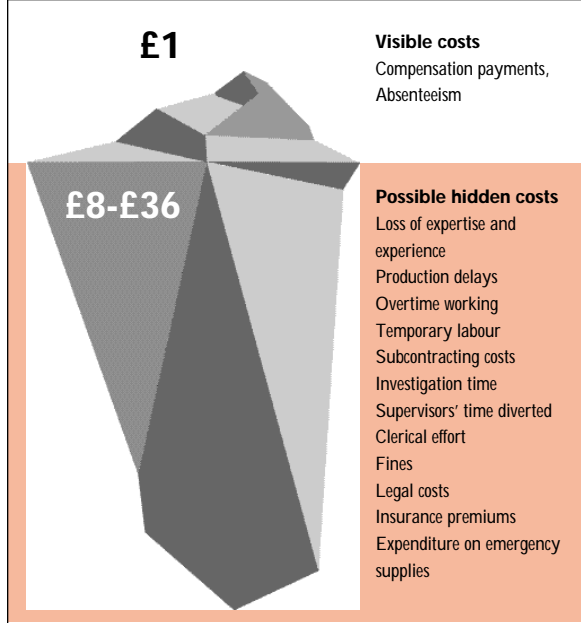
Length of working day in hours	16	8	4	2	1	0.5
Average vibration level (m/s^2) over a workingday to give the action level of 2.8m/s^2 (A8)	2	2.8	4	5.6	8	11.2

What are the costs of HAWS to employers?

Survey findings⁴ suggest that 20% of VWF sufferers take an average of 12 days per year sick leave because of their condition. Sufferers often make a claim for compensation from their employers, and settlements can be substantial - six-figure sums have been paid out. Agreements between certain unions and insurance companies mean that large numbers of claims are settled out of court on an agreed monetary scale. The real costs to employers can be hidden since they include additional costs such as extra administration, recruiting and training of replacement staff, and higher insurance premiums.⁵

HSE studies have shown that, just like an iceberg, the true costs to an employer of failing to manage hand-arm vibration (HAV) are not always immediately visible.

Figure 1 Typical costs of HAVS to employers



Key legal duties

Employers have a duty under the Health and Safety at Work etc Act 1974 to provide and maintain working conditions and practices that are, so far as is reasonably practicable, safe and without risks to health. The Management of Health and Safety at Work Regulations 1996 expand on this general duty, and require employers to make a suitable and sufficient assessment of the risk to health (including HAVS) and to make suitable arrangements to control those risks. This includes appropriate health surveillance regarding risks.⁶ In addition, there are further requirements to ensure the suitability of tools and equipment, and their maintenance, under the Provision and Use of Work Equipment Regulations 1998.⁷

Where is there a risk of HAVS in the foundry?

A suitable risk assessment should be carried out to establish whether there is a problem caused by vibration in the foundry. Advice on carrying out an assessment is given in Foundries information sheet No 10 *Assessing the need for action*. Where a problem is identified, then action should be taken to reduce the risk from HAV.

The risk of HAVS is highest in, but not restricted to the dressing shop. The whole foundry process, from initial design onwards, should be considered and the following questions asked:

Questions to ask

- Can the foundry be organised so as to reduce the exposure of individuals to vibration?
- Can improved design eliminate or reduce the need for fettling? This will reduce the risk of HAVS. Also, since the costs of fettling can constitute anything up to 50% of the cost of a casting, then a reduction in the need for fettling can reduce the overall costs in the foundry.
- Can the exposure of people to vibration be reduced by control measures: ie improved, vibration-reduced tools; better tool selection; and better maintenance regimes for tools etc?
- Do employees know how to protect themselves?

The hierarchy of control

In order to reduce hand-arm vibration, you should use the control measures listed overleaf. Each listed measure should be examined in turn, and if reasonably practicable, applied before the next measure is considered. Remember that not all of the control measures may be applicable or practicable in your foundry. In some cases, you may need to apply more than one control measure to achieve an acceptable reduction in exposure to vibration.

