WISH

Waste Industry Safety and Health Forum

FORMAL GUIDANCE DOCUMENT

PRINCIPLES OF MACHINERY SAFETY RECYCLING AND RECOVERY PLANT

This guidance has been developed by the Waste Industry Health and Safety (WISH) Forum to help control safety and health risks in the waste management industry associated with machinery safety and recycling, recovery and similar plant used in the waste and recycling sector. The Health and Safety Executive (HSE) were consulted in the production of this publication. It endorses the sensible, proportionate, reasonable, and balanced advice on managing risk during waste-related activities as set out in this guidance.

Machinery safety is often a technical topic involving complex standards and requirements that are frequently not easy to understand and interpret. This guidance is not a technical document and does not aim to be comprehensive. It gives an overview of some of the main issues with the safety of machinery in common use at waste recycling and recovery plants, such as conveyors, balers, screens, shredders etc. You will also need to access and read other sources of information, including:

- WISH WASTE 29 ‘Practical advice on lock-off for recycling machinery’, available on the WISH website at https://www.wishforum.org.uk/wish-guidance/
- WISH WASTE 13 ‘Designing and operating material recycling facilities (MRFs) safely’, available on the WISH website at https://www.wishforum.org.uk/wish-guidance/
- WISH has produced a series of information documents on specific items of recycling and recovery machinery, such as on conveyors, balers and trommel screens. These are all available at https://www.wishforum.org.uk/information/
- Specific waste industry machinery guidance from the HSE available at https://www.hse.gov.uk/waste/machinery.htm
- General work equipment and machinery guidance from the HSE available at https://www.hse.gov.uk/work-equipment-machinery/index.htm

In many cases you may also need to seek competent advice, either in-house or external.

Contents

Case studies – the case studies in this document are based on real accidents. However, they have been anonymised by the removal of names, dates etc to prevent any distress to relatives and friends of the injured person/s. Some details have also been omitted for the sake of conciseness.

Tips/summaries – summaries and tips are also given through this document. These are not part of this formal guidance and are only included to assist operators in their decision making.

1. Introduction and scope

1.1 Introduction

1.1.1 Fatal machinery accidents at GB waste and recycling sites have increased significantly over the past 20 years. Prior to 2000 zero fatal machinery accidents were recorded in the industry, and only a handful of serious injuries (source HSE Bommel Report). Today machinery safety is the most common cause of fatal accidents at British recycling and recovery plants. The latest Health and Safety Executive (HSE) data shows an average of three waste and recycling sector machinery fatal accidents a year over the past five years (see HSE statistics publication available at: https://www.hse.gov.uk/statistics/industry/waste-recycling.pdf).

1.1.2 To an extent this rise in fatal machinery accidents has mirrored the increase in recycling and recovery over recent years. The more wastes we recycle and recover the more machinery we tend to use. This link is not inevitable and other sectors which use as much, if not more, machinery do far better. The manufacturing sector has a fatal accident rate ten times lower than the waste and recycling industry. As a sector, we need to recycle and recover more wastes, but we also need to do this without endangering the lives of our workers.

Case study - a worker was fatally injured in a mobile agricultural baler at a materials recovery facility (MRF). Despite being designed for animal forage, the baler was being used with refuse derived fuel (RDF). It had been known for three years before the accident that the baler could not cope with large/rigid items. However, the company made no effort to modify or replace the baler – effectively, it became the workers' problem to minimise blockages by manually extracting the largest pieces of non-compactable material and unblock the baler when this failed. There was little training and no safe system of work or lock-off procedure in place. On the day of the accident, a second baler on site was out-of-action, leading to greater pressure to keep the remaining baler operating. An untrained worker who was helping clear the blockage inadvertently started the baler when another operator was in the bale chamber. The baler was not isolated and locked-off and the operator in the baler was killed.

***Note** – machinery safety is a complex area. Unless you have suitably competent internal advice you are likely to require external advice. It is not expected that recycling managers be engineers with an in-depth knowledge of machinery safety. However, it is expected that anyone involved in the design, procurement, and modification of machinery has sufficient knowledge to be able to challenge and question decisions made on machinery safety. Designers and suppliers of machinery have a duty to ensure machinery is safe to use. Employers whose workers use machinery also have the same responsibility and relying completely on designers and suppliers to provide safe machinery without input from the employer/user is not acceptable.*

1.1.3 While reading this guidance, some overarching issues should be kept in mind:

- Ensuring that machinery is safe to use and maintained in a safe condition is a continuous process. When installed and commissioned recycling machinery may be safe to use. However, over time damage can occur, guards removed and not replaced, interlock systems can fail or become defective. Machinery safety is not something you do just once when the plant is new – it is something which needs checking throughout the life of the plant
- Likewise ways of working and safe systems of work require monitoring to ensure that they are still being followed correctly, such as via supervision and periodic management checks. Any system of work which is not monitored and reviewed may soon fall into disuse and/or workers start to use unsafe 'work-arounds', usually with the aim of saving time
- Physical safeguarding 'hardware', such as guards, emergency stops etc, is important. However, 'soft' issues are equally important, such as training and competence, change management, ways of working etc

1.1.4 This document takes a broader approach than focusing only on physical machinery safety measures, although inevitably physical aspects comprise a large portion of this guidance. It considers key principles, such as how the machine will be used, selecting the most suitable machine for the job, the effect of organisational culture may have on worker and manager behaviour alike and the importance of considering how individual machines fit together in a production assembly.

1.2 Scope and audience

1.2.1 This guidance is primarily aimed at recycling and recovery plant managers, in-house engineers and maintenance staff, in-house safety officers and advisors and similar personnel. It would also be relevant to anyone involved in the purchase, modification, and use of machinery, such as procurement managers.

