
# A practical guide to
# Machinery Safety
Edition 4

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# Contents

## Welcome

**Machinery Safety is one of the most significant issues facing every manufacturing company in Europe today. It's just as important as productivity and is essential for the well being of everyone involved.**

The Laidler group of companies has come together to provide this practical guide to the field of machinery safety, basing it around common hazards and issues that they come across on a regular basis.

The aim of this guide is to introduce machinery safety and provide suggestions and guidance as to the best route to compliance. Crucially though, it is only a guide and an interpretation of the regulations. The onus is placed firmly on the machine manufacturer and user to show compliance with all relevant legislation.

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- Mechanical or electrical engineers involved in specification, design, maintenance or modification of machinery
- Managers responsible for production, maintenance or design of factory equipment.
- Anyone else connected with specifying and purchasing machinery and equipment.

**Seminar Agenda**
- CE Marking and PUWER regulations
- EN Standards and their affect on industry
- Case Studies
- Discussion with a full Q&A session
- Current and forthcoming legislation
- Risk Assessment and it's implications
- Safety Related Control Systems

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section one

# Sponsors

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Safety Systems Technology



TÜV SÜD Product Service is a leading international expert in providing testing, certification, training and consultancy services to a range of industries covering the Aerospace, Defence, Machinery, Marine, Medical & Health, Radio & Telecoms, Rail, Trade, Electronics & Consumer sectors.

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  - Environmental
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  - CB Scheme
  - NRTL
  - Management Systems
- Training

Laidler Associates is part of the machinery division of TÜV SÜD Product Service and is the UK market leader in machinery safety, which covers machinery safety legislation and risk assessments providing solutions on a world-wide basis. Laidler Associates provides comprehensive, cost effective and supremely practical consultancy, advisory, training, seminars, project management and custom software services in the following key areas:

- CE Marking
  - Machinery Directive
  - Low Voltage Directive
  - Electromagnetic Compatibility (EMC) Directive
  - Pressure Equipment Directive
  - ATEX
- Pre-Purchasing CE Audits
- Project Management of Complex Machinery Installation
- Equipment Safety Audits
- Provision and Use of Work Equipment Regulations (PUWER)
- Electromagnetic Field Testing
- Risk Assessment
- SEMI
- Lifting Operations and Lifting Equipment Inspections (LOLER)
- Training and University Courses

Safety Systems is part of the machinery division of TÜV SÜD Product Service, and provides engineering services to ensure machinery compliance, including full engineering project management of compliance solutions bespoke guarding and safety product sales. As market leaders in machinery safety compliance engineering, we have the knowledge and experience to design and install the most appropriate safety solutions using products from our wide ranging portfolio from leading manufacturers. Services include:

- Project Definition and Design Studies
- Multidiscipline Project Management
- System Specification and Design
- Electrical Design and Build Including Control Circuits
- Guarding Design
- Commissioning and Installation
- Ongoing Support and Training
- Modifications to Ensure Legal Compliance
- ESPE (light curtain) Assessment

# Case Studies



## Case Study

### Laidler helps Proven Energy to prove compliance

In line with its commitment to developing and supplying products that are confirmed as meeting the highest standards for safety and performance, Proven Energy, the UK's largest supplier of small wind turbines, decided that they needed assistance with the self-declaration of their latest P35-2 12.1 kW wind turbine to the new European Machinery Directive. Accordingly, the company engaged leading safety and compliance consultant Laidler Associates, part of the Machinery division of TÜV SÜD Product Service, to help with completing the compliance procedure including the preparation of the technical file.

As a well established manufacturer of wind turbines, Proven Energy was well aware that it could satisfy the CE marking requirements in relation to its products by self-declaring them for compliance with the EMC, Low Voltage and Machinery Directives. The company decided, however, that due to the changes to the requirements with the new Machinery Directive, it would be prudent to have assistance which would give both them and their end users the highest possible level of confidence.

The product that was of most immediate concern to the company was its new P35-2 turbine, which has a rated power of 10.5 kW and a reference annual energy (RAE) output in excess of 23,000 kWh. These characteristics, combined with its compact construction and economical pricing, make it an ideal choice for use by agricultural landowners, in commercial premises, and in small-scale wind farms.

Its market potential was, therefore, excellent and was still further boosted when the P35-2 became the first small wind turbine to be awarded full certification under the Microgeneration Certification Scheme (MCS). Understandably, Proven Energy was eager to put the P35-2 on sale at the earliest possible date.