The hierarchy of control

- 1 Elimination**
modifying the process to eliminate the need for the hazardous operation.
- 2 Substitution**
using an alternative operation to achieve the same aims, but with a lower risk.
- 3 Engineering controls**
reducing the risk from the operation by engineering means.
- 4 Management controls**
limiting the exposure or risk of exposure by management techniques.
- 5 Personal protection**
last resort measures if adequate control cannot be achieved by other means.
(It is of limited application to HAVS.)

Elimination

There are three main methods by which fettling can be eliminated, so reducing exposure to vibration along with the possible benefits of reducing dust and noise. All need close co-operation between the different foundry departments for these solutions to be effective.

- Design casting and runner systems to allow for non-manual cut-off/knock-off. Correct positioning of runners and risers can allow the use of semi-automatic cut-off machines, knock-off guns, hydraulic wedges or other non-manual methods (see pages 11 and 12).
- Control flash by changes in pattern design and tolerances, binder system, cope/drag alignment tolerances, clamping/weighting arrangements and wall thickness/reinforcement (see pages 14 and 15).
- Produce the casting after knock-off/cut-off in a form suitable for direct machining.

Ask if your customer requires a high standard of fettling. If not, you can lower your costs as well as reduce your employees exposure to vibration.

These approaches to elimination can be fully utilised by mechanised foundries with long production runs, but some may be used by jobbing foundries to good effect.

Substitution

With any substitution, it is important to fully assess all the risks from both the original and proposed new operations so that the overall benefit can be determined. Possible solutions include the use of autofettlers, cropping machines and semi-automatic surface grinders, which mainly apply to mechanised, long-run foundries. There may be vibration-reduced alternatives to chipping and grinding, such as flame cutting (though this can have the disadvantage of increased fumes), or alternatives to conventional grindwheels such as belts. Other sections in this booklet expand upon possible substitution methods.

Engineering controls

Replacing older design fettling machines by newer machines incorporating 'state of the art' design features is one option. The features offered by manufacturers are constantly improving. Ask your supplier for details of these features and 'in-use' vibration data they are able to supply.

Retrofitting for your present machinery may be possible, but care should be taken that it does effectively reduce vibration and that it is cost effective. Ergonomic improvements, balancing rigs, using lighter or more powerful machines, or providing vibration isolated work rests and hand grips can sometimes be beneficial.

Management controls

There are a number of management controls available which can help reduce the effects of vibration exposure, or limit the exposure itself. These include basics like:

- choosing the right tool for the job;

- establishing a purchasing policy for vibration reduced tools;⁸
- regularly maintaining tools;
- providing adequate training and supervision to encourage good fettling practice and prevent wheel abuse;
- ensuring that workers in other production areas are aware of the effects their work has on the fettling shop;
- minimising the use of chipping hammers etc, by limiting their use to assessed specific operations and operating under a formal 'system of work ' procedure;
- ensuring that the correct grade or hardness of grindwheel is used in any grinding operation;
- providing frequent work breaks and job rotation; and
- maintaining good temperature control.

More controversial suggestions include:

- implementing a no-smoking policy to discourage smoking among fettlers (smoking impairs circulation); and
- properly managing piecework systems to avoid unsafe practices and unnecessary exposure to vibration.

Personal protection

Anti-vibration gloves may have little effect at the most hazardous frequencies and, in some cases, may increase the vibration reaching the hand. Warm gloves and clothing can help reduce vibration by keeping the hands warm and improving blood flow.

Casting design for easy knock-off/cut-off

The removal of the runner/feeder system (commonly known as knock-off or cut-off depending on the method used) and grinding down the resulting stubs are usually manual operations. They can lead to significant vibration exposure. Improving the design of the casting and running system can minimise the effort required to knock-off.

Added benefits of improved design can include:

- reduced exposure to noise during knock-off;
- limited exposure to both dust and noise when carried out prior to shotblasting; and
- significant savings in handling and fettling costs.

