



# **Noise control in woodworking: Review and illustration of control methods**

Prepared by researchers at the  
**Health and Safety Executive**

**RR1223 (2025)**

**Research Report**

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Prepared 2025

First published 2025

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**Exposures to high noise levels at work can cause hearing damage and contribute to safety risks. Some processes in the woodworking industry produce high levels of noise and present ongoing risks from noise exposures. There is a lack of up-to-date information on effective noise control measures.**

**HSE inspectors judge whether all reasonably practicable control measures have been taken to reduce noise exposures in workplaces based on established technology. Research on the latest machines or technologies available is required to keep inspectors abreast of current noise control benchmarks.**

**This research reviewed observations made by HSE specialist inspectors, industry specialists and outcomes of discussions with both machine and machine-tool manufacturers to better understand the application of noise controls to woodworking machines. The work was concluded with measurements to illustrate the control of noise from one common woodworking machine, a five-head multi-cutter.**

**This work will be used to focus inspector interventions, support any revised guidance for dutyholders and influence industry and trade bodies to develop industry-led solutions that reduce the risks from high noise exposures in woodworking.**

**DOI: <https://doi.org/10.69730/hse.25rr1223>**

This report and the work it describes were funded by the Health and Safety Executive. Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

# Noise control in woodworking: Review and illustration of control methods

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# Acknowledgements

The author would like to thank:

- This report is dedicated to memory of Jon Gibson for his help and enthusiastic support at the start of this project.
- Advanced Machinery Services Ltd. for access to their facilities and cutting machine at their Skeffington Mill, Leicestershire site and the provision of materials and their hospitality and support during both the measurements and an information-gathering day at their site.
- Leitz Tooling UK for supplying helical cutters for testing and their hospitality in supporting us at an information-gathering day at their premises in Harlow.

# Abbreviations

## General acronyms

HSE	Health and Safety Executive
CNAWR	the Control of Noise at Work Regulations 2005

## Noise measurement terms

noise source	a machine or other system that generates noise
noise level	a measure of the loudness of noise in decibels
A-weighting	a frequency weighting that simulates the response of the human ear to sound - this weighting is used for the evaluation of daily exposures to noise in the workplace (the C-weighting is also used for workplace noise assessment, but C-weighting is used for exposures to high levels of peak noises, such as explosive or impactive noise)
dB	decibels – the units used to express noise levels
dB(A)	unit for measures of noise level with the A-weighting applied
$L_{eq}$	equivalent continuous noise level – the $L_{eq}$ has the same total sound energy as the fluctuating level measured, the $L_{eq}$ is therefore a value that represents the time-averaged noise level
$L_{Aeq}$	$L_{eq}$ measured with the A-weighting applied
$L_{EP,d}$	daily noise exposure – the $L_{Aeq}$ over a full working day, normalised to a standard 8-hour period (the daily exposure action and limit values for continuous noise exposure defined in the CNAWR are based on values for the $L_{EP,d}$ )
frequency analysis	an assessment of the noise levels of the various frequency components of sound signal
octave-band	a frequency analysis that divides the frequency spectrum into bands whose upper frequency limit is twice that of its lower frequency limit - also referred to as constant percentage bandwidth filtering, as the bandwidth is a fixed percentage of centre frequency
1/3 octave band	a frequency analysis which divides each octave band into three bands of constant percentage bandwidth
transmission path	the route noise takes from the noise source. As well as transmission through air, the transmission path may include

transmissions through structures that are re-radiated into the air from the surfaces of those structures

### **Woodworking machinery terms**

LEV	local exhaust ventilation
PCD	polycrystalline diamond (tipped saw blades)
TCT	tungsten carbide tipped (saw blades)
enclosure	the sealed structure around a machine designed to reduce noise emissions, prevent access during machine operations and prevent wood dust emissions
hood	panel of the enclosure that lifts to provide access for set up and cleaning
sawblade tooth	cutting element of a sawblade - comprising the cutting tip and gullet
cutting tip	cutting end of a sawblade tooth
gullet	spaces between sawblade teeth – important for removing waste material.

# Key Messages

The Control of Noise at Work Regulations 2005, places duties on employers to reduce the risk of hearing damage resulting from exposures to noise in the workplace. Some processes in the woodworking industry produce high levels of noise and present ongoing risks from noise exposures.

HSE inspectors have to judge whether all reasonably practicable control measures have been taken to reduce noise exposures in workplaces. However, there is a lack of up-to-date information on effective noise control measures for cutting machines in the woodworking industry.

HSE scientists reviewed observations made by HSE specialist inspectors, industry specialists and outcomes of discussions with machine and machine-tool manufacturers to better understand the application of noise controls to woodworking machines. Noise measurements to illustrate the control of noise from one common woodworking machine, a five-head multi-cutter, were analysed.

Whether the wood cutting is by blade or cutting block, noise emissions can be minimised by ensuring appropriate cutters are selected and set up to provide the right feed rate, blade cutting speed and cutting depth for the timber species being cut. Noise control features such as helical cutters on cutting blocks, spiral or segmental cutouts or laminated blades can provide significant noise reductions over standard cutters. However, it is important to understand the limitations of these controls, as they may not be suited to every application.

Machine and cutter maintenance is critical to ensuring that low-noise systems stay low-noise. Blades can be sharpened, re-tipped and balanced to keep the cutting efficient and to ensure low noise emissions are maintained.

The dust extraction on cutting machines also generates noise; this arises from turbulence of the air flow. Low noise systems are available that reduce the turbulent noise. Effective dust extraction systems minimise the wear-rate of cutters which reduces servicing costs and ensures that low noise levels are maintained.

These results will be used to inform inspector interventions, support any revised guidance for dutyholders and assist industry and trade bodies to develop solutions that reduce the risks from high noise exposures in woodworking.

# Executive Summary

## Background

Exposures to noise at work can cause hearing damage and contribute to other safety risks such as difficulties with communication and not being able to hear warning signals or the noises associated with approaching plant or machinery. However, there is a lack of up-to-date information on effective noise control measures in the woodworking industry.

Some processes in the woodworking industry produce high levels of noise, which present risks from noise exposures in the working environment. Noise levels can vary widely between machines depending on their use and there are many established noise control measures that employers might be expected to adopt.

## Aims

The aims of this work were to:

- review noise control methods used in the woodworking industry
- confirm whether the expected noise reduction of modern reduced-noise helical cutting blocks was achieved
- use the measurements obtained to illustrate other noise control measures applied to a common woodworking machine

## Methods

The research reviewed observations made by HSE specialist inspectors, industry specialists and outcomes of discussions with both machine and machine-tool manufacturers to better understand the application of noise controls to woodworking machines. The work was concluded with measurements to illustrate the control of noise from one common woodworking machine.

## Findings

Information from the woodworking industry showed that whether the cutting is by blade or cutting block, noise emissions can be minimised by ensuring the cutters are selected and set up to provide the right feed rate, blade cutting speed and cutting depth for the timber species being cut.

Noise control features such as helical cutters on cutting blocks, spiral or segmental cutouts or laminated blades can provide significant noise reductions over standard cutters.

However, it is important to understand the limitations of these controls, as they may not be suited to every application.

Machine and cutter maintenance is critical to ensuring that low-noise systems stay low-noise. Blades can be sharpened, re-tipped and balanced to keep the cutting efficient and reduce noise emissions.

Dust extraction generates noise through turbulence of the air flow. Low-noise extraction systems are available that reduce the turbulent noise in the extraction system. Effective dust extraction systems minimise the wear-rate of cutters which reduces servicing costs and ensures that low noise levels are maintained.

Measurements on a five-head multi-cutter showed that the machine's enclosure was effective at reducing noise. When the enclosure's hood was opened, the directional noise from the dust extraction local exhaust ventilation (LEV) system rose by around 5 – 6 dB(A).

The outfeed tunnel provides useful noise reduction, primarily in the vicinity of the outfeed. Noise was reduced by 3.6 dB(A) at the outfeed when cutting. There is a smaller, but still useful, noise reduction of the LEV system noise of 2.5 dB(A).

Helical cutters were shown to create significantly lower noise levels than the equivalent straight cutters. On their own, replacing straight cutters with helical cutters was shown to reduce the noise levels by 5.4 dB(A).

The finish provided by a helical cutter is not as good as that provided by a well-maintained straight cutter, therefore, helical cutters are sometimes (as was the case with this study) used in conjunction with straight cutters providing the final finishes. Replacing three of the five straight cutters with helical cutters reduced the noise levels by 3.2 dB(A).

Helical cutters were also shown to be quieter when free running, with noise levels reduced by as much as 5.1 dB(A) when the hood was closed, or 5.4 dB(A) when the hood was open.

The results from this study will be used to inform inspector interventions, support any revised guidance for dutyholders and assist industry and trade bodies to develop solutions that reduce the risks from high noise exposures in woodworking.

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# 1 Introduction

## 1.1 Background

The Control of Noise at Work Regulations 2005 (HSE, 2021) requires employers take actions to prevent or reduce risks to health and safety from noise in the workplace. Employers are required to eliminate or reduce the risks to health from noise. This involves eliminating noise at source or, where this is not reasonably practicable, reducing the level so far as reasonably practicable.