By the beginning of 2010, it had the compliance work associated with the Low Voltage and EMC Directives in place but, for the Machinery Directive, things were a little more complicated. This was because a new version (2006/42/EC) of the Machinery Directive came into force late in December 2009. As no transition period between this and the previous version of the Machinery Directive was allowed, it was essential for Proven Energy to be sure that its P35-2 wind turbine complied fully with the new version.

While product testing for the P35-2 had been completed, Proven Energy knew that the new version of the Machinery Directive introduced significant changes, not least in the area of documentation. To avoid delay in bringing its



product to market, it decided to engage the services of an expert to verify compliance. The company's choice was Laidler Associates, which it selected on the basis of proven track record and excellent reputation in handling projects of this type.

Laidler Associates undertook a comprehensive review of the materials relating to the compliance of the P35-2 wind turbine with the Machinery Directive and did indeed identify a number of shortcomings. Although these were far from major, they would undoubtedly have hindered compliance.

"Laidler Associates was not only very responsive, it was also clear that the company had a deep understanding of how the requirements of the regulations implementing the Machinery Directive related to our product," said Jonathan Nowill, Engineering Director of Proven Energy. "But what was really impressive was the report that Laidler Associates produced for us. This included a detailed "to do" list that laid out very clearly the exact steps we needed to take to ensure compliance. The list was easy to follow, and undoubtedly saved us a lot of time and trouble."
As an example of the type of issue identified by Laidler Associates, the user manual was found to contain insufficient information on foreseen ways in which the wind turbine might be used or misused. This shortcoming, and the others highlighted in the Laidler Associates report, were quickly remedied.

"Having carried out the work recommended by Laidler Associates, and organised our compliance documentation in the way that the company suggested, we can have total confidence that the P35-2 satisfies the requirements of the latest version of the Machinery Directive," said Jonathan Nowill. "Naturally, this is very important for us but it's also important for our customers – they don't have to take our word for it that our products meet all of the relevant standards, as this has now been independently confirmed."
A further endorsement of the work carried out by Laidler Associates for Proven Energy was recently provided by the Health and Safety Executive (HSE).

"As part of discussions we were having with the HSE, we presented our compliance documentation," said Jonathan Nowill, "and we were delighted when the HSE team told us that they were very satisfied with it both in terms of content and clarity. That's exactly the sort of response we like to get, especially from a government body! There's no doubt that Laidler Associates played a big role in helping us to reach this position and I have to conclude by noting that the very modest amount we spent on the company's services was money well invested!"



## Case Study

### Smoothing the way for Minima to boost office recycling

Full compliance with EU requirements was essential for the success of a novel can and plastic bottle compactor developed by Minima Eco for use in offices, but the requirements for achieving compliance were far from clear. However, Laidler Associates, one of the UK's foremost safety and compliance consultants, provided Minima Eco with a complete, efficient and cost-effective solution.


The Minima Office developed by Minima Eco is an easy-to-operate and attractively styled electrically powered machine that individually compacts steel and aluminium cans, plastic bottles and tetrapak containers to approximately 20% of their original volume. This minimises the amount of storage space that these items occupy pending recycling and also cuts handling and transport costs.

To ensure that this innovative product could be sold throughout the EU, Minima Eco knew that it would have to confirm that it complied fully with all relevant EU Directives so that the CE marking could be applied. For help in achieving this, the company approached Laidler Associates.

An initial assessment quickly showed, however, that it was by no means certain which directives were applicable. Although the Minima Office is undeniably a machine, Machinery Directive 2006/42/EC explicitly excludes "ordinary office machinery", so the question arose as to whether the new Minima Office would fall within this definition.

To obtain a definitive answer to this question, Laidler Associates used their established list of contacts which includes the Health and Safety Executive and the Department for Business Industry and Skills who ultimately decided that the machine was not an ordinary office machine and, therefore, that compliance with the Machinery Directive was needed.

With this issue clarified, Laidler Associates carried out all of the work necessary to demonstrate compliance of the Minima Office not only with the Machinery Directive, but also with the Low Voltage and EMC Directives. This work included compiling the relevant technical files and drawing up the Declaration of Conformity.

"Working with Laidler Associates has taken all of the concerns and complexity out of achieving compliance," said Robert Hall, Managing Director of Minima Eco. "The company has supported us and provided invaluable advice at every stage of the product development process from the original prototype right through to the certification of the production models. In a nutshell, Laidler Associates has saved us a lot of time, money and stress!"