Designing and planning for runner removal

Although the aim is to produce a sound casting, failure to take other matters into account can lead to problems later. You should consider:

- providing an adequate means of handling the casting during finishing and use; and
- designing for efficient runner and riser removal.

Knock-off methods

Manual knock-off is used where the metal is sufficiently brittle, and where in-gates and riser heads can be notched. Hammering gives significant exposure to impact and vibration. Knock-off guns or hydraulic wedges can lower exposure to impact and vibration, but to allow their use the casting/runner system may need to be redesigned (especially in the case of hydraulic wedges). For larger castings, a crane-operated ball knock-off may be appropriate.

Designing for knock-off

Casting/runner systems should be designed so that the gates, risers and feeders easily break off just clear of the casting. This helps prevent break-in as well as minimising the effort needed for stub removal. It can be achieved by using breaker cores, Connor block runners, or wide, thin section in-gates. With small to medium-sized castings it is likely that the runner system will be detached during any vibratory or tumble shake-out. Alternatively, removal should only require a comparatively light tap with a hammer. The resulting minimal stubs will generally be amenable to direct machining if positioned appropriately.

As in-gate and feeder size increases, so does the force needed to remove them. You should consider providing mechanical assistance such as a knock-off gun (portable or manipulator-mounted) which 'fires' a rod to remove the gate or feeder. The casting needs to be designed so that the gun can actually reach the parts to be removed, and action needs to be taken to prevent injury from the ejected part which may travel at high speed in an unpredictable direction.

Careful design of both casting and runner system can permit the use of wedges. Both sides of the wedge need something for the wedge to work against for it to be successful. Some foundries have designed their own hydraulic tools for removing runners, although these are not yet commercially available.

For large castings, a suspended ball - using the principles seen in building demolition, is sometimes used for knock-off. Control is difficult and this system requires that the runner must be well clear of any casting projections to prevent product damage.

Cut-off methods

Casting cut-off systems are not instantaneous and therefore they vibrate rather than impact.

Common arrangements include the use of abrasive cut-off discs mounted on:

- a pedestal grinder, where the feeder system is manually pressed against the rotating fixed abrasive disc;
- a bench-mounted lifting arm (similar to a cross-cut circular saw fitted with a cutting disc), where the rotating abrasive disc is pulled down onto the feeder; and
- a portable straight or angle grinder.

All of the above involve transmission of vibration from the casting or abrasive wheel to the operator.

By decreasing ingate/feeder size, cut-off time (and so vibration exposure per casting) can be reduced.

Try to avoid creating long stubs. To minimise employees' vibration exposure caused by extensive and awkward fettling, and to minimise possible damage to the casting, the following design principles should be considered:

- position runner systems that permit easy access for the cut-off wheels;
- avoid locating ingates in casting hollows; and
- mount the ingate on the joint line of the casting if this permits the simultaneous removal of both residual stub and joint-line skim.

The use of remote abrasive cutting using a manipulator or jig to hold the castings, in conjunction with an automatic or semi-automatic cut-off wheel, can help reduce exposure as the operator is not holding either vibrating tool or casting.

Using bandsaws on softer metals (eg aluminium) should be avoided if excessive vibration and noise is experienced.

Thermal cutting operations (eg oxy-gas, arc-air, plasma cutting) are sometimes used on harder materials. Despite being largely manual operations, vibration levels are often comparatively low. Unfortunately, these methods can introduce the problems of increased fumes and noise unless rigorously controlled.

Laser cutting or abrasive water jet cutting eliminate exposure to vibration and should be considered where the capital costs make them a reasonably practical solution.

Summary

Reducing time spent fettling also reduces:

- the employees' exposure time to hazardous vibration; and
- the cost of a casting.

The following steps can promote efficient knock-off and cut-off, so reducing fettling time.