Exposure to noise at work can cause hearing damage and contribute to other safety risks such as difficulties with communication and not being able to hear warning signals or the noises associated with approaching plant or machinery.

The woodworking industry can be one of the noisiest working environments (HSE(c); HSE, 2014). Noise levels can vary widely between machines depending on their use (HSE, 2014).

HSE guidance on noise in woodworking (HSE, 2014) identifies a range of established noise control measures that employers might be expected to adopt. One of these is the use of reduced noise cutter blocks (HSE(a)), based on guidance in the second edition of HSE's guidance on the Control of Noise at Work Regulations 2005 (HSE, 2006).

## 1.2 Research aims.

The aims of this work were to:

- review noise control methods used in the woodworking industry
- confirm whether the expected noise reduction of modern reduced-noise helical cutting blocks was achieved
- use the measurements obtained to illustrate other noise control measures applied to a common woodworking machine

## 1.3 Method

The research included an information gathering stage relating to noise control options. This information gathering included input from HSE specialist inspectors, industry specialists and discussions with both machine and machine-tool manufacturers to better understand the application of noise controls to woodworking machines. The work was concluded with measurements to illustrate the control of noise from a common woodworking machine.

## 2 Noise-control Information gathering

### 2.1 Industry literature

HSE guidance HSE WIS13 (HSE, 2014) is the document that is widely referenced by suppliers and manufacturers in web pages and other publications.

Many publications and web sites on the control of noise in the woodworking industry were found to simply reproduce sections of HSE guidance HSE WIS13. A small number of sources were found that were considered to extend the guidance in HSE WIS13 or provided more detailed information, these were:

***British Woodworking Federation: How Can I Reduce Noise From My Woodworking Machines To Safe Levels? (British Woodworking Federation Group, 2011)***

This brief review covers the basic noise control messages: buy quiet, correct blade / machine for job, maintenance, barriers / enclosures and hearing protection is the last resort.

***Phase To of Canada: Noise Control in Woodworking Industry (phaseto.com). (Cmar, 2006)***

This review from a Canadian acoustics company provides a useful summary of many of the noise generation and noise control issues, including tooling, enclosures, tunnels and isolation. It also provides some information on what noise reductions might be observed after implementing noise controls, for example, helical cutters are reported to reduce noise levels by 5 dB or more.

It notes that noise levels at woodworking machines are generally more than 95 dB(A) at the operator location, with typical noise levels of:

- planing and moulding machines: 100 – 105 dB(A)
- band saws: 95 – 100 dB(A)
- table saws, bench saws, ripping saws: 100 – 110 dB(A)

***OSHA (USA) A Guide for Protecting Workers from Woodworking Hazards (OSHA (USA), 1999)***

This is a general guide covering all woodworking hazards, although it mainly focuses on dust control. The noise section provides basic guidance; it divides the control into those related to the noise source and those related to the noise transmission path.

Examples provided for noise source control are:

- maintaining motors and all moving parts in optimum operating condition
- reducing the speed of operation of the equipment to the slowest level consistent with product quantity and quality goals

- moving power equipment operations out of wooden or steel-frame buildings and into stone, cement, or brick structures
- ensuring that equipment frames are as rigid as possible, that equipment is firmly seated on a solid floor (preferably a cement slab), and that no piece of equipment is in contact with any other equipment or walls.
- isolating noisy equipment with rubber footings, springs, or other forms of damping suspension, to reduce the radiation and amplification of noise via vibrations
- applying vibration-damping materials to all resonating surfaces and constructing (where possible) sound absorbent hoods around points of operation

Examples given for noise transmission path control are:

- segregating operations to limit, as far as possible, the number of employees exposed to excessive equipment noise
- enclosing equipment within barriers designed to absorb noise and/or reflect it in harmless directions, such as toward ceilings covered with sound absorbing material
- moving or locating noise-producing equipment away from employees

***ACC New Zealand: Noise control in the wood processing industry (McBride, 2010)***

The aims of this study were to identify the significant sources of noise exposure, investigate simple control measures and assess the prevalence of noise induced hearing loss.

The study was based on work primarily in sawmills (eight sites) and so covers machines used in debarking, bandsaws and chainsaws, with additional work in wood processing (five sites, of which two were both milling and processing). The analysis was based on a control hierarchy:

- control at the source
- control of the path
- control at the receiver

An extract from the executive summary states that:

*“In general, noise levels were in the 90-100 dB range, regarded as very noisy. Few workplaces in New Zealand have such consistently high levels. Although the problem might seem insoluble, simple solutions at each stage could be identified. At the source of the noise, new designs of both band and circular saws can reduce the noise by up to 6 dB (a quarter of the noise). During sawmilling operations, a significant amount of noise came from timber handling, where damping of panels and reduction of “ringing” noise by filling rollers with sand could once again reduce the levels by 3 dB (half the noise). These are all critical points for action by the industry.”*

**Michigan Tech University: Saw Noise Control (Spruit, et al., 2004)**

While this is an academic study of vibrational modes in saw blades, it includes useful insights into the vibration of the cutting deck, control of vibration modes in saw-blade design and some ranking of noise sources.

**WorkSafe Victoria: Controlling circular saw noise (WorkSafe Victoria, n.d.)**

This article covers circular saws for use when cutting wood, metal, masonry and plastic. It states that:

*“Noise levels from circular saws can vary from 80 dB(A) up to 120 dB(A). Noise levels vary depending on the type of saw and the material being cut. Other variables include:*

- *Saw blade diameter and thickness*
- *Number of teeth.*
- *Tooth design.*
- *Gap between teeth, (the gullet).*
- *Level of damping.*
- *Speed of blade.*
- *Feed rate.*
- *Condition of the saw”*

When using circular saws, this guidance recommends choosing a saw blade with the greatest number of teeth and the smallest teeth suitable for the job, the smallest possible gullets (see Figure 1) and built-in vibration damping such as laser-cut slots or laminated blade construction.

It also notes that tungsten carbide tipped teeth (see Figure 1) which stay sharper longer can reduce cutting noise by up to 14 dB(A).

**Leitz: Diamond or Carbide tipping (Leitz, n.d.)**

Although not specifically related to noise control, this short blog provides an interesting comparison of the relative merits of diamond-tipped or carbide tipped saw blades.

According to this reference, Tungsten Carbide Tipped (TCT) blades are: lower cost, more able to withstand impacts, suitable for a wider range of applications, easier to maintain and better suited to cutting metals. Polycrystalline Diamond (PCD) tipped blades are said to be better suited to glass, ceramics and composites, and are longer lasting. Additionally, they produce a better surface finish, allow higher cutting speeds with lower friction and less heat generation.

It concludes by saying:

*“Ultimately, the choice between PCD and TCT tooling depends on the specific machining requirements and the material being worked on. By understanding the differences and benefits of each tooling option, manufacturers can make informed decisions to optimize their machining processes and achieve superior results.”*

## 2.2 HSE Specialists

Information obtained from visits by HSE specialist inspectors to woodworking sites identified examples of where noise control either was being applied, or could be applied, to reduce noise levels. The noise issues identified can be summarised as:

### 1. Noise from Local Exhaust Ventilation (LEV)

Where LEV is not well designed it can contribute as much noise into the working areas as the woodworking machinery. Specific issues identified were:

- poor maintenance and repair
- generation of tonal noise
- lack of noise control consideration on the design of LEV ducting systems
- LEV extraction fan systems in work areas

### 2. Air noise

The release of compressed air can generate air turbulence, which will produce high levels of noise. Solutions for the control of noise from the release of compressed air are well known and readily available. Specific issues identified were:

- blow-down – use of non-entrained nozzles
- blow-down – use of a brush rather than air
- exhaust silencers

### 3. Enclosures

Enclosures around machinery can be very effective at reducing the noise emitted to working areas around the machine. However, gaps in the enclosure will allow noise to escape and ineffective or missing absorbent materials will allow noise levels to build within the enclosure. Specific issues identified were:

- build-up of waste/ dust / shavings affecting use of or integrity of enclosures
- absence of foam or other noise absorbent linings
- absence of acoustic tunnels or flaps at openings
- poor maintenance
- operating consoles close to in-feed or outfeeds where noise levels are highest

### 4. Cutting blades

Noise generated by the cutting process can be controlled by ensuring that the correct blade is used for the material and required quality of cut. Any blade should be sharp and well balanced. Low-noise blades or helical cutters are options to consider, along with cutting features such as slotted in-feed tables, to reduce the turbulent noise from straight cutters. Specific issues identified were:

- sharpness
- low-noise blades
- helical cutters

- slotted feed-in table

## 5. Hammering

Impactive noise from hammering operations can be addressed by various means including automation, and the use of damping materials or systems to prevent transmission of noise or to reduce vibration of machine parts. Specific issues identified were:

- automation
- damping

## 6. Workplace setup

The purchase of machinery and the design and planning of workspaces and tasks can have long-term impacts on noise levels. Having planned machinery replacement processed and purchasing low noise machinery will contribute to a low-noise workplace. Designing work areas so that workers can work away from noisy machine operations or have quiet areas that they work in when not directly operating machinery or quiet areas where they can operate and monitor machinery remotely. Specific issues identified were:

- lack of a 'buy quiet' policy
- old machines tend to be noisy
- plan layout /tasks to allow for workers to operate at distance from machines
- for automatic machines, move operators away from machine once operating

## 7. Task setup

Effective specification and design of work tasks is important. Not only should it lead to efficient use of machinery, but it can also reduce noise levels. Specific issues identified were:

- size of cut - removing too much material for blades in one pass
- cutter speed – too fast for cutter/ material

## 2.3 Tooling manufacturer

### 2.3.1 Tooling design and selection

Discussions with a major machine tool manufacturer on noise control were wide ranging and linked reducing noise to other positive health, safety, environmental and economic benefits. Getting the right cutting tool for the job, used in the right way will:

- increase efficiency
- save energy
- decrease costs
- save materials
- increase quality
- reduce set up time
- reduce or eliminate the need for post-cut finishing
- help protect the environment

- increase safety
- reduce noise

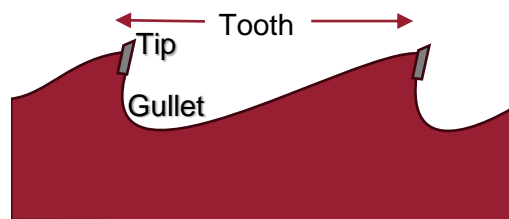
Optimum feed rates, blade cutting speeds and cutting depths vary with different timber species.