1.2.2 This guidance covers recycling and recovery machinery such as balers, shredders, fragmentisers, compactors, conveyors etc. It does not cover non-powered work equipment, heavy mobile plant (such as forklifts, loading shovels etc) or road vehicles.

Case study – two workers at a recycling plant entered a trommel screen to clear a blockage. The machine had not been securely isolated and locked-off. A third person was unaware that the workers were in the trommel (interior of the trommel not visible from the control panel) and started the machine, resulting in fatal injuries to both of the workers in the trommel.

1.3 Why does the waste and recycling industry have a problem with machinery safety?

1.3.1 As noted above, the waste and recycling industry has a far worse machinery safety record than many other sectors which use as much if not more machinery. The reasons behind this can be many and varied, including:

- The common use of machinery in the waste industry is fairly new (perhaps 20 years). Other sectors such as manufacturing have a far longer history of machinery safety, in some cases more than 100 years. This relative lack of experience can have consequences. For example, expecting managers, supervisors, workers etc from fairly simple activities such as waste transfer stations and waste collections to operate complicated and powerful recycling machinery without significant training and skills enhancement is likely to result in raised risk levels. This can lead to a failure to understand and appreciate machinery safety issues such as retained/stored energy, effective isolation and lock-off, the limits of interlock systems, the need for daily/weekly tests on emergency stops etc
- The pace of work at recycling plants is often reactive, being driven by the volume of wastes being received (if a plant stops for whatever reason waste does not stop being produced). Other sectors tend to use proactive measures such as setting a desired volume of production. This reactive approach may be exacerbated by variations in waste arisings through the year and financial penalties. When combined with the waste and recycling industry's 'can-do' culture this can lead to problems. For example, essential maintenance being skipped and machinery being 'run-until-it-breaks', often to the degradation of safety standards
- Compared to virgin raw materials, such as used at a manufacturing plant, wastes are often variable in size, density, moisture content, rigidity, shape etc and are often contaminated. This tends to lead to a greater frequency of blockages, need for cleaning etc, and a greater requirement for human 'interventions' such as blockage clearance. This higher need for interventions can be exacerbated by time pressure from waste continuing to 'pile-up' if a plant is down leading to front line workers feeling under pressure to take short cuts or to make-up their own work systems without considering the consequences fully
- It is common for recycling machinery to have originally been designed for a different use, such as conveyors originally designed for use in quarries or balers originally designed for agricultural use. This can cause problems. For example, excessive spill from conveyors because of a lack of spill plates, insufficient power in a baler to handle rigid wastes rather than agricultural materials etc. These can all lead to a greater need for interventions to clear detritus, blocks etc. A key principle of machinery safety is to have the right machine for the right job. Even when starting with the right machine, issues such as changes to the waste type/s being processed can result in the machine not being the 'right one' anymore

- Recycling machinery is often modified and/or added to over time, such as the addition of a shredder or over-band magnet to an existing recycling line or changing one type of screen for another, without considering the consequences adequately. For example, guards may no longer fit correctly resulting in them being ineffective or left-off, or a failure to connect together emergency stop systems (activating any stop on an assembly should result in the whole of the machine assembly stopping). A common issue is the addition of a shredder, screen, magnet or whatever resulting in the existing power supply being exceeded. Instead of uprating the existing supply a second (or in some cases a third, fourth etc) supply is added (because it is often cheaper) leading to multiple isolation switches/points, more complicated isolation and lock-off processes and a higher risk of confusion and failure of isolation and lock-off processes
- Because of a lack of knowledge and experience waste and recycling employers often do not have sufficient input into machinery safety during the design of new or modified machinery and just assume the machine will come fully guarded and compliant (often not the case). The comment above regarding the waste and recycling sector having only a relatively short experience of machinery safety often also applies equally to designers and suppliers
- Second-hand machinery can sometimes be supplied with missing guards and/or little or no documentation such as operating manuals leading to employers and/or workers ‘making it up’, sometimes incorrectly
- It is impractical to fully guard some types recycling machinery. For example, balers, shredders etc often require large feed openings (feed chutes, hoppers etc) to accept larger sized wastes, sometimes exacerbated by automatic activation such as ‘magic eyes’ which can start machinery unexpectedly. If the feed opening is large enough workers or other persons may also be able to get into the machine, even if feed hopper/chute height etc is designed to prevent this, sometimes leading to a greater reliance on human-based controls such as isolation and lock-off when openings need to be approached to clear blockages etc. In these cases, processes such as isolation and lock-off need to be robust, supported by good training and instruction, and monitored and checked frequently to ensure they are being followed. Experience and the accident history of the sector shows that often waste and recycling operators are often not good at these aspects of machinery safety and fail to maintain the necessary level of attention to enforcing the necessary safety practices over time
- Waste and recycling plants often have a greater proportion of temporary and transient employees than many other sectors leading to a greater need for frequent training and instruction. In addition, workers for whom English is not their first language may pose understanding issues

- The documentation provided by designers and suppliers of recycling and recovery machinery is sometimes less than complete and/or inaccurate. For example, employers need to be aware of the interlocks and other safety systems installed on their machinery. Sometimes these may have been fitted after the original manufacture of the machinery (for example fitted when the machine was being installed, during commissioning etc) or may simply have been omitted from mention in the manuals supplied. As a result, reliance on OEM (original equipment manufacturer) documentation for recycling and recovery machinery to identify safety systems may be flawed resulting in a need to inspect physically and the testing of safety systems before machinery is put into final use – to do this adequately employers need to have a good understanding of machinery safety, which as noted above can sometimes not be the case at recycling and recovery plants

1.3.2 Most of the above are not direct physical aspects of machinery safety, such as standards for guards, interlocking systems etc. Mostly they are associated with experience, competence, culture, behaviour and other 'human factors'. Physical safeguarding is important but 'human factors' are equally critical, and you should understand this. If you recognise any, or all, of the above as being relevant to your operation then you should take this into account when designing, putting in place, and monitoring and checking your systems of work.