- 1 Determine the components, sizes and position of the running system required for production of a sound casting.
- 2 Examine the options for runner removal, taking into account their size, position and material.
- 3 Explore the possibilities for remote operation or mechanical assistance.
- 4 Optimise the design of casting and runner system to allow runner removal by the preferred method and leaving minimal stubs.

A few minutes thought at the design stage can save hours of expensive and hazardous fettling!

Reduction and removal of flash

Flash is the unwanted penetration of metal into joints of a mould and can be caused by:

- poor fit at mould assembly due to excessive tolerances built in at the pattern design stage;
- poor pattern making practice;
- box wear/distortion at the moulding/core making stage;
- misalignment caused by poor control of locating pins/prints etc; and
- movement or distortion caused by insufficient mould strength (binder system, cure time, reinforcement).

Elimination or reduction of flash by design and process control

Flash is the casting 'defect' which leads to most fettling. Any reduction in flash or its subsequent removal will reduce exposure to vibration per casting, and save money spent in unnecessary fettling.

The aim is to produce a sound casting with minimal flash, and not to produce a poor casting that can be made acceptable by expensive fettling.

To significantly reduce excessive flashing, all aspects of the casting process, from initial design to pouring, may need to be examined. Communication between designers, moulders/coremakers, patternmakers and fettlers is needed. They should be aware of how their activities affect others in the process so that an effective solution can be found.

Questions to ask

- Does the design minimise the need for fettling, eg minimum number of cores, joint lines accessible?
- Can a triangular section be designed onto the joint line to give an aesthetically acceptable joint with minimal fettling?
- Are the core/core print tolerances minimised, taking into account pattern production methods? (CNC machined patterns should allow tighter tolerances than handmade ones.)
- Are core dressers/setters trained to use the minimum of core rubbing needed to give a good fit?
- Is the sand/binder system appropriate for this casting, and well compacted and fully cured?
- Is the mould reinforcement adequate?
- Are the mould/core components set firmly to prevent movement under pressure from the molten metal?
- Is wall support adequate to prevent break-out?
- Are locating pins, lugs and prints set accurately to allow proper alignment?
- Are the weighting/clamping arrangements adequate to prevent cope lift?
- To allow proper alignment and prevent metal seepage are pattern equipment and core/moulding boxes in good condition?
- By modifying the design or casting process can other defects requiring remedial fettling, such as sand burn-on, be minimised?

Removal of flash

It is unlikely that flash will be completely eliminated, especially at jobbing foundries, so it is important that its removal is properly managed.

The method of flash removal should be chosen to minimise vibration exposure. Since this depends on both vibration level and exposure time, a method with high vibration

levels but short exposure times may be better than one which has lower vibration levels but much longer fettling times. The fettlers' daily vibration exposure should not exceed HSE's current action level of 2.8 m/s² (see Table 1 on page 3).

Chipping hammers should generally be avoided where possible because of the high vibration levels produced. If they must be used, then choose 'vibration reduced' models. Currently, even some 'vibration reduced' versions can reach HSE's action level in less than one hour's use. But holding the chisel, or using conventional chipping hammers, can exceed the action level in minutes. This type of work should be given priority for action to reduce vibration exposure.

Depending on the metal being cast, it is often possible to remove flash in relatively large pieces using manual hammer blows. While this is the preferred method, the risk of work-related upper limb disorders (WRULDS) should be managed.

Some foundries that produce castings that are particularly prone to flash problems are designing a notched 'flash wing' which can be readily removed with a hammer or detached at shake-out or shotblast. This may particularly apply to flash between adjacent cores, which should form a port which can then be simply rodded through.

The alternatives for removing substantial amounts of flash include:

- pincers/nibblers (though care should be taken to ensure that this does not increase the risk of WRULDs);
- cut-off wheels and discs;
- cropping machines (especially on long run production); and
- methods such as arc/air (though this may increase the risks associated with fume evolution and noise).