The manufacturer noted that it is often the case that the policy of end-users is 'run-to-blunt'. This leads to noisy, poor quality and possibly un-safe cutting and increased machine wear with increased downtimes for maintenance.

### **Saw Blades**

The basic components of the cutting edge of a saw blade are illustrated in Figure 1. There are many features that can be designed into circular-saw blades to minimise noise generation. The blades should be:

- highly circular
- well balanced
- aerodynamic



**Figure 1 Component parts of the cutting edge of a saw blade**

In addition, some specific features helping to reduce noise may be incorporated, such as:

- spiral or segmental cutouts
- laminated blade
- variable tooth density

Spiral or segmental cutouts, illustrated in Figure 2, are designed to prevent or minimise blade resonances by breaking up the blade structure and so preventing blade vibrations at frequencies related to the diameter of the blade.

Laminated blade structures use an inner layer of different material, which can be either a resilient material or a different metal which has different resonance characteristics. Like the segmental cutouts, these laminated blades are designed to prevent or minimise disk resonances.

A regular spacing of teeth around a blade can cause tonal noise related to the strike-rate of individual teeth against the material being sawn. The tonal noise is radiated by the

sawblade surface. By using variable tooth density around the disc, the noise generated is spread across a range of frequencies and tonal noise is reduced.



**Figure 2 Circular saw blades illustrating: Left: Segmental cut outs, Middle: Spiral cutouts and Right: both segmental and spiral cutouts**

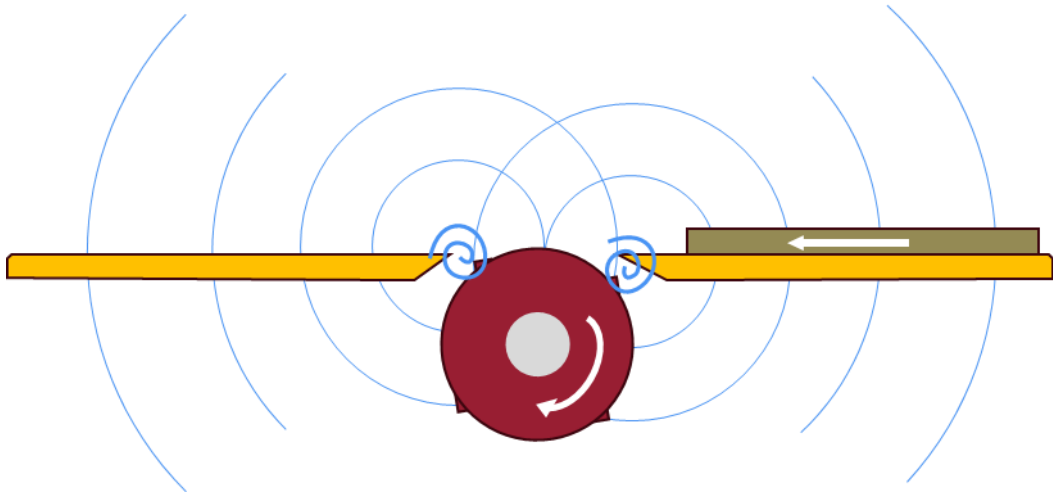
### ***Cutting Heads***

Cutting heads are used in planer moulding machines to produce lengths of wood with smooth planed surfaces or shaped surfaces.

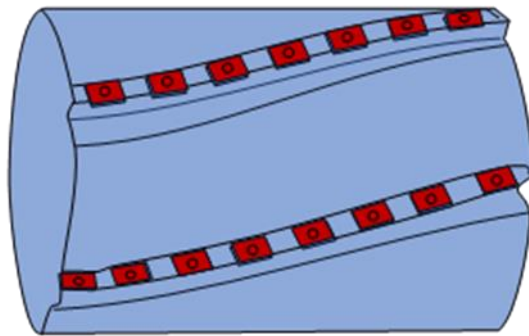
Turbulent noise is generated by a rotating cutter as the straight cutting blade passes the cutting table at speed, see Figure 3.

Reduced noise cutting blocks are designed to reduce noise by breaking the cutting edge up into smaller elements. By ensuring that the cut is created by a sequence of multiple short cutting elements, rather than a full-width blade, the air turbulence (and the associated noise) is reduced. The helical or spiral cutter design illustrated in Figure 4 further reduces the noise by distributing the cutting points around the full cylinder of the cutting block.

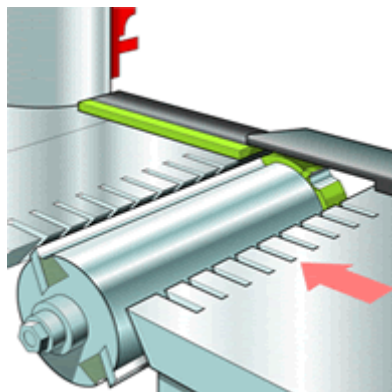
A similar result can be achieved by using slotted cutting table lips (see Figure 5), where the total length of the narrow gap to the cutting blade that causes turbulence is substantially reduced, thereby reducing noise.



**Figure 3 Illustration of turbulent noise generation as cutter blades pass the cutting table.**



**Figure 4 Illustration of a reduced noise cutter block with helical cutting blade arrangement.**



**Figure 5 Slotted table lips on a planer (diagram taken from (HSE(a)))**

### **2.3.2 Tooling servicing**

Ensuring that cutters are sharp, properly aligned and balanced will maximise the life of tooling, while maintaining the efficiency of cutting, maintaining the best possible quality of cut and keeping noise levels to a minimum.

Blade and cutter servicing is an important consideration in maintaining low-noise cutters. Cutters and saw blades can be sharpened, re-tipped and balanced.

It is important to recognise that the costs of tooling should include consideration of both the servicing costs as well as accounting for the extended lifetime of the tool due to the servicing.

## 2.4 Machinery manufacturer/supplier

### General

The British Woodworking Federation advise (British Woodworking Federation Group, 2011) that:

- purchasers of new machinery should consider the noise levels of each machine and select low noise machines
- the machine structures should be designed to minimise direct noise radiation and reduce vibration transmission through the machine
- acoustic absorbers, shields or enclosures for control of unavoidable noise sources should be an integral part of machinery design
- the most suitable blade and machine should be used for the job
- using the wrong machine or blade can increase noise
- poorly adjusted saw guides can increase noise levels by 3 dB(A) and the use of unnecessarily heavy gauge saw blades can also produce higher noise levels
- make sure that your maintenance schedule is followed
- well-maintained machines tend to make less noise
- well maintained machines can produce idling levels in the region of 80-90 dB(A) while poorly maintained machines, which are otherwise virtually identical, may idle at levels as high as 110 dB(A)
- erecting barriers or putting a noise enclosure around a particular machine will reduce the noise exposure of workers in the area
- effective enclosures may be constructed from a variety of materials
- homemade enclosures can be as efficient as commercial supplied models and may cost much less
- a well-constructed enclosure is capable of attenuating sounds by 10-15 dB(A)

- hearing protection should only be provided as a last resort - you must try and reduce the noise level before using hearing protection as a control measure

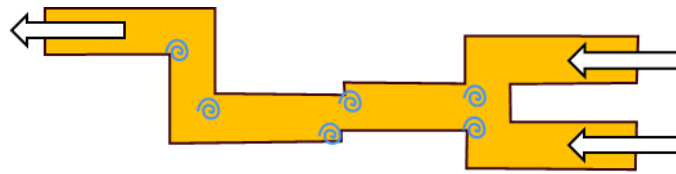
## Enclosures

Having a suitable noise enclosure is an established noise control measure for many wood working machines (HSE(b)). They may be either an integral part of the machine or retrofitted. It should be of suitable design, and should enclose the machine as completely as possible, and be properly maintained and used.