Case study – at a recycling plant access to the underneath of a large load conveyor was protected via machine/perimeter fencing with access gates for cleaning, blockage clearance etc. The fencing and gates had been installed following comments made during a regulator inspection of the site. However, within a few years the gates had become damaged resulting in easy access. A worker accessed under the conveyor while the machine was running via the damaged gates and suffered fatal head injuries when he came into contact with the moving conveyor. Machinery safety is not a one-off exercise – it needs to be a continuous process to ensure that the level of machinery safety provided is maintained and remains effective.

2 General principles of machinery safety

2.1 Overarching principles

2.1.1 Generally, people are hurt by machinery because they come into contact with a moving dangerous part, such as the end-roller of a conveyor or compaction ram of a baler (there are other hazards such as electricity, heat etc but physical contact is the most common). In most cases, this occurs when performing 'interventions' such as maintenance, blockage clearance, cleaning, adjustments etc involving the removal/opening of guards and/or approach otherwise to a dangerous part. The more frequently interventions are required the higher the likelihood of controls such as isolation and lock-off failing – this is simple statistics. The first overarching principle is to eliminate or at least reduce the need for interventions, such as by:

- Having the right machine for the right job: powerful enough to handle the wastes being processed but not excessively powerful, appropriate to the waste type/s being processed, and maintained appropriately to minimise breakdowns etc
- Reducing the need for and frequency of interventions such as blockage and detritus clearance and cleaning. For example, ensuring the design of waste chutes is appropriate to the wastes processed, spill plates and scraper bars on conveyors to reduce detritus build-up, pre-treating wastes such as by shredding or using a pre-sort to reduce blockages by large items etc
- Removing the need to directly approach a dangerous part and/or remove guards. For example, use of automatic or remote oilers and greasers, design of guards at conveyor tail rollers so that they do not need to be removed to track belts etc

2.1.2 Elimination and reduction by design is a fundamental aspect of machinery safety. However, in many waste and recycling operations eliminating all need for interventions is unlikely to be 100% practical (you should still start with design), and machinery safety measures are very likely to be required. Isolation and lock-off is also a critical control. You should read and understand WASTE 29 'Practical advice on lock-off for recycling machinery', available on the WISH website at https://www.wishforum.org.uk/wish-guidance/

Case study – a maintenance engineer at a recycling plant attempted to track one of the belt conveyors at the site. He was working alone and the guard at the tail roller of the conveyor required removal to access the tracking adjustment mechanism. During tracking his spanner slipped. The engineer instinctively reached-out to try and stop the spanner falling to the floor, as a result his hand became entangled in the nip point of the roller, and he was drawn into it. He sustained multiple fractures to his arm and serious soft tissue and tendon damage requiring the amputation of his arm.

2.2 Selection of physical machinery safety measures

2.2.1 Physical machinery safety measures should be selected in accordance with the hierarchy set out in PUWER (Provision and Use of Work Equipment Regulations) in the order laid out. Specific to the waste and recycling sector this in outline means:

- First eliminate risks through design where practical (as above)
- Where not practical use fixed close guarding
- Where this is not practical use other guarding such as interlocked guards
- If none of the above are practical use of other measures such as perimeter/machine fencing

2.2.2 Regardless of the level of physical measures selected, instruction, information, training, and supervision will always be required.

***Note** – adequate consideration must be given before moving down the hierarchy given above. For example, if a fixed, close, solid guard causes excessive detritus build-up, resulting in a need for more frequent intervention to clear detritus, other designs of fixed guard must first be considered before moving down the hierarchy. This might include use of fixed mesh guards to allow detritus to fall through, fitting drop-out chutes to fixed guards to allow detritus to fall-out etc. For examples relating to specific items of recycling machinery, such as conveyors, trommel screens, balers etc see the relevant information sheets available at: https://www.wishforum.org.uk/information/. You should also be wary of the concept of 'safe by position' as a form of control as experience and history is that this often fails.*

Case study – a deflection/change of direction roller on a belt conveyor located under a picking cabin at a recycling plant had been deemed 'safe by position' and had not been guarded because it was well above ground level, and it was thought it could not be reached. However, as part of the normal operation of the plant wastes would build-up in the bays/bunkers under the cabin. One day as the result of a puncture the loading shovel used to empty the bays/bunkers was not available and consequently wastes built-up in the bays/bunkers more than would be usual to the extent that the bays/bunkers were becoming full. A worker at the plant attempted to level the wastes in a bay/bunker to allow picking to continue. To do this he climbed-up the pile of wastes under the cabin, so defeating the distance to the deflection roller. He became entangled in the roller and died later in hospital. It is common at recycling plants for wastes to build-up under picking cabins, under the head rollers of output conveyors and similar, or for containers such as skips to be placed in these locations. 'Safe by position' does not work if there is a pile of waste, a waste container or other item placed under conveyor rollers, or any other dangerous part, allowing access by climbing.

2.3 Considerations in use

2.3.1 Waste and recycling plants are harsh environments, damage to plant including safeguarding is foreseeable and sometimes frequent, and misuse of safeguards is also foreseeable.