Manual fettling is not the only way of removing residual waste metal. Automated or semi-automated methods can reduce employees' exposure to vibration. These are usually, though not exclusively, found in larger foundries producing long runs of a limited range of castings.

Mechanical alternatives include automatic or semi-automatic cut-off machines, cropping machines and automatic grinding machines of varying complexity up to and including a fully programmable robot fettler.

The mechanical alternatives below can save a great deal of fettling, but their main drawback is the need for repetitive manual loading/unloading of castings. Ergonomic issues need to be considered. The benefits of using devices such as tilting/tipping stillages and magnetic/vacuum handling devices etc also need to be evaluated.

Automatic or semi-automatic cut-off machines

These consist of an enclosure containing a slitting wheel and a moveable clamping mechanism to hold the casting and the runner system. The clamping mechanism is then moved to apply each runner to the wheel. Such systems have been used successfully in both long-run and jobbing situations. But the casting and runner systems must be designed to allow access of the runners to the wheel to give minimal stub at cut-off.

Cropping machines

These are small presses used to clip off joint line flash, used for smaller castings. Dies have to be prepared for each individual casting type, so this technique is favoured for long production runs.

Manipulators

Manipulators are moveable jigs which either hold castings against a grindwheel, or hold a grinding tool against a casting. They are a form of remote manual operation, usually with a feedback system to the operator to prevent over-fettling. This technique does not have the set-up programming problems of other methods and can be applied to a jobbing situation. Where several grinding operations are required on each casting, manual handling can be considerably reduced. Manipulators could be particularly beneficial to jobbing foundries which have an identified HAVS problem.

Automated grinding stations

These can range from automatic single operations without programming through to a full robot fettler which can pick-and-place and carry out a range of grinding operations. A range of simpler (and cheaper) autofettlers to cover the range of castings produced are more commonly used. Common applications include:

- Machines for peripheral grinding of cylindrical or circular castings. They consist of an in-belt and out-belt with fettling station between. Castings are clamped on a central indexing point and spun against a grindwheel.
- Carousel-type machines. Small castings are fitted to a rotating jig, and the exposed sides ground flat. Finished castings are discharged to belt or stillage.
- Straight-through machines. Larger castings such as cylinder blocks or heads are usually presented and discharged on a belt and have one or two faces ground flat.
- Jigs. They are used with a conventional pedestal grinder, they hold the casting while traversing across the wheel.

Good grinding practice

Poor grinding practice increases the risk of HAVS. To ensure good grinding practice choose the right tools for the job and proper training for the fettle.

Tool selection

Grinding machines should be selected to effectively remove the material to be ground off. Grinders with built-in vibration reduction are preferred.

An advance in grinder vibration reduction is the recent development of automatic spindle balancing (ASB). Field research has shown that angle grinders fitted with ASB can generally be operated for a full shift without the HSE action level for vibration being exceeded.

In the case of pedestal grinders, efforts have often been made to isolate the work rest from being affected by the grinding vibration by mounting it independently from the machine. Potentially, vibration reduction can be achieved but this is not always successful.

Wheel selection

Choosing the correct type of grinding wheel can reduce noise, dust and vibration as well as reducing fettling costs. Too hard a wheel will rapidly lose cutting efficiency and lead to unnecessary vibration exposure (see Table 2).

The nature of the grindwheel is specified by a series of numbers and letters together with further codes defining the shape, size and fittings.

The wheel specification code consists of four parts, eg A14 QB, namely:

- A** an alphanumeric code denoting the type of abrasive, eg A-alumina, 63A - zirconia mixture.
- 14** a number denoting abrasive grain size - for most fettling operations this will be in the range 12-36.
- Q** a letter denoting the 'hardness' or grade ranging from E (soft) to Z (very hard).
- B** a letter or letters denoting the bond type - for fettling this will usually be B for resinoid and/or possibly BF for reinforced resinoid.