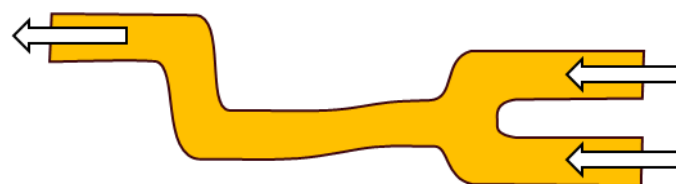
### 2.4.1 Dust extraction

Dust extraction is an integral part of any woodworking process and will contribute to the overall noise of the machine. The general issues around fan noise and design of ventilation systems are outside the scope of this report, but information can be found from many sources, for example (HSE - Engineering Industry Noise Task Group), (Burgess & Thompson, 2014).

A dust extraction system has the capability of generating noise through turbulence of the air flow. Turbulence is caused by air flowing around turns or joins in the ducting systems (Figure 6 Illustration of dust extraction ventilation with bends and joins that are likely to generate turbulent noise). Bends, joints and manifolds should be suitably designed to be smooth without sharp corners or uneven joins (Figure 7).



**Figure 6 Illustration of dust extraction ventilation with bends and joins that are likely to generate turbulent noise.**



**Figure 7 Illustration of dust extraction ventilation designed to minimise the generation of turbulent noise.**

The motor and fans for the extraction systems can be planned to be away from working areas or in enclosed systems and isolated from areas where personnel work.

Low noise extraction systems are available that reduce the turbulent noise in the extraction system.

Efficient dust extraction systems also ensure that wood debris is removed from the cutting area as quickly as possible, minimising the wear rate of the cutters which both reduces servicing costs and ensures that low noise levels are maintained.

# 3 Machinery and measurement environment

## 3.1 Multi-cutter

The machine used for all measurements was a Wadkin Bursgreen M523EL-5 five-head multi-cutter (serial number 2212012).



**Figure 8** Wadkin Bursgreen MS525EL-5 with the enclosure lid down (photo IMG\_2284.jpg), also showing microphone positions and wood ready for cutting on the in-feed.

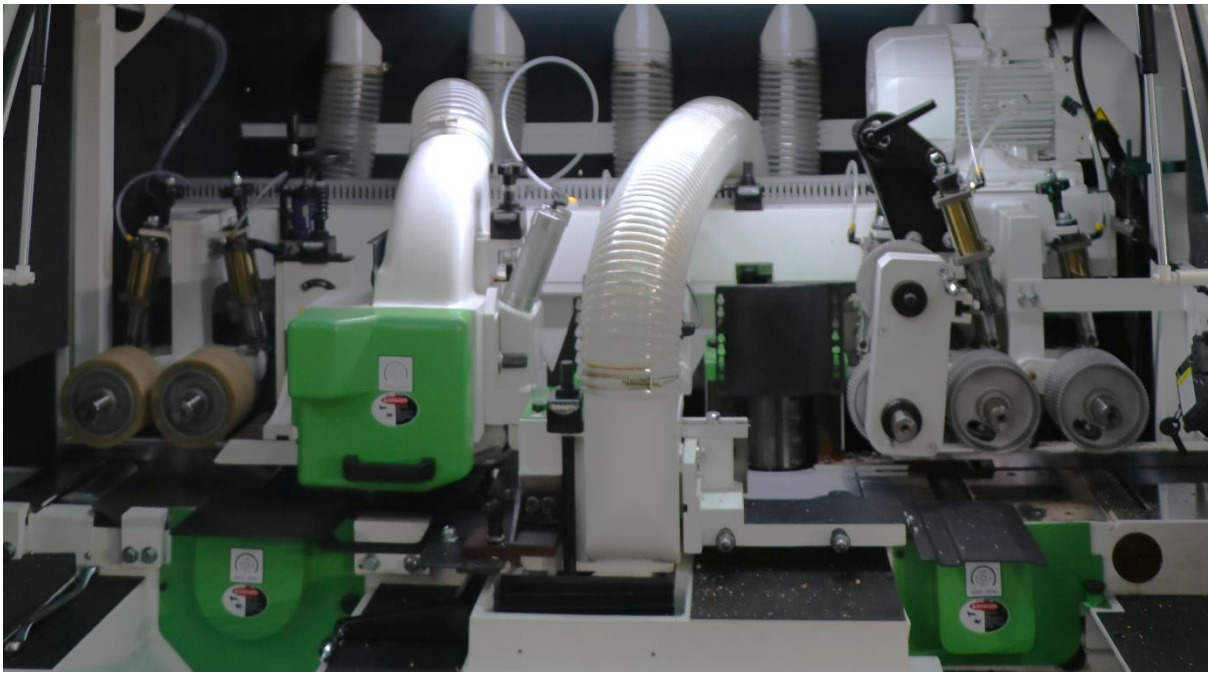


Figure 9 M525EL-5 with enclosure lid up, showing rollers and cutters as illustrated schematically in Figure 10 (Photo IMG\_2243.jpg)

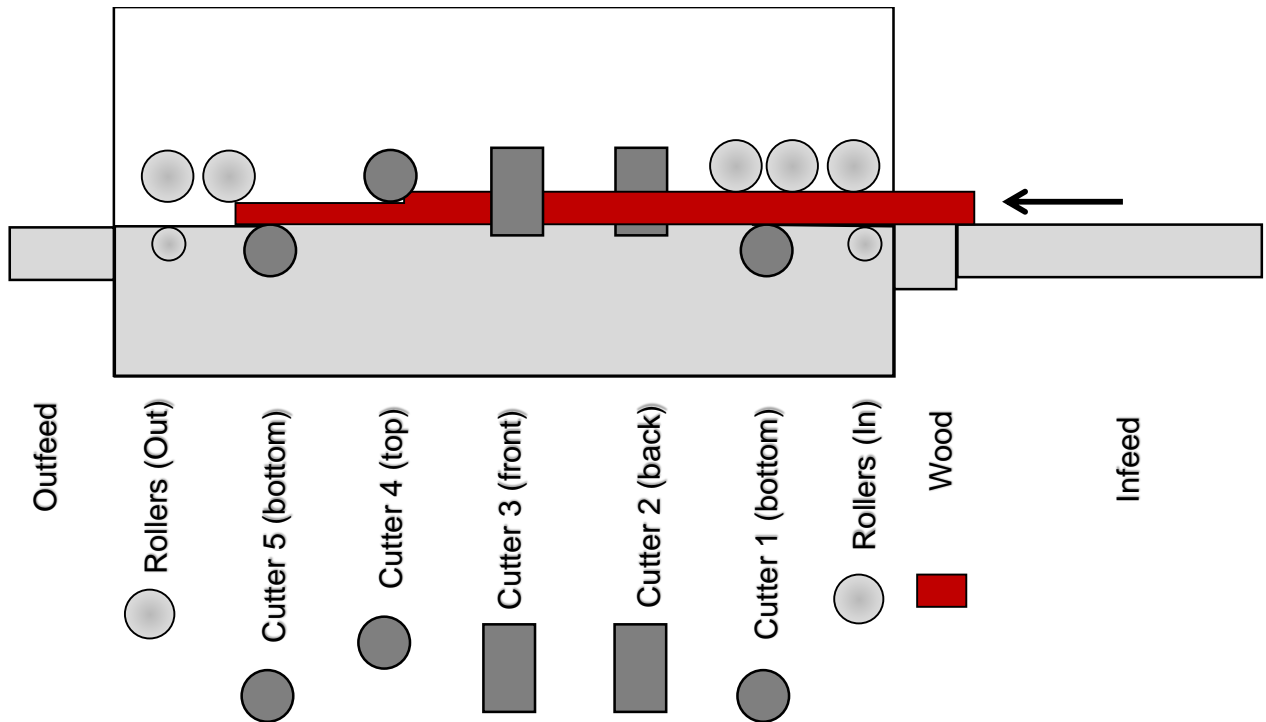


Figure 10 Schematic side-view illustration of cutters and rollers in 5-headed multi-cutter.

## 3.2 Measurement environment

All tests were carried out on 31 October 2023 in the demonstration area of Advanced Machinery Services Ltd., Skeffington Mill, Leicestershire.

The machine was located as shown in Figure 8, in open space, away from walls. No other machines were operating in the area when the noise measurements were taken.

## 3.3 Cutting heads

Two types of cutting head were used, to allow comparison between a standard planer block and helical cutter. As the helical cutters are only appropriate on the first three cutters (initial bottom cut, rear cut and front cut), two different configurations were tested:

1. cutters #1 – #3: conventional 3 mm steel planer blocks (Wadkin Tooling blocks supplied by Advanced Machinery Services Ltd.), see Figure 11, where:
  - cutter #1 was a 230 mm twin blade SP22304012 (230 mm wide, 125 mm diameter, 40 mm bore, z2)
  - cutters #2 and #3 were 130 mm, quad blades SP41304012 (130 mm wide, 125 mm diameter, 40 mm bore, z4)
2. cutters #1 – #3: helical cutters (supplied by Leitz Tooling UK), see Figure 12, where:
  - cutter #1 was a 230 mm quad blade HeliPlan 30466 (236 mm wide, 125 mm diameter, 40 mm bore, z4)
  - cutters #2 and #3 were 130 mm, quad blade HeliPlans 30423 (130 mm wide, 125 mm diameter, 40 mm bore, z4)

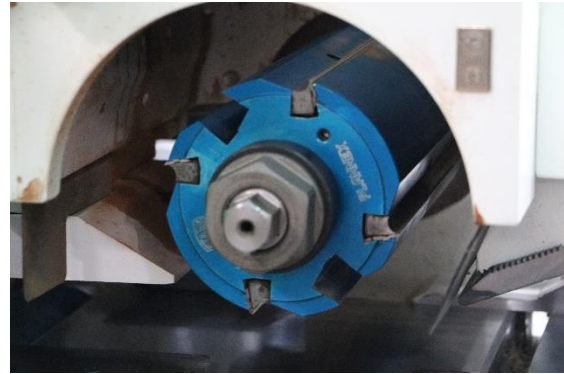
For all tests, cutters #4 and #5 were 230mm Stark Plannex TH78 aluminium-bodied cutters (supplied by Advanced Machinery Services Ltd.) with replaceable straight blades, see Figure 13.