- Guards, interlocks, emergency stop systems etc should be robust, including their fitting and fixings. Dust and moisture ingress should also be considered
- Misuse of machinery safety systems can and does occur. This might be deliberate or inadvertent. For example, in picking cabins workers tend to have a habit of scavenging items from waste streams, such as soft toys (teddy bears etc) and hanging them on pull-wire emergency stops so potentially jamming their operation
- Systems such as interlocks and emergency stops require specialist maintenance and repair. In-house maintenance staff should be suitably competent. External maintenance and repair contractors likewise. For example, your local 'jobbing' electrician may not have the knowledge and experience required to repair complex interlock and emergency stop systems
- You should include damage and misuse in your routine monitoring and checking processes. For example, are all guards still in place, are they undamaged, still securely fixed in place etc

Case study – a recycling plant used a large rotary shredder to shred plastics. This had been an addition to the plant, had been installed by in-house staff and no main isolation switch had been fitted. There was no method to securely isolate and lock-off the shredder. As a result, workers had taken to using the shredder's emergency stop system as a substitute for isolation and lock-off. Over time the stop system became faulty and had been badly repaired to the extent that the stops only acted as 'pause' buttons, rather than reset of the system at the control panel being required to return power after a stop had been pressed. A worker at the plant was in the shredder clearing a blockage. A second worker was holding-in an emergency stop to prevent the machine from starting. His hand slipped off the stop button and the shredder started fatally injuring the worker clearing the blockage.

Left to right: damaged emergency stop, non-robust fixings (self-tapping screws) resulting in an interlock pulling free of its mounting, deliberately tampered with interlock, damaged fixed guard (bolt fixing sheared)

3 Fixed guards, interlocked guards, fencing, and emergency stops

***Note**: the information given below is general and outline only. For further information on machinery safety for specific items of recycling machinery, such as conveyors, balers etc, see machinery safety information sheets available at: https://www.wishforum.org.uk/information/.*

3.1 Fixed guards

3.1.1 Fixed guards are typically used where access is not frequent. If access is frequent interlocked guards might be more appropriate. For example, if a fixed guard secured by six bolts needs to be removed daily it is foreseeable that at some point not all six bolts will be replaced, or may be lost, resulting in the guard becoming insecure. Issues to consider with fixed guards include:

- They should be robust enough for the use intended and the environment they are in
- Fixed guards should be secured by more than one fixing (bolts, nuts etc)
- Fixings should be tight, secure and require a tool to remove (no over-centre clips etc only)
- If there are gaps/openings in fixed guards (such as with mesh fixed guards or openings for cleaning, lubrication etc) there are specific standards which must be applied, such as on the relationship between the size of the opening/gap and distance to the dangerous part – you are likely to need to seek competent advice on these standards
- Removal of guards should be subject to a safe system of work, including isolation and lock-off

Case study – workers had entered a trommel screen to clear a blockage. The interior of the screen was fitted with 'teeth' elements. While in the trommel the screen started moving under their body weight (rotating as the workers moved around in the trommel drum). One worker slipped and fell partially into the output chute at the lower end of the trommel and onto the 'teeth' elements sustaining serious soft tissue damage, a fractured leg and puncture wounds.

Left to right: mesh fixed guard at a conveyor tail roller, fixed guard removed for cleaning, inadequate fixed guard (access possible from below), fixed guards with hinges to reduce manual handling issues when opening

3.2 Interlocked guards

3.2.1 Interlocks are typically fitted where access is required frequently. Interlocked guards can be hinged, sliding, removable etc. Their key feature is that when a guard is opened or removed the interlock activates and the machine stops, or in the case of most key interlocks that the guard cannot be opened or removed with the machine still running. Interlocks come in various types: tag, magnetic, trapped and exchange key interlocks (commonly called Castell keys) etc (see summary below). Interlocking systems also come in different 'safety performance levels' dependent on such features as the reliability of the components used, the sophistication of the interlock's control systems etc. The selection of interlock type and safety performance level required is based on factors such as the intended use, environment to be used in, the risk and likely severity of injury should the interlock system fail etc. This is a complex area, and you are likely to need to seek competent advice. Issues to consider with interlocked guards include:

- Closing or replacing an interlocked guard must not result in the machine starting. Reset of the machine at its control panel to allow it to start must be required
- The vast majority of interlocks operate on control circuits not direct on the machine's power supply – they should not be used instead of isolation (see WISH WASTE 29 'Practical advice on lock-off recycling machinery', available at https://www.wishforum.org.uk/wish-guidance/)
- Interlock fixings and fittings should be robust and require a tool to remove the interlock. You might want to consider the use of security bolts/nuts to reduce the risk of tampering
- Where the risk of injury is high the standard of interlocking used must also be high, such as the use of exchange key systems or other systems with a very high safety performance level
- Interlocking systems should be part of routine checks and tests, including for physical damage. Functional tests should also be carried-out. These can either be 'live' (opening the guard to see if the machine stops) or if this would be unsafe 'dead' tests (isolating the power, then open the guard and ensure all personnel are clear, then try to turn the machine back on)
- Procedures and ways of working with interlocks should be part of monitoring. For example, checking with employees that they know the process for the use of an exchange key system




Left to right: magnetic' type interlock on a baler access door, tag interlock, transfer box on an exchange key system (red arrow shows insertion socket for master key – see summary below), magnetic type interlock

Summary – outline and basic summary of some typical interlock operation

Switch systems

Tag type interlocks. These have a switch 'box' fixed to the structure around the guard and a 'tag' fixed to the guard. Opening the guard pulls the tag out of the box activating the safety/control circuit stopping the machine. They are simple but can be prone to damage and may be easier to defeat than other types. The degree of protection depends on the safety performance level of the system.

Magnetic interlocks. Instead of having a tag, magnetic interlocks have a sensor which registers the presence of a 'magnet' fixed to the guard. Opening the guard pulls the magnet away from the sensor activating the safety/control circuit. Typically magnetic interlocks are less prone to damage than tags and may be a better choice in recycling plants but can still be fairly easy to defeat. Not all magnetic interlocks are the same. Some are 'coded' (like a bar code) and are less easy to defeat. Be wary of maintenance engineers with magnets stuck to their toolbox lids etc – they may be using them to defeat magnetic interlocks. The degree of protection depends on the safety performance level of the system.

Key systems. *Note – it is common for the terms below to be used interchangeably*

Captive key interlocks. These are normally used where a series of guards or other items need to be opened or operated in a predetermined order. In essence they are keyed locks, the key of the first guard etc needs to be used to open the first guard then removed to open the second, releasing a further key and so on. These are unlikely to be suitable for higher risk situations but are typically robust. They are not that common on recycling plants.