Wheel hardness

Harder material to be ground will generally require alumina abrasive, finer grit size and softer grade; while soft materials may need silicon carbide abrasive and will need coarser grit and harder grade wheels. High stock removal rates generally need coarser grit and harder grade wheels with a high power machine.

As far as managing HAVS is concerned, a critical factor for a particular fettling operation is the hardness. The cutting wheel should ensure that as abrasive particles have their cutting points worn away they are released from the wheel matrix and new sharp-edged particles are exposed. If too soft a wheel is used then abrasive particles are removed from the wheel surface before they have lost their cutting edges, which is wasteful. When too hard a wheel is used (a much more common situation) then there may be more serious consequences, as described overleaf.

Consequences of using too hard a wheel

It is a false economy to use a wheel that is too hard (see Table 2). Although wheel life is extended, the worn-down abrasive particles remain firmly bonded to the wheel surface and the surface of the wheel becomes polished (known as glazing). Because the wheel no longer cuts efficiently the time taken to fettle a casting is greatly extended.

Glazing causes 'skipping' of the casting against the wheel. This causes lobing of the wheel, which is difficult to dress out. There is some evidence that skipping causes relatively high levels of impulsive vibration, an important factor in causing HAVS. The lack of cutting action can lead fettlers to use undue pressure or abuse the wheel by impacting the wheel against the casting (or vice versa) to try to achieve some cutting. At best this leads to further wheel distortion and greatly increased vibration exposure and at worst to wheel breakage, which can have very serious consequences.

Alternatively, (and less frequently because it takes time) fettlers will dress off the worn abrasive, often reducing the wheel life unproductively. In any case, the net result is greatly increased fettling times per casting, with consequent longer exposure to dust, noise and vibration and unnecessary fettling payments.

On changing to a free-cutting wheel of the correct grade, it is not unknown for the wheel to fettle two and a half times the number of castings even though it lasts only half as long as a wheel that is too hard. There is, therefore, a net productivity increase per wheel and a greatly reduced fettling time per casting, which results in lower fettling costs per casting.

Table 2 Wheel hardness selection

	<input checked="" type="checkbox"/> Too soft a wheel	<input checked="" type="checkbox"/> Optimum wheel	<input checked="" type="checkbox"/> Too hard a wheel
Wheel performance	<input checked="" type="checkbox"/> Short life <input checked="" type="checkbox"/> If very soft it may not cut at all	<input checked="" type="checkbox"/> Maximum metal removal rate <input checked="" type="checkbox"/> Minimum fettling per casting	<input checked="" type="checkbox"/> Apparent long life, BUT <input checked="" type="checkbox"/> Will glaze and stop cutting after a while
Health effects		<input checked="" type="checkbox"/> Minimum exposure to vibration per casting	<input checked="" type="checkbox"/> Long exposure to vibration <input checked="" type="checkbox"/> Long noise exposure per casting <input checked="" type="checkbox"/> Long exposure to dust per casting
Long-term costs	<input checked="" type="checkbox"/> HIGH due to <input checked="" type="checkbox"/> Short life <input checked="" type="checkbox"/> Possible scratching of casting	<input checked="" type="checkbox"/> OPTIMUM	<input checked="" type="checkbox"/> HIGH due to <input checked="" type="checkbox"/> Failure to fettle efficiently <input checked="" type="checkbox"/> Possible wheel abuse and breakage by fettlers

Differing grades for different operations

Unfortunately, because of the effects of wheel surface speed, feed force and contact area, this selection process should be carried out for each type of grinding machine in use and ideally for each type of grinding operation. However, where the same machine/wheel combination is used for a range of different types of operation and/or casting size, then clearly a compromise must be made.

There can be differences in the feed forces used by different fettlers; about one grade difference could result for an optimum wheel. When considering wheel hardness, the best wheel for 'average' fettlers should be selected to avoid extremes. Compromise should favour softness to ensure that the wheel remains free cutting. Note that the actual grade letter used to indicate bond strength may vary slightly between different suppliers.