**Figure 11 Wadkin straight cutter blocks (Left: 230 mm horizontal cutter, photo IMG\_2309.jpg. Right: 130 mm vertical cutter, photo IMG\_2311.jpg)**



**Figure 12 Leitz HeliPlan® helical cutter block (Left: 230 mm horizontal cutter, photo IMG\_2298.jpg. Right: 130 mm vertical cutter, photo IMG\_2295.jpg)**



**Figure 13 Stark Plannex horizontal aluminium cutter blocks (Left: 230 mm horizontal cutter, photo IMG\_2251.jpg. Right: cutter #4 in machine, photo IMG\_2250.jpg)**

### **3.4 Test materials**

Two wood types were used, a softwood (redwood) and a hardwood (sapele). The length of each sample of wood was 2.1 m. The starting dimensions were 50 mm x 150 mm.

The samples were cut down by 5 mm from both depth and width on each test. Through the tests the initial wood dimensions reduced to a minimum of 20 mm x 120 mm.

The tests were organised to ensure that the same test material dimensions were used for comparisons of softwood and hardwood or straight-cutter and helical cutter.

## 4 Measurement method

Measurements were taken at four locations along the length of the machine. The microphones were positioned along the front face of the machine, approximately 1 m from the path of the wood at a height of 1.5 m, see Figure 8 and Figure 14. Microphones #2 and #3 were in line with the right and left edges, respectively, of the enclosure door.

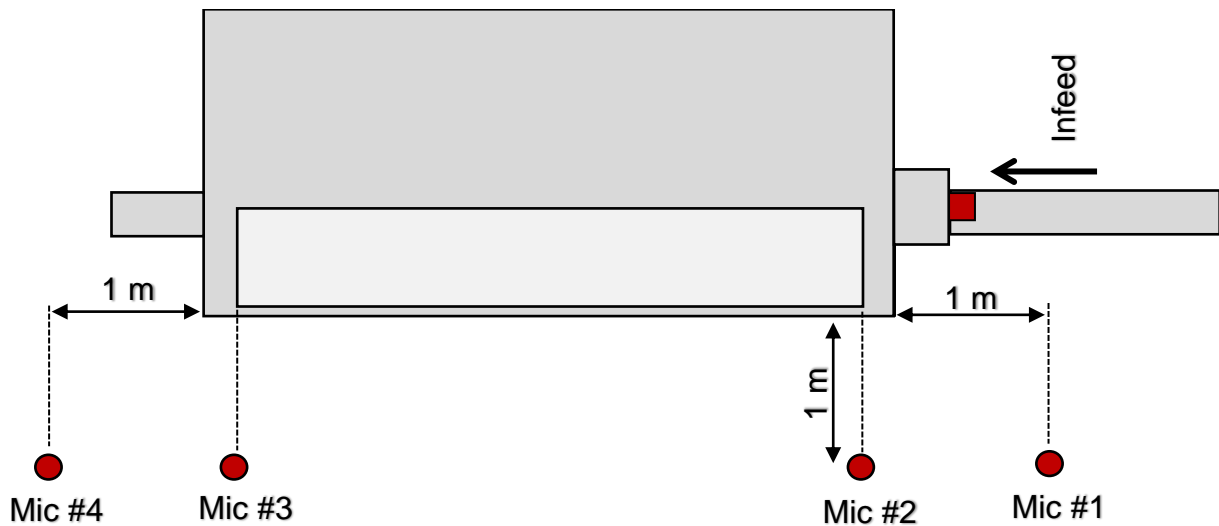


Figure 14 Plan illustration of microphone positions

### 4.1 Instrumentation

The microphones were all Brüel & Kjær (B&K) type 4190C1 ½-inch free-field microphones with type 2669C pre-amplifiers, see Table 1.

Table 1 Microphones used for measurements.

	Microphone #1	Microphone #2	Microphone #3	Microphone #4
Name	4190 C 1 (NVI 740)	4190 C 1 (NVI 741)	4190 C 1 (NVI 742)	4190 C 1 (NVI 743)
ID	2510521	2510522	2510523	2510524
Type	4190 C 1	4190 C 1	4190 C 1	4190 C 1
Description	Free-field 1/2" Microphone 4190, 2669C	Free-field 1/2" Microphone 4190, 2669C	Free-field 1/2" Microphone 4190, 2669C	Free-field 1/2" Microphone 4190, 2669C
Sensitivity	50.4m V/Pa	51.2m V/Pa	51.8m V/Pa	48.3m V/Pa
Calibration date	11 Oct 2023	11 Oct 2023	11 Oct 2023	11 Oct 2023

## 4.2 Microphone calibrations and sensitivity checks

The microphones were calibrated at the HSE laboratories prior to the visit (on 11<sup>th</sup> October 2023, see Table 1) using a B&K type 4226 multi-function calibrator, serial number 1531353, which was calibrated by a DANAK accredited laboratory in October 2022 (re-calibration due in October 2024). This multi-function calibrator was also used for end of measurement calibration checks.

An out-of-calibration single frequency B&K type 4231 calibrator was used for field-checks of microphone sensitivities. The results given by this calibrator were checked against the B&K 4226 multi-function calibrator prior to the site visit, to provide confirmation of its suitability for use for field-sensitivity checks.

## 4.3 Signal acquisition and processing

Data acquisition was performed using a B&K type 3050A-610 LAN-XI DAQ module, serial number 3050-109700.

Signal processing and post processing were performed using B&K Labshop and Connect analysis software.

### 4.3.1 Data acquisition and on-site processing

For the on-site measurements, B&K Labshop was set up to record data from the four microphones and provide A-weighted  $L_{eq}$  ( $L_{Aeq}$ ) and 1/3<sup>rd</sup> octave-band frequency analysis.

### 4.3.2 Post visit data processing and analysis

For signal processing following the site visit, B&K Connect was used to provide  $L_{Aeq}$  analyses of selected sections of the time signals.

# 5 Analysis

## 5.1 Cutting time analysis

The cutters were spaced as shown in Table 2, with estimated time for the wood to arrive and leave each cutter and roller given for the two feed speeds used, i.e. 6 m/minute and 12 m/minute.

**Table 2 Calculation of the time a 2.1 m length of wood first arrives at a cutter (tStart) and time wood leaves a cutter (tEnd) for the two feed speeds of 6 and 12 m/min.**

Roller/cutter ID	Cutting face	Cutter type	Distance from cutter #1 (m)	Feed speed 6 m/min		Feed speed 12 m/min	
				tStart (s)	tEnd (s)	tStart (s)	tEnd (s)
Input Roller			-0.25	-2.5	18.5	-1.25	9.25
Cutter #1	Bottom	Either: all straight or all helical	0	0	21	0	10.5
Cutter #2	Back		0.25	2.5	23.5	1.25	11.75
Cutter #3	Front		0.5	5	26	2.5	13
Cutter #4	Top	Straight	0.78	7.8	28.8	3.9	14.4
Cutter #5	Bottom	Straight	1.01	10.1	31.1	5.05	15.55
Exit Roller			1.31	13.1	34.1	6.55	17.05

## 5.2 Background noise levels

The background noise level in the demonstration area was very low, such that a conversation could easily be held, see Table 3.

**Table 3 Background noise levels in the test area**

	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Day 1*	54.3	52.7	53.1	54.0
Day 2	54.9	51.7	48.4	50.9

\* This measurement was affected by noise from a conversation being held in the vicinity of the machine (measured levels between 59.8 and 60.8 dB(A)). Other measurements were not affected by this type of noise, so the results shown here are adjusted to remove the periods affected by the conversation.

### 5.3 Dust extraction noise

The M532EL-5 test machine was connected to the workshop's dust extraction ventilation system, see Figure 15 Dust extraction system (left: front view, right: rear view).



**Figure 15 Dust extraction system (left: front view, right: rear view)**

The extraction system could be operated with the main hood open or closed, so measurements were made in both conditions, see Table 4. However, it is worth noting that, when cutting, the machine hood had to be in the closed position.