Trapped key interlocks. These have a unique key fitted to the machine's control panel. Removing the key activates the safety/control circuit. The guard has a fitting for the key – the key must be inserted into this fitting to allow the guard to be opened. In brief, the key is removed from the control panel, stopping the machine, and is then used to open the guard. These are typically robust and, dependent on the safety performance level provided, may be suitable for higher risk situations.

Exchange key interlocks. These are similar to trapped key interlocks but can be used with multiple guards. As above, the 'master' key is removed from the control panel, stopping the machine, but instead of being inserted direct into a guard the master key is inserted into a transfer box which then releases multiple guard keys, one for each guard covered by the system. Each guard key is unique and will only open its dedicated guard. These are typically robust and, dependent on the safety performance level provided, may be suitable for higher risk situations.

Time delay/motion sensors on interlocks. A timing function does not allow the guard to be opened until a predetermined period of time has elapsed. Used with guards covering dangerous parts which may continue to move after power has been removed, such as fast spinning shredders which can take time to spin-down. An alternative is interlocking systems fitted with a motion sensor which does not allow a guard to be opened until motion of the dangerous part has stopped.

Other interlock types are available. The above are the most common in use on recycling machinery.

3.3 Perimeter/machine fencing

3.3.1 Machine/perimeter fencing and enclosures with entry gates are fairly common at recycling and recovery plants, typically where fully compliant fixed or interlocked guarding would be impractical and/or result in excessive detritus, blockage etc problems. If designed and used appropriately fencing can be effective. However, there is a history in the sector of serious and fatal accidents where workers have climbed over fencing and accessed dangerous parts. Where it is appropriate, fencing should be robust and designed so that it does not facilitate or enable climbing. Your design assessment should consider factors such as the height of your workforce, whether nearby structures or accumulation of wastes next to a fence would make climbing easier etc. Fencing should extend sufficiently close to floor level to ensure workers cannot crawl under it, although a narrow gap can be left to facilitate cleaning.

3.3.2 In practice, WISH suggests a minimum fence height of 2 metres. However, depending on the work environment fencing may need to be higher (some companies specify 2.2 or 2.4 metres as their starting point). Note – some machinery safety advice and guidance include standards for 'reaching-over' protective structures. These are aimed at preventing workers from reaching-over to access a dangerous part. They are not aimed at preventing climbing. You know your work environment and are best placed to assess the risks. The more you have optimised your process the less need there will be for interventions and the lower the temptation for workers to try and climb over fencing. The more frequently breakdowns, blockages etc occur the higher the temptation is likely to be. Other considerations with fencing include:

- Fencing should be profiled around structures etc. There should be no gaps through which a person can squeeze. Where dangerous parts are close to the inside of fencing the same standards as for openings and gaps in guards apply. You may need to seek competent advice
- Access equipment such as ladders, wheeled stairs etc should be secured away from fencing so that they cannot be used to defeat the fencing

Left to right: Fencing raised at access stairs to prevent climb-over, key interlock fitted to an enclosure access gate, switch interlock fitted to a gate, machine fencing at a large recycling and recovery site

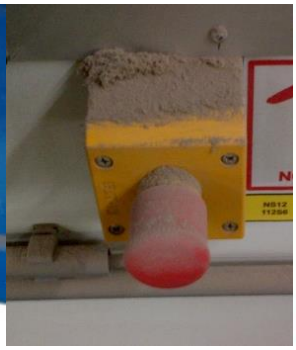
- Where fencing runs alongside walkaways, stairs, structures etc its height needs to take this into account. For example, increasing the height of fencing near to access stairs
- If access into an enclosure is frequent, then entry gates should be interlocked
- Entry gates should be the same height as, or higher than, the fencing itself
- Just because fencing has been fitted does not mean that all dangerous parts within an enclosure do not need to be guarded – this is an issue for risk assessment including factors such as the type of activity being carried-out within the enclosure

3.3.3 One significant issue with fencing is a person closing the entry gate behind themselves once inside an enclosure, so defeating any interlock fitted. Even with key interlocks such as Castell systems, keys can often be removed from a gate once a person is inside. Strict procedural control is required, including isolation and lock-off. You may also consider 'hold-back' systems to prevent a gate being closed once a person is inside. However, it is often possible to defeat these, typically with the connivance of a second person.

3.4 Emergency stops

3.4.1 E-stops should be fitted to all recycling machines. The number and location of emergency stops are matters for risk assessment. However in general, stops should be provided at control panels, workstations, and near to where interventions are conducted. In larger plants, a general rule is that a person stood anywhere in the plant should be able to see the nearest e-stop. Stops can be either push button type or pull-wire (sometimes called tripwires or pull cords). Pull-wire emergency stops are often favoured with conveyors. Considerations with emergency stops include:

- Emergency stops should be clearly marked
- Push button emergency stops should have a positive manual action to release them, such as by twisting to release or keyed (where a key is required to release a stop)


Left to right: Switch at one end of a pull-wire stop on a conveyor, keyed button emergency stop, dusty stop – likely not been tested recently (plus dust ingress can cause stops to fail, typical signage for a pull-wire emergency stop

- Releasing an emergency stop must not cause a machine to restart. A reset at the control panel must be required to restart the machine
- Emergency stops must not be used as isolation and lock-off
- Pull-wire emergency stops should have either switch at both ends or a switch at one end and a spring mount at the other. Static mounts are not acceptable
- Emergency stops should be included in routine checking and testing, including functional tests. As with interlocks (see above) tests can be ‘live’ or ‘dead’ dependent on the situation

Tips – keyed stops require a key to be inserted to release them. If the key is kept by the manager, then workers have to ask to obtain it and managers can then ask why the stop was used – you need to know if an emergency stop has been used and why.