This advice is particularly relevant to abrasive wheels, but most comments will also apply to abrasive coated discs and/or belts used in fettling departments.

Training Sufficient training should be provided for fettlers to know how to select the right machine for each job, and how to use it correctly. If a fettler is to mount wheels, then adequate training is required under the Provision and Use of Work Equipment Regulations 1998.⁷ Additional training may be required if a job changes substantially. Learning from other colleagues is unlikely to be the best form of training.

Common bad practice:

- Impacting castings on wheels (or vice versa) is a dangerous practice which could lead to wheel breakage. The practice originates from using a wheel of too hard a grade which rapidly loses cutting efficiency. Instead, grinding should generally be carried out with a smooth, steady pressure to avoid sudden loading.
- Grinding on the sides of edge grinding wheels and stopping wheel rotation by applying the wheel to, say the grinding bench, are poor practices - these can lead to undue stresses in the wheel that it is not designed for.

Training should be supported by adequate supervision to ensure that competency has been reached and maintained.

Summary

Grinding wheels should be selected for maximum cutting efficiency and not maximum life, as is often currently the case. In conjunction with other approaches to HAVS reduction this should significantly reduce exposure, limit dust and noise, and give cost savings per casting.

Alternatives to conventional abrasive wheel grinding

There are some alternative grinding techniques that effectively eliminate the problems associated with out-of-balance wheels and discs, although there could still be resonance effects. They should be considered as part of a HAV control programme.

Abrasive belts

Abrasive belt fettling is a well-established technique which normally exposes the operator to less vibration than conventional abrasive wheel grinding. It is frequently seen in finishing fettling such as the final joint line skim, which might involve a small portable linisher. Larger belts can be used for initial rough dressing.

Metal burrs

Equally well established is the use of metal burrs or rotary files instead of stone points for interior or fine fettling. Because the abrasion is only at the surface of the tool the potential for becoming out of balance is reduced. Excessive sideways forces on these relatively small tools can cause the shaft to bend, resulting in increased vibration. The burrs should be replaced if there is any evidence of this occurring.

Impregnated steel wheels

A recent development is the use of steel wheels with a relatively thin layer of nickel impregnated with a very hard abrasive such as diamond or cubic boron nitride on the edges or sides as appropriate. This abrasive layer is very hard wearing and can last many times longer than conventional wheels. Because of its construction, there is little potential for the wheel to become unbalanced, so in theory, it should vibrate less than conventional wheels. This is still to be tested in practice.

Other management controls

There are other techniques which can be used to reduce an employee's exposure to vibration or minimise its effects on health.

Economic and health and safety benefits can be gained by improved inter-departmental co-operation. Better communication can lead to the production of quality castings which require minimal subsequent fettling.

Careful consideration should be given to piecework and other incentive schemes to ensure that the exposure of fettlers to vibration is not excessive.

Work organisation

- Job rotation may help to reduce the period of exposure to vibration. (In practice, this may be difficult in a foundry because many of the other jobs available may also expose the worker to vibration.)
- Frequent breaks may help. Long periods of exposure to vibration should be avoided; short bursts of activity are better.
- Mixing tasks within a job may help to prevent fatigue.

Pre-work warm up

Ensuring good blood circulation is important. Possible approaches could include spending a few minutes carrying out suitable exercises, immersing hands in warm water or using a warm air hand dryer prior to starting work. (These procedures can be also used after breaks.)

Keeping the hands warm

It is advised that work is carried out where the ambient temperature is adequate. Warm clothing and gloves can be beneficial. The cooling effect of exhaust air from pneumatic machines can be minimised by directing the exhaust air away from the workers' hands. This is often best achieved by fitting an exhaust tube and leading it back along the supply line.

Discouraging smoking

Smoking affects blood flow, so a reduction in smoking just before and during working may help. Smokers should be made aware of the relationship between smoking and HAVS.

Summary

Where practicable, the need for grinding should be eliminated or reduced by good design and control of the casting process.