**Table 4 Comparison of the dust extraction noise levels with the enclosure hood open and closed.**

	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Day #1, Extraction on, no cutting				
Hood open	72.5	76.4	76.9	71.4
Hood closed	71.1	71.2	70.9	69.8
Difference	1.5	5.1	6.0	1.7
Day #2, Extraction on, no cutting				
Hood open	72.4	75.9	76.7	71.0
Hood closed	71.0	70.9	70.7	70.0
Difference	1.4	4.9	6.1	1.0

## 5.4 Repeatability of cutting measurements

Although no systematic measurements were made of the repeatability of measurements, three sets of measurements were repeated under the same conditions, these were:

1. Softwood samples, of dimensions 45 x 145 mm, with helical cutters at a 12 m/min feed speed.
2. Extraction only with the hood open, measured on day #1 and day #2.
3. Extraction only with the hood closed, measured on day #1 and day #2.

The results are compared in Table 5.

**Table 5 Comparison of repeated measurements.**

	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Helical cutting, softwood, dimensions 45 x 145 mm, with a 12 m/min feed speed				
Sample #1	85.9	86.3	85.7	85.3
Sample #2	85.9	86.1	86.4	85.7
Difference	0.0	0.2	-0.6	-0.4
Extraction only - Hood closed				
Day #1	71.1	71.2	70.9	69.8
Day #2	71.0	70.9	70.7	70.0
Difference	0.0	0.3	0.2	-0.2
Extraction only - Hood open				
Day #1	72.5	76.4	76.9	71.4
Day #2	72.4	75.9	76.7	71.0
Difference	0.1	0.5	0.2	0.5

## 5.5 Feed speeds

The majority of tests were performed with the machine running at 12 m/min (referred to as 'fast'), however other feed speeds were available on the machine. To provide some indication of the effect of feed speed on noise level, for the straight cutter only, a slower speed of 6 m/min ('slow') was used for comparison. Tests were performed for both samples of soft and hardwoods, see Table 6.

**Table 6 Comparison of soft and hardwoods being cut with straight cutters at different feed speeds (slow = 6 m/min, fast = 12 m/min)**

	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Slow-Softwood- 2.1m(50x150mm)	89.9	89.0	88.1	86.0
Fast-Softwood- 2.1m(50x150mm)	89.5	88.8	88.2	86.3
Difference	0.4	0.2	-0.1	-0.3
Slow-Hardwood- 2.1m(45x145mm)	88.5	87.8	87.0	85.0
Fast-Hardwood- 2.1m(45x145mm)	88.5	88.4	87.8	86.2
Difference	0.0	-0.6	-0.8	-1.2

## 5.6 Comparison of straight and helical cutters free running

One source of noise from cutters is that generated by the blade passing the cutting plate, which causes air turbulence noise. For a straight cutter, the full-length of the cutting blade passes the cutting plate on each rotation; a helical cutter breaks up the blade, so that only short sections of blade pass the cutting plate at any moment in time, so the noise generated is lower.

To confirm that helical cutters do reduce turbulence noise, tests were performed with the machine free running. For these tests, a normal set-up mode of the machine was used with no wood being pulled through the machine. In this mode, the enclosure hood could be either open or closed and the extraction system was not running. Comparisons were made running Cutter #1 only, running cutters #1, #2 & #3 only and then running all cutters. In the last case, cutters #4 & #5 were straight cutters in all measurements (so, only cutters #1, #2 & #3 were changed between straight and helical cutters). Results of the comparisons are shown in Table 7.

**Table 7 Comparison of free running straight and helical cutters.**

	Hood open or closed	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
<b>Cutter #1 running</b>					
Straight cutter	Closed	78.1	75.4	72.8	70.7
Helical cutter	Closed	73.5	70.5	69.5	67.7
Difference	Closed	4.6	4.9	3.3	3.0
Straight cutter	Open	79.4	80.1	78.7	73.3
Helical cutter	Open	74.5	79.5	77.1	69.2
Difference	Open	4.9	0.6	1.5	4.1
<b>Cutters #1, #2 &amp; #3 running</b>					
Straight cutters	Closed	79.4	79.1	77.5	74.6
Helical cutters	Closed	75.6	74.0	73.6	70.3
Difference	Closed	3.8	5.1	3.9	4.2
Straight cutters	Open	81.8	86.1	85.4	76.9
Helical cutters	Open	76.8	81.9	80.0	71.8
Difference	Open	5.0	4.2	5.4	5.1
<b>Cutters #1, #2, #3, #4 &amp; #5 running (cutters #4 &amp; #5 straight cutters in all cases)</b>					
Straight cutters	Closed	81.0	82.5	79.1	78.6
Helical cutters	Closed	79.4	81.7	78.0	78.1
Difference	Closed	1.6	0.8	1.1	0.5
Straight cutters	Open	84.3	90.8	90.4	80.3
Helical cutters	Open	82.2	89.5	87.8	80.6
Difference	Open	2.1	1.3	2.6	-0.3

## 5.7 Outfeed tunnel

The primary function of the outfeed tunnel is to restrict access to rotating machinery components within the machine enclosure. The outfeed tunnel can also provide some noise control, absorbing some of the noise escaping directly from the cutting process. However, on the machine tested, it is possible to remove the outfeed tunnel and, while it is not recommended by the supplier, some users choose to do this, for example where space is limited.

Table 8 shows the results of noise measurements with and without the outfeed tunnel fitted. Measurements were made for three conditions: with extraction only (with the hood

closed), with the straight cutters all running, but no cutting taking place (hood closed) and with a section of softwood running through the machine.

**Table 8 Comparison of noise levels with and without the outfeed tunnel fitted.**

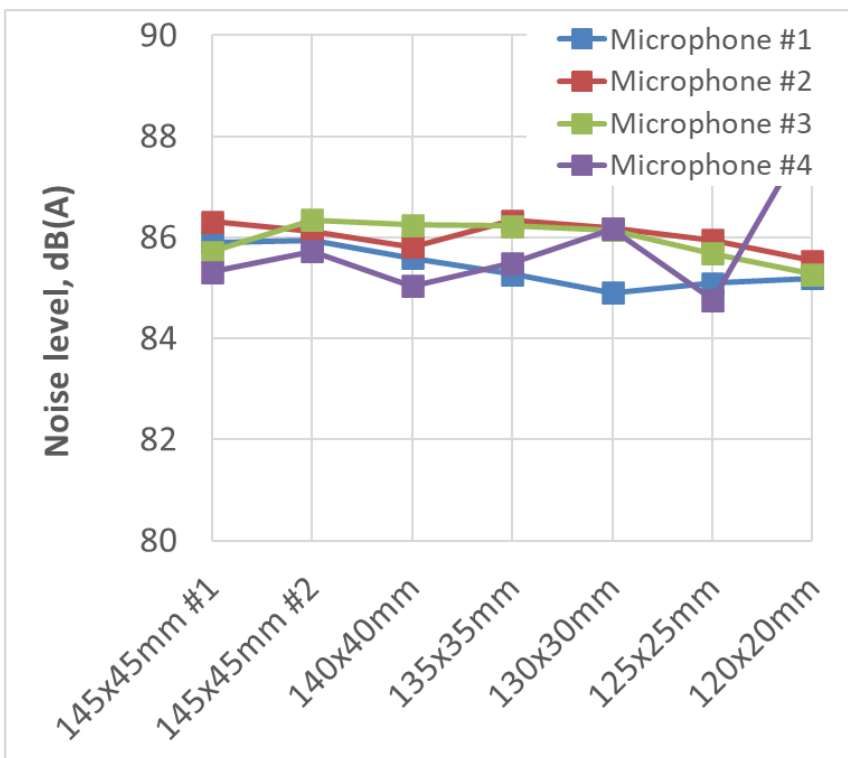
	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Extraction only - Hood closed				
Tunnel on	71.0	70.9	70.7	70.0
Tunnel off	70.8	71.1	70.5	69.9
Difference	0.2	-0.2	0.2	0.1
Straight cutters running – no cutting (extraction on, hood closed)				
Tunnel on	81.0	82.5	79.1	78.6
Tunnel off	80.5	82.6	80.5	81.1
Difference	0.5	-0.1	-1.4	-2.5
Fast feed - straight cutters – Softwood (45 x 145 mm) (extraction on, hood closed)				
Tunnel on	91.4	89.0	88.2	85.8
Tunnel off	90.6	89.4	88.7	89.4
Difference	0.8	-0.4	-0.5	-3.6