4 Other considerations

4.1 Other forms of machinery safety measure

4.1.1 Other forms of safeguarding exist but are not common in recycling plants. These include optical systems such as light beams and grids, pressure mats, two-handed controls (common on waste collection vehicles but not in recycling) etc. If your plant has a type of safeguarding not covered in this guidance you should seek competent advice to ensure that it is appropriate. Two forms of alternative safeguarding which do sometimes occur in recycling plants are:

- Slow running and/or 'inch' control. These are systems which only allow a machine to run at a slow speed, or only to move a small amount, in specific situations. For example, when feeding new wire into a baler wire-tie mechanism via a 'feed-box' opening the box may activate a switch which then only allows the wire mechanism to run at slow speed to make wire replacement safer. If your plant has such systems, you need to know how they work, and they need to be included in routine tests and checks to ensure they still work
- Light beams are sometimes used, such as at the feed point on guillotines used to cut the spines off books, magazines etc. Light beams can be affected by dust, and they have significant limitations. If you have light beams on your plant, you should seek competent advice

4.2 Interventions, access, and secure isolation and lock-off

4.2.1 Interventions such as cleaning, maintenance, blockage clearance etc need to be planned in advance and should not take place in an ad-hoc manner. Safe access for interventions must be provided and secure isolation and lock-off are vital components of safe systems of work for interventions. Guidance and advice are available:

- Planning for interventions and secure isolation and lock-off are covered in WISH WASTE 29 'Practical advice on lock-off for recycling machinery', available on the WISH website at https://www.wishforum.org.uk/wish-guidance/
- Safe access in general is covered in WISH WASTE 13 'Designing and operating material recycling facilities (MRFs) safely', available on the WISH website at https://www.wishforum.org.uk/wish-guidance/
- Specific access issues relating to individual items of machinery, such as balers and trommel screens, are included in the relevant machinery safety information documents available at https://www.wishforum.org.uk/information/

4.2.2 You should read and understand these documents as relevant to your plant.

4.2.3 Some recycling plants have openings in guards and/or bars over openings which allow reach tools (poles etc) to be used but are too small for a person to squeeze/reach through. For example, at the top of a baler feed chute an access hatch with 'jailers bars' fitted or a gap in a guard at a screen. Gaps (between the bars of a jailer bar grid, size of opening in a guard etc) must be small enough to prevent human access. As for any gap in a guard, the size of gaps will depend on the distance to the dangerous part. There are standards for this, and you may need to seek competent advice. Another potential issue is the transfer of energy. For example, could the 'live' end of a reach tool come into contact with a moving dangerous part causing movement of the tool which can be transferred to the person holding the other end.

4.2.4 Access systems, whether fixed or mobile, should be safe to use and free from falls-from-a-height risks. consideration should also be given to access systems potentially providing access to dangerous parts – for more detail see the access sections of WISH WASTE 13 'Design and operation of MRFs' available at: https://www.wishforum.org.uk/wish-guidance/.

Case study – a typical arrangement for larger balers is that they are loaded via a feed chute. These are often fed by an inclined conveyor which lifts wastes to the top of the chute, from where they drop down inside the chute into the baler mechanism. At a recycling plant blockages at the top of a feed chute were common – larger sized wastes tended to 'bridge' across the chute, other wastes then piled-up on top of the 'bridge' causing a blockage. No fixed or mobile platform was provided to allow safe access to the top of the chute. As a result workers resorted to walking up the inclined conveyor to access the chute top. When workers did this, they turned the conveyor off at its main isolation switch. They mistakenly believed this also isolated the baler itself – it did not. Usually, workers could clear a blockage using reach tools (poles, brooms etc), but this did not always work and in these cases they then 'kicked' at the blocked wastes to clear the blockage. One day a blockage cleared suddenly and the worker who was kicking at it fell through the blockage, down the feed chute and into the baler mechanism. The baler's 'magic eye' sensor automatically registered that the baling chamber was full, in this case by the worker, and activated the baler ram, crushing the worker and fatally injuring him.

Left to right: Access platform at the top of a baler feed chute, jailers bars fitted at an access hatch, winch mechanism operating a drawbridge to allow safe access to a screen, trommel screen with gantry and door access

4.3 Checks, tests, and monitoring

4.3.1 Checks, tests, and monitoring should be carried out. The frequency and content of checks, tests and monitoring are a matter for risk assessment. For example, you may decide for a simple baler and feed conveyor that emergency stops will be tested every day, or for a larger assembly that stops will be tested sequentially so that all are tested over a week. However, operators should include in their assessment that most recycling and recovery machinery is large and powerful and typically poses a higher risk.

- **Checks**. For example, all guards in place, secure, all fixings in place, undamaged, no physical damage to emergency stop and interlock systems, no signs of tampering with or defeat of safety devices and systems etc
- **Tests**. For example, functional tests of interlocks, emergency stops and other safety devices such as slow-run and optical systems
- **Monitoring**. For example, to ensure that safe working procedures, in particular critical processes such as isolation and lock-off, are being used and that workers have not established their own ‘work-arounds’ or ad-hoc ways of working

4.3.2 The results of checks, tests and monitoring should be recorded, analysed and revisions made if issues are discovered. For example, if workers are found not to be following isolation and lock-off procedures correctly the frequency of monitoring should be increased (and any other appropriate action/s taken).

4.4 Maintenance

4.4.1 In common with all machinery, recycling and recovery plant should be maintained appropriately to ensure it remains functional and safe to use. The machine’s operating manual is the starting point for information on what needs maintaining, how and how frequently (if you do not have an operating manual contact the supplier to obtain a replacement). However, be aware that not all safety devices may be identified in the equipment supplier’s manuals, especially where the machine has been integrated into a larger plant. The ‘health and safety file’ supplied at the completion of the construction/completion of the plant as required by the CDM (Construction Design and Management) Regulations, can be a source of useful additional information. Operators may want to go further into planned preventative maintenance or risk centred maintenance and similar. Guidance on the maintenance of work equipment is available on the HSE’s website at: https://www.hse.gov.uk/work-equipment-machinery/maintenance.htm. Safety systems and devices should be included in maintenance.