Residual metal should be removed by non-manual methods where possible.

The remaining manual grinding should be carried out using good grinding practice and vibration-reduced tools including:

- choosing the correct grinding machine;
- choosing the correct grinding wheel for the job;
- training;
- supervision;
- steady grinding pressure;
- avoidance of wheel abuse; and
- providing a good working environment, including temperature control.

Health surveillance

HSE recommends health surveillance for workers who are regularly exposed above 2.8 m/s². Health surveillance will not prevent injury in the way that control measures outlined in this leaflet will, but it can be used to detect early signs of injury and prevent significant handicap.

Detailed advice on health surveillance is given in HSE publications *Surveillance of people exposed to health risks at work*⁸ as well as in *Hand-arm vibration*⁹ and *Health surveillance in the foundry industry*.¹⁰

References

- 1 *RIDDOR explained* HSE31(rev1) HSE Books 1999 (single copy free or priced packs of 10 ISBN 0 7176 2441 2)
- 2 Griffin MJ *Handbook of human vibration* Academic Press 1996 ISBN 0 12 303041 2
- 3 Bednall AW and Pitts P 'Exposure to hand-arm vibration in foundries' *Foundry trade journal* March 1996
- 4 Hodgson J, Jones J, Clegg T *Self-reported work-related illness in 1995* Research Report HSE Books 1998 ISBN 0 7176 1509 X
- 5 *The costs of accidents at work* HSG96 (Second edition) HSE Books 1997 ISBN 0 7176 1343 7
- 6 *Management of health and safety at work. Management of Health and Safety at Work Regulations 1999. Approved Code of Practice and guidance* L21 (Second edition) HSE Books 2000 ISBN 0 7176 2488 9
- 7 *Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice and guidance* L22 (Second edition) HSE Books 1998 ISBN 0 7176 1626 6
- 8 *Health surveillance at work* HSG61 (Second edition) HSE Books 1999 ISBN 0 7176 1705 X
- 9 *Hand-arm vibration* HSG88 HSE Books 1994 ISBN 0 7176 0743 7
- 10 *Health surveillance in the foundry industry* IACL104 HSE Books 1998

**Further
reading and
information**

Vibration solutions: Practical ways to reduce the risk of hand-arm vibration injury HSG170 HSE Books 1997
ISBN 0 7176 0954 5

Health risks from hand-arm vibration: advice for employers
INDG175(rev1) HSE Books 1998 (single copy free or
priced packs of 10 ISBN 0 7176 1553 7)

*Health risks from hand-arm vibration: advice for employees and
the self-employed* INDG126(rev1) HSE Books 1998
(single copy free or priced packs of 15
ISBN 0 7176 1554 5)

Buying new machinery INDG271 HSE Books 1998 (single
copy free or priced packs of 15 ISBN 0 7176 1559 6)

*Hazards associated with foundry processes: hand-arm vibration
- assessing the risk* Foundry Information Sheet FNIS10
HSE Books 1999

*Power tools: How to reduce vibration health risks. Guide for
employers* Leaflet INDG338 HSE Books 2001 (single copy
free or priced packs of 15 ISBN 0 7176 2008 5)

Video: Hard to handle hand-arm vibration: managing the risk
HSE Books 1998 ISBN 0 71716 1881 1

CD-ROM: *The successful management of hand-arm vibration*
HSE Books 1999 ISBN 0 7176 1713 0

While every effort has been made to ensure the accuracy
of the references listed in this publication, their future
availability cannot be guaranteed.

See inside back cover for details of how to order HSE
publications and products.

This booklet was prepared by the Foundries Industry Advisory Committee and has been agreed by the Health and Safety Commission. It contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

Printed and published by the Health and Safety Executive
09/01 C30

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 Journal of Applied Behavior Analysis in the field of
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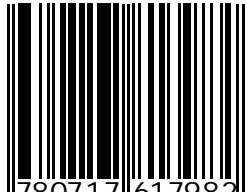
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