## 5.8 Wood dimensions

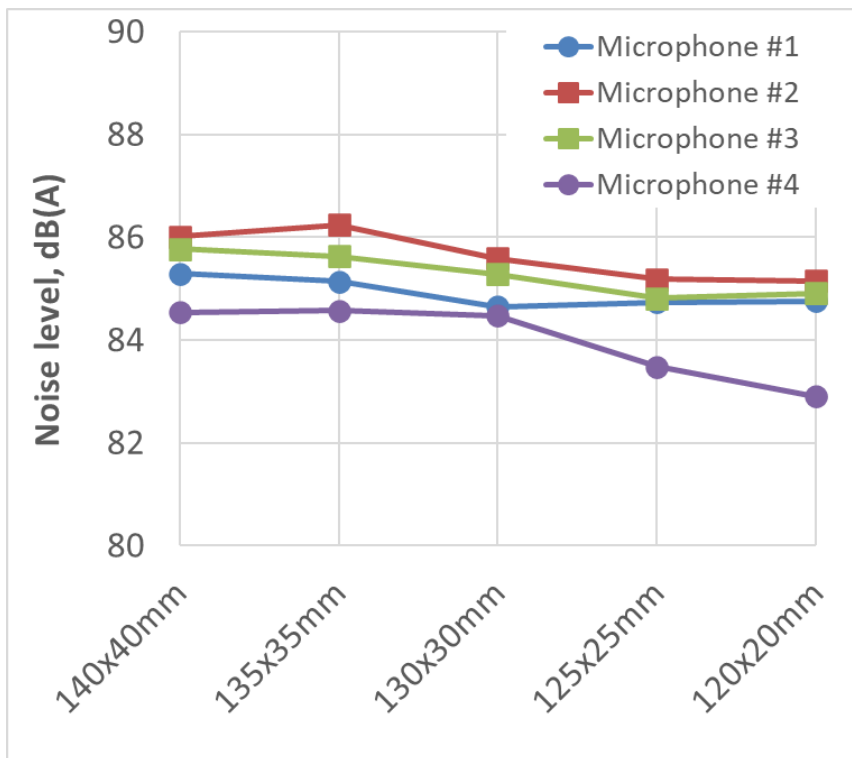
To assess how change in the wood dimensions might be affecting other tests, a series of measurements were made with both soft and hardwood samples as the wood dimensions reduced. All these tests were carried out with the helical cutters fitted in cutting positions 1, 2 and 3, using the fast 12 m/min feed speed. The results are shown in Table 9 and illustrated in Figure 16 and Figure 17.

**Table 9 Comparison of noise levels with wood dimensions**

	Microphone #1 Leq dB(A)	Microphone #2 Leq dB(A)	Microphone #3 Leq dB(A)	Microphone #4 Leq dB(A)
Softwood (2.1 m), helical cutters, fast feed speed				
145x45mm #1	85.9	86.3	85.7	85.3
145x45mm #2	85.9	86.1	86.4	85.7
140x40mm	85.6	85.8	86.3	85.0
135x35mm	85.3	86.3	86.2	85.5
130x30mm	84.9	86.2	86.2	86.2
125x25mm	85.1	86.0	85.7	84.8
120x20mm	85.2	85.5	85.3	88.2
Hardwood (2.1 m), helical cutters, fast feed speed				
140x40mm	85.3	86.0	85.8	84.5
135x35mm	85.1	86.2	85.6	84.6
130x30mm	84.7	85.6	85.3	84.5
125x25mm	84.7	85.2	84.8	83.5
120x20mm	84.8	85.2	84.9	82.9



**Figure 16 Comparison of noise levels as wood dimensions are reduced: softwood (2.1 m), helical cutters, fast feed speed.**



**Figure 17 Comparison of noise levels as wood dimensions are reduced: hardwood (2.1 m), helical cutters, fast feed speed.**

## 5.9 Straight and helical cutters (while cutting)

Direct comparison of the straight and helical cutters is complicated by the fact that cutters #4 and #5 are straight cutters on all measurements. Two analyses have therefore been performed:

‘Whole-cut analysis’: Analysis from the point where the wood first meets cutter #1 to when the wood leaves cutter #5.

‘Cutters #1 – #3 analysis’: Analysis from the point where the wood first meets cutter #1 to the point where the wood meets the cutter #4.

The relative times calculated in Table 2 have been used to limit the analysis periods for the cutters #1 – #3 analysis.

Due to the sequencing of measurements, no measurements were made for the straight cutters at dimensions of 40 x 140 mm or smaller and no measurements were made with the helical cutters on wood dimensions 50 x 150 mm or, for hardwood, 45 x 145 mm, therefore comparisons have been made across the 45 x 145 mm and 40 x 140 mm dimension materials.

Table 10 shows the results from analyses of the whole cut and the shorter analyses of the periods where only cutters #1, #2 and #3 were actively cutting.

The measurements with the helical cutter allowed the difference in finish between helical and straight cutters to be demonstrated. The helical cutter can leave tracks along the length of the wood, where the sequential cutters do not perfectly align with one another. In the case of the wood samples being worked on during these tests, these tracks were not obvious to an un-trained eye but were noticeable when pointed out.

**Table 10 Comparison of cutting with straight and helical cutters**

Wood dimensions	Whole-cut analysis				Cutters #1 – #3 analysis			
	Mic. #1 Leq dB(A)	Mic. #2 Leq dB(A)	Mic. #3 Leq dB(A)	Mic. #4 Leq dB(A)	Mic. #1 Leq dB(A)	Mic. #2 Leq dB(A)	Mic. #3 Leq dB(A)	Mic. #4 Leq dB(A)
<b>Softwood - straight cutters</b>								
50 x 150 mm	89.5	88.8	88.2	86.3	92.4	90.0	88.6	86.6
45 x 145 mm	88.9	88.5	88.1	86.0	91.4	89.0	88.2	85.8
<b>Softwood - helical cutters</b>								
45 x 145 mm	85.6	85.8	86.3	85.0	85.5	84.8	84.6	83.3
45 x 145 mm	85.9	86.3	85.7	85.3	87.6	85.7	84.8	84.3
40 x 140 mm	85.9	86.1	86.4	85.7	86.8	85.6	84.6	83.8
<b>Hardwood - straight cutters</b>								
45 x 145 mm	88.5	88.4	87.8	86.2	90.2	89.0	87.7	86.2
<b>Hardwood - helical cutters</b>								
40 x 140 mm	85.3	86.0	85.8	84.5	84.8	85.2	83.3	83.5

**Table 11 Differences between of cutting with straight and helical cutters and different wood dimensions.**

	Whole-cut analysis				Cutters #1 – #3 analysis			
Comparison	Mic. #1 Diff. dB(A)	Mic. #2 Diff. dB(A)	Mic. #3 Diff. dB(A)	Mic. #4 Diff. dB(A)	Mic. #1 Diff. dB(A)	Mic. #2 Diff. dB(A)	Mic. #3 Diff. dB(A)	Mic. #4 Diff. dB(A)
Straight cutters (45 x 145 mm) minus helical cutters (45 x 145 mm)								
Softwood - 1	3.0	2.2	2.4	0.7	3.8	3.3	3.4	1.5
Softwood - 2	3.0	2.4	1.7	0.3	4.6	3.4	3.6	2.0
Straight cutters (45 x 145 mm) minus helical cutters (40 x 140 mm)								
Hardwood	3.2	2.4	2.0	1.7	5.4	3.8	4.4	2.7
Helical cutters (45 x 145 mm) minus helical cutters (40 x 140 mm)								
Softwood - 1	0.3	0.5	-0.6	0.3	2.1	0.9	0.2	1.0
Softwood - 2	0.3	0.3	0.1	0.7	1.3	0.8	0.0	0.5

## 6 Discussion

### 6.1 Background noise levels

Measured background noise levels were very low, at less than 55 dB(A), (see Table 3), similar to a quiet home or normal spoken conversation and are therefore extremely unlikely to have any impact on results of measurements with machinery operating, where measured noise levels were greater than 70 dB(A) for just the ventilation system running (Table 4).

### 6.2 Dust extraction noise

The dust extraction (LEV) noise with the hood closed with no cutting taking place was measured at 70 to 71 dB(A), see Table 4. This is substantially lower than when the machine is cutting (and the hood is closed), where the measured levels were greater than 83 dB(A) (for example, see Table 9). The dust extraction noise is therefore unlikely to influence any noise measurement whilst cutting.

### 6.3 Noise reduction of the hood

With the hood open, Table 4 shows that the measured noise level from the dust extraction system was substantially higher directly in front of the machine (mics #2 & #3) by 3.5 and 5.7 dB(A) compared to being at the side (microphones #1 & #4). Closing the hood is clearly effective directly in front of the machine, reducing the level by between 4.9 and 6.1 dB(A).

Table 4 shows that the reductions in noise due to closing the hood is noticeably less at microphones #1 & #4, than they are at microphones #2 and #3. With the hood open, the noise levels at microphones #1 and #4 are 4 to 5 dB less than those at the other positions. This suggests that with the hood open, microphones #1 and #4 were already shielded from the direct noise from the dominant elements of the ventilation noise with the hood open.

### 6.4 Repeatability of cutting measurements

Table 5 shows variability in measurement results while helical cutting up to 0.6 dB(A). The repeated measurements of extraction only with hood open and hood closed show a similar measurement variability, between 0.2 and 0.5 dB(A). Differences between measurements of  $\pm 0.6$  dB(A) or less should therefore be regarded as being within the measurement uncertainty and should not, be attributed to changes in the machine parameters.

## 6.5 Feed speeds

Table 6, shows that differences between slow and fast cutting for softwood were negligible, being less than  $\pm 0.4$  dB(A) and therefore well within the expected measurement uncertainty. The differences between slow and fast cutting for hardwood were a little more noticeable, with fast cutting being 1.2 dB(A) louder than slow cutting at microphone #4.

## 6.6 Comparison of straight and helical cutters free running

Table 7 shows that the differences between a straight and helical cutter, when free running, were between -0.3 and 5.4 dB(A). The -0.3 dB(A) value is for microphone #4. This microphone was closest to cutters #4 and #5, which were always straight cutters. A difference of -0.3 dB(A) is within the expected uncertainty of these measurements, so can be regarded as representing no change in noise level.