4.4.2 Records of maintenance should be kept and periodically analysed to ensure that the schedule and content of maintenance remains valid. Any faults with safety systems and devices discovered during maintenance should be investigated and as required actions taken aimed at preventing such faults occurring again.

4.5 Purchase and modification of machinery

4.5.1 The purchase and modification of machinery is a complex and technical area. Unless you have suitable, competent in-house resource you are likely to require external advice. Guidance on the selection of work equipment is available on the HSE's website at: https://www.hse.gov.uk/work-equipment-machinery/selection-conformity.htm, on buying new machinery at: https://www.hse.gov.uk/pubns/indg271.htm, on modifying machinery at: https://www.hse.gov.uk/work-equipment-machinery/refurbished-modified-machinery.htm and on second-hand machinery at: https://www.hse.gov.uk/work-equipment-machinery/second-hand-products.htm.

4.5.2 When purchasing new machinery you as the operator (called the 'user' in some legislation) should take an active role in its design and specification and not simply rely on designers and suppliers to provide you with the 'right piece of kit' without your input. You should be clear about the intended use of the machinery, what waste types and volumes will be processed, the environment it will be used in, anticipated potential future uses etc. Suppliers have a duty to provide machinery which is safe to use, but you as the 'user' also have a duty to ensure it is safe to use – this is not a duty you can 'pass-off' onto the supplier or designer. The supplier should also be able to advise you of your machine's design life. This is theoretical and based on the level of use, misuse, environmental conditions, and the maintenance regime carried out.

4.5.3 It is not recommended that major modifications to machinery are undertaken by the 'user' (the correct machine should have been purchased initially). Major modifications to machinery will result in the removal of the initial 'certification' by the supplier and a new conformity assessment may be required. Where it is necessary to undertake minor modifications, you should risk assess these in advance. Your assessment must be appropriate and suitable to the nature and extent of the modification. This is not an area for unwritten and ad-hoc assessments 'written on the back of a fag-packet' or assessments which downplay the risks. You should ensure that guards, interlocks, emergency stops etc remain effective, still fit correctly, and function safely. For example, that guards at the interface between existing and additional items of machinery still comply with the required standards, that emergency stop, and interlock systems are tied together to ensure activation across the whole of the modified machine assembly etc. If the modification is substantial, you may also need to comply with formal 'conformity' standards. This is a technical area, and you will need competent advice.

Case study – baler rams move forward and backward: forward to bale wastes and backward to allow more wastes to fall-into the baling chamber. The ram moves backwards with as much force as it moves forward. At a recycling plant a piece of waste metal jammed in the rear of a baler ram causing the baler to stop working. The rear of the ram was inadequately guarded and crawling access to both sides of the ram was possible. A worker squeezed into the gap in one side of the guarding to remove the jammed piece of metal. He did not isolate and lock-off the baler. He managed to free the piece of metal but at this point the baler started working again and the ram moved backwards towards him. The worker could not escape in time and suffered fatal crush injuries.

4.6 Changes in waste type

4.6.1 It is common for the waste types accepted by a waste and recycling site to change. This may be because of customer/client demand or a decision by the operator to change or expand the waste types accepted. Some items of recycling and recovery machinery are fairly flexible regarding waste type (although there are limits with all items of machinery, and you need to know what the limits are for your machinery), others may be less so. You should assess the potential impacts of a change in waste type in advance. For example, can your machinery cope with the proposed new waste type, is it powerful enough and has sufficient capacity, do some parts of your machinery require modification (such as different 'teeth' on a shredder, larger or different design of waste chutes if waste particle size/shape will change, increasing or reducing 'hole' size or gapping on screens etc). You should not approach changes in waste type on a 'suck it and see' basis.

4.6.2 Following a change in waste type you should monitor the frequency and location of blockages, bridges, detritus build-up, cleaning requirements etc. Have these changed, are more frequent interventions required? You should analyse the results of your monitoring and make changes and modifications (although see above) as required, including ultimately to stop accepting the new waste type if significant problems are not capable of being rectified. For more information see the 'changes in waste type' section in WISH WASTE 13 'Design and operation of MRFs Feb 2022' available at: https://www.wishforum.org.uk/wish-guidance/.

4.7 Moveable machinery

4.7.1 Most recycling and recovery machinery is fixed in place. However, some items are designed to be moveable, either from location-to-location or within the same site. For example, a wheeled or tracked mobile trommel screen or a mobile rock-crusher designed to be transported on a flatbed lorry. This type of machinery can pose specific issues, including:

- Often moveable recycling machinery needs to be 'folded' or partially dismantled for ease of transport or movement. For example, a mobile shredder where the output conveyor folds to allow transport/movement. This can require the removal of guards and/or other structures, disconnection of systems etc. You should have in place a checklist to ensure that everything that needs replacing, connecting etc is actually replaced, connected etc once the machine is in place and before it is used. You should also provide instruction that if a guard or other safeguard has been lost in transit or damaged that the machine must not be used until a replacement has been obtained or repairs undertaken
- Isolation and lock-off provision may not be to the standard expected on static machinery. For example, many moveable recycling machines have an 'ignition' key which can be removed (some also have a battery isolator switch – you should check for this type of feature and as appropriate include it in your lock-off procedures). These 'ignition' keys are almost always in control circuits and should be treated as interlocks and similar and are not true isolation, and they make the use of multiple individual lock-off padlocks difficult (see multiple persons working section in WISH WASTE 29 'Practical advice on lock-off for recycling machinery', available on the WISH website at https://www.wishforum.org.uk/wish-guidance/). You should consider enhanced arrangements if practical. For example, it is often possible to fit a hinged hatch or guard over the machine's control panel with a hasp and staple fitted allowing the use of lock-off padlocks more easily (although this does not overcome the control circuit issue noted above)
- Moveable recycling machinery is typically designed to operate as stand-alone equipment. Some operators have incorporated them into static machine assemblies. For example, adding what was a moveable trommel screen to a static recycling line. Such modifications require careful assessment (see above on modification). For example, emergency stop systems need to be tied-into the existing static plant to ensure that activation of any stop causes the whole of the machine assembly to stop – the systems may be incompatible