It is clear from Table 7 that helical cutters can reduce the noise levels by as much as 5.4 dB(A). In most cases, the noise reductions were apparent both when the hood was closed and when it was open.

It is not clear why there was only a small reduction in noise level between straight and helical cutters at microphones #2 and #3 when the hood was in the open position and with only cutter #1 running. These results appear inconsistent with other results given in Table 7, so may not be a true reflection of the noise reductions that could be expected at these locations.

## 6.7 Outfeed tunnel

Removing the outfeed tunnel is expected to have greatest impact on the measured noise levels at microphone #4. Table 8 shows that for noise from the extraction system, there is no significant change when the tunnel is removed at any of the microphone positions. There is a 2.5 dB(A) change at microphone #4 with the cutters running but not cutting, a smaller difference than at microphone #3.

When cutting is taking place, the differences seen in Table 8 are large at microphone #4, 3.6 dB(A), but become insignificant (at or below the threshold for measurement uncertainty) at microphones positions # 1 and #2.

## 6.8 Wood dimensions

Table 9, Figure 16 and Figure 17 show that the differences in noise level, over the range of dimensions tested, are small. There is some evidence of a minor reduction in noise levels with reduction in wood dimensions for hardwood, but this is at most a 2 dB(A) reduction at microphone #4. Generally, the reductions are less than 1 dB(A) across the full range of wood dimensions.

The result for microphone #4 for softwood at the smallest wood size appears to be an anomaly, the lack of a similar higher level at microphone #3 suggests that this may have been noise generated close to microphone #4, perhaps caused by the machine operator when moving to take the wood from the machine.

## 6.9 Straight and helical cutters (while cutting)

For softwoods, there is a direct comparison of straight and helical cutters available for the 45 x 145 mm dimensions wood. For hardwood, a direct comparison at one wood dimension was not available, therefore data from the two largest dimensions (45 x 145 mm and 40 x 140 mm) has been compared.

Table 11 shows that the use of the helical cutters clearly reduces the noise levels around the machine. When considered over the full cutting period, noise level reductions caused by using the helical cutters (shown in Table 10) are up to 3.2 dB(A). When the effect of the two straight cutters (Cutters #4 and #5) is removed, the reductions are greater, with reductions up to 5.4 dB(A).

It is important to recognise the possible effect of the different wood dimensions on these hardwood comparisons. Table 10 compares the difference between 45 x 145 mm and 40 x 140 mm dimensioned softwood. For the cutters #1 – #3 analysis, the differences are up to 2.1 dB(A). This is consistent with results shown in Table 8, Figure 9 and Figure 10, and shows that these differences are small compared to the measured differences between straight and helical cutters.

## 6.10 Noise risks

Although the measurements reported here were not intended to assess risks from using the machine, it is useful to put the result into context, and consider potential noise exposures compared to the action and limit values in the Control of Noise at Work Regulations 2005 (HSE, 2006).

To estimate daily exposures, it is necessary to know how long an individual worker is likely to be exposed to the various noise levels. In this study, the machine is not operating in a production environment, so there is no information on daily exposure times. However, to illustrate the impact on daily exposures an example working pattern was used. In this working day totalling 8-hours, it is assumed that the machine operator spends:

- 1 hour with the machine off, and no dust extraction operating (in this case this is background noise).
- 1-hour setting-up and closing down, with dust extraction operating, and the hood up, but no cutters operating.
- 6-hours of the main machine operation, where the operator spends:
  - 2 hours at the in-feed location,
  - 2-hours at the out-feed location and

- 2 hours split between locations to the left and right-hand sides at the front of the machine.

This breakdown is shown in Table 12, for straight-cutters and Table 13 for helical cutters. The associated noise levels are based on the measurements in Table 3, Table 4 and Table 10 (in some cases averaged values of similar measurements have been used). The HSE noise calculator spreadsheet (HSE, 2021) has been used to calculate the personal; noise exposure values given in Table 12 and Table 13.

**Table 12 Illustrative calculation of daily noise exposure, based on the use of straight cutters**

Task name / description	Noise level $L_{Aeq}$ (dB(A))	Daily exposure time		Personal noise exposure per task (dB(A))
		(hours)	(mins)	
Machine prep. No dust extraction, cutters not running.	52.2	1		43
Machine prep. Dust extraction running, cutters not running, hood open, operator at the left-hand side of front of machine.	76.4	1		67
Cutting softwood, straight cutters #1, #2 & #3. Operator at the in-feed location.	89.5	2		83
Cutting softwood, straight cutters #1, #2 & #3. Operator at the left-hand side of the front of machine.	83.2	1		74
Cutting softwood, straight cutters #1, #2 & #3. Operator at the right-hand side of the front of machine.	86.1	1		77
Cutting softwood. Operator at the out-feed location.	85.5	2		79
		Total daily exposure time (hh:mm)		Daily exposure, $L_{EP,d}$ (dB(A))
		8:00		86

**Table 13 Illustrative calculation of daily noise exposure, based on the use of helical cutters**

Task name / description	Noise level $L_{Aeq}$ (dB(A))	Daily exposure time		Personal noise exposure per task (dB(A))
		(hours)	(mins)	
Machine prep. No dust extraction, cutters not running.	52.2	1		43
Machine prep. Dust extraction running, cutters not running, hood open, operator at the left-hand side of front of machine.	76.4	1		67
Cutting softwood, helical cutters. Operator at the in-feed location.	85.7	2		80
Cutting softwood, helical cutters. Operator at the left-hand side of the front of machine.	86.1	1		77
Cutting softwood, helical cutters. Operator at the right-hand side of the front of machine.	86.0	1		77
Cutting softwood. Operator at the out-feed location.	85.1	2		79
		Total daily exposure time (hh:mm)		Daily exposure, $L_{EP,d}$ (dB(A))
		8:00		84

# 7 Conclusions

## 7.1 Machine and tool selection use and maintenance

Noise control starts with the selection of the most appropriate machinery and tooling. Low-noise emissions are associated with higher cutting efficiencies and higher quality cutting.

Whether the cutting is by blade or cutting block, noise emissions can be minimised by ensuring the cutters are selected and set up to provide the right feed rate, blade cutting speed and cutting depth for the timber species being cut.

Noise control features such as helical cutters on cutting blocks, spiral or segmental cutouts or laminated blades can provide significant noise reductions over standard cutters. However, it is important to understand the limitations of these controls, as they may not be suited to every application.

Machine and cutter maintenance is critical to ensuring that low-noise systems stay low-noise. Blades can be sharpened, re-tipped and balanced to keep the cutting efficient and reduce noise emissions.

Dust extraction generates noise through turbulence of the air flow. Low noise extraction systems are available that reduce the turbulent noise in the extraction system. Effective dust extraction systems minimise the wear-rate of cutters which reduces servicing costs and ensures that low noise levels are maintained.

## 7.2 Measurement reliability

The measurements reported here benefitted from the very low background noise levels available in the demonstration area at AMS Ltd. The dust extraction system also created relatively low noise levels, making it possible to carry out good and reliable measurements of the noise from the cutting processes.

The assessment of the measurement repeatability showed that noise from the machine was consistent, with a variability on comparable measurements of the order of  $\pm 0.5$  dB(A).

## 7.3 Hood

The hood on the machine's enclosure was effective at reducing noise. The hood reduced directional noise from the ventilation by around 5 to 6 dB(A).

## **7.4 Tunnel**

The outfeed tunnel provides useful noise reduction, primarily in the vicinity of the outfeed. Noise was reduced by 3.6 dB(A) at the outfeed when cutting. There is a smaller, but still useful, noise reduction of the ventilation system noise of 2.5 dB(A).

## **7.5 Helical or straight cutters**

Helical cutters were shown to create significantly lower noise levels than the equivalent straight cutters. On their own, replacing straight cutters with helical cutters was shown to reduce the noise levels by 5.4 dB(A).

The finish provided by a helical cutter is not as good as that provided by a well-maintained straight cutter. Therefore, helical cutters may be used in conjunction with straight cutters, as they were on the machine used here. Replacing three of the five straight cutters with helical cutters reduced the noise levels by 3.2 dB(A).

Helical cutters were also shown to be quieter when free running, with noise levels reduced by as much as 5.1 dB(A) when the hood was closed, or 5.4 dB(A) when the hood was open.

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**Exposures to high noise levels at work can cause hearing damage and contribute to safety risks. Some processes in the woodworking industry produce high levels of noise and present ongoing risks from noise exposures. There is a lack of up-to-date information on effective noise control measures.**

**HSE inspectors judge whether all reasonably practicable control measures have been taken to reduce noise exposures in workplaces based on established technology. Research on the latest machines or technologies available is required to keep inspectors abreast of current noise control benchmarks.**

**This research reviewed observations made by HSE specialist inspectors, industry specialists and outcomes of discussions with both machine and machine-tool manufacturers to better understand the application of noise controls to woodworking machines. The work was concluded with measurements to illustrate the control of noise from one common woodworking machine, a five-head multi-cutter.**

**This work will be used to focus inspector interventions, support any revised guidance for dutyholders and influence industry and trade bodies to develop industry-led solutions that reduce the risks from high noise exposures in woodworking.**

**DOI: <https://doi.org/10.69730/hse.25rr1223>**