4.8 Information, instruction, training, supervision, and communication

4.8.1 Suitable information, instruction and training on machinery safety should be provided to workers. This should be appropriate to the level of risk potentially posed and the nature of tasks performed. For example, most picking cabins on recycling plants are relatively controlled environments, the level of machinery safety provided is usually adequate, and the tasks undertaken by picking operatives are often limited. As a result a basic level of information, instruction and training may be all that is required (information, instruction and training should still be given). However, for higher-risk tasks a higher level of information, instruction and training needs to be provided. For example, if a picking operative's job is extended to include cleaning, blockage clearance and similar tasks then the level of information, instruction and training needs to be enhanced to be appropriate to these higher-risk tasks.

- **Information** needs to be provided on the risks and hazards faced. Some accidents have been partially caused by worker failure to recognise risk. For example, not recognising the risk posed by belt conveyor end rollers. In some cases workers have believed they could pull their hand out of a nip-point at an end roller if they became entangled – they cannot as the pressure is too great. In other cases workers have believed that they could escape the risk. For example, that they could get-out of a shredder or baler feed hopper/chute if the machine inadvertently started – history shows that they cannot. Information should also include safety systems such as emergency stops, how they work etc
- **Instruction** needs to be provided on the 'dos and don'ts' regarding machinery. For example, clear instruction not to climb on conveyors, to isolate and lock-off for interventions, to replace guards after cleaning, blockage clearance etc, not to climb into waste chutes and similar. While there is no legal obligation to write-down such instructions, experience is that written instructions are more effective than verbal instruction only. Account should be taken regards workers whose first language may not be English, such as the use of diagrams, photographs etc (this equally applies to information and training)
- **Training** needs to be provided on safe ways of working and how to operate machinery safely. This training should include demonstration by workers that they fully understand what to do, how to do it and what not to do. In particular for workers expected to perform interventions training on isolation and lock-off needs to be provided (see training, enforcing lock-off and monitoring section in WISH WASTE 29 'Practical advice on lock-off for recycling machinery', available on the WISH website at https://www.wishforum.org.uk/wish-guidance/. Refresher training should be provided periodically

4.8.2 Supervision is vital to ensure procedures and systems of work are followed. The level of supervision should be appropriate to the level of risk posed. For example, in the relatively controlled environment of a picking cabin the level of supervision may be fairly low. Conversely, it should be much higher where intervention tasks, isolation and lock-off etc are involved. Supervisors should be informed and trained in the hazards and risks posed by machinery, the operation of the machinery, how safety systems and devices work etc. They should also be trained in the 'softer' skills required and be aware that they are not 'one of the lads' anymore and they have an important role to play in ensuring the safe operation of machinery. Experience is that frontline supervision is one of the most important roles in ensuring safe working.

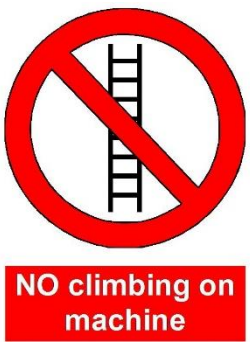
4.8.3 Worker communication and consultation is a key component of virtually all safety management. Recycling and recovery workers will often know more about issues such as where blockages occur and how frequently, where detritus is an issue, problems with access to perform intervention tasks etc than you do as a manager. Workers should be involved in risk assessment, the production of safe ways of working etc to ensure these are suitable and sufficient, practical, and effective. This communication should be proactive. You should proactively seek the opinions and knowledge of your workers rather than simply waiting for them to approach you. You can also consider involving workers in issues such as the purchase and modification of machinery – they may have valuable insights. For information on worker involvement and safety leadership see WISH INFO 09 'Employee engagement self-assessment' and WISH INFO 01 'H&S leadership self-assessment', both available at: https://www.wishforum.org.uk/information/.

4.9 Signage

4.9.1 Signage should not be relied on as a primary machinery safety control measure. However, signage can be a useful back-up to other more effective control measures. Signage is required is some machinery situations, such as emergency stops. In other cases whether signage is used, and its location, is a matter for risk assessment. Examples include:

- Warning and/or other signs at frequently accessed guards, machine/perimeter fencing access gates etc, such as reinforcement signs that isolation and lock-off are required prior to access
- Warning signs at areas where dangerous parts may be accessible, even if a deliberate effort may be required such as feed hoppers to shredders etc similar
- Signage at machine/perimeter fencing prohibiting climbing, or as any other location where climbing could result in access to a dangerous part

4.9.2 Signs should be compliant with relevant standards and include the use of pictograms as required, in particular where there may be workers whose first language is not English. Signs should also be kept clean and be clearly visible.



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The Waste Industry Safety and Health (WISH) Forum exists to communicate and consult with key stakeholders, including local and national government bodies, equipment manufacturers, trade associations, professional associations and trade unions. The aim of WISH is to identify, devise and promote activities that can improve industry health and safety performance.

Further information

This guidance is issued by the Waste Industry Health and Safety (WISH) Forum to help control safety and health risks. Following the guidance is not compulsory, unless specifically stated, and you are free to take other action. But if you do follow the guidance, you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance. This guidance is available free to download at: https://www.wishforum.org.uk/.