# Legislative Framework

Section two 2



To enable the European Union to trade successfully across boundaries, the European Commission embarked on a policy of harmonisation. Initially the Commission proposed Directives, which would identify a unified approach to the production and trade of products and goods across Europe. However these Directives were prescriptive and it was felt that this was having a detrimental effect on innovation and invention. To counter this the Commission introduced the New Approach Directives (CE Directives). These Directives are not prescriptive and lay down minimum criteria for compliance. The New Approach Directives are similar in format for ease of reference and use. Perhaps the most significant aspect of the new legislation is the conformity assessment procedure (the means by which the compliance is ensured). The Directives offer a flexible approach.

### SIGNIFICANT DIRECTIVES

Machinery Directive 2006/42/EC
EMC Directive 2004/108/EC
Low Voltage Directive 2006/95/EC
Plus amendments to all of the above

## Framework

## Machinery Directive

## EMC

## Low Voltage

## Pressure Equipment

## ATEX

## Work Equipment

## EN Standards

## Maritime Specifics

# Legislative Framework

section two 2



## Machinery Directive

**Scope**

All machines supplied in the European Economic Area (EEA) from January 1st 1995, must comply with the Machinery Directive and be safe. There are few exclusions to the Directive making this one of the most significant of all the New Approach Directives.

The scope of the Machinery Directive defines a machine as the following:

1. An assembly fitted with or intended to be fitted with a drive system other than directly applied manual or animal effort, consisting of linked parts or components , at least one of which moves, and which are joined together for a specific application

2. Machinery referred to in 1 missing only the components to connect it on site or to sources of energy and motion.

3. Lifting apparatus whose only power source is directly applied manual effort.

4. An assembly of machines and / or partly completed machinery which, in order to achieve the same end are arranged and controlled to function as an integral whole.

5. Interchangeable equipment means a device which, after placing into service with machinery or tractor is assembled with that machinery or tractor by the operator himself in order to change its function.

Safety components for machinery, described as:

- which serves to fulfil a safety function,
- which is independently placed on the market,
- the failure and/or malfunction of which endangers the safety of persons, and
- which is not necessary in order for the machinery to function, or for which normal components may be substituted in order for the machinery to function.

The New Approach Directives lay down minimum criteria for compliance. These criteria are called The Essential Health and Safety Requirements (EHSR).

The preferred way to comply with EHSRs is by Risk Assessment and the application of harmonised EN standards, which are replacing the national standards of member states.

## EMC Directive

**Scope**

The EMC Directive states that most electrical and electronic products made or sold in Europe must:

- Be so constructed that they do not cause excessive electromagnetic interference and are not duly affected by electromagnetic interference,
- Carry CE Marking



If your product is sold, used by yourself, given away or used in anyway, it must comply with the Essential Protection Requirements as laid down in the Directive. Ignorance of the legislation is no excuse and a punitive penalty structure is documented.

The requirements under the EMC Directive are:

- That the product must not interfere with any other product in any way.
- The product must meet certain standards in that it must not suffer interference from any other product.

## Low Voltage Directive

**Scope**

The Low Voltage Directive states that:

- Only electrical equipment which does not jeopardise the safety of people, domestic animals and property shall be placed onto the market.
- Equipment operating at voltage between 50v & 1000v AC and 75v &1500v DC should comply.

The requirements under the Low Voltage Directive are:

- That the product is electrically safe
- The product has been constructed in accordance with accepted good engineering practice and is safe
- The product has been designed and constructed in accordance with the Principal Elements of the Safety Objectives of the Directive.

Electrical equipment shall be designed and constructed to ensure that it is safe when connected to the electricity supply, by providing a level of protection against electric shock.

## Pressure Equipment Directive

**Scope**

The Pressure Equipment Directive (PED) 97/23/EC which affects equipment operating at a pressure greater than 0.5 bar, entered into force on 29th November 1999 and is mandatory from 29th May 2002.PED is generally considered one of, if not the most complex and difficult to understand of the new approach directives. Many organisations, particularly small and medium sized companies with limited resource to allocate specifically to the task of conformance, are reporting difficulties in interpretation and application.

The PED impacts upon design, production, final inspection/test, marking and labelling and instructions for use/maintenance. Therefore, in most affected companies no single person will be able to resolve all issues particularly when choosing to apply a quality assurance module.

The PED requires that each affected item of pressure equipment be categorised according to specific criteria.If you are not fully conversant with the directive this process can be time consuming and can result in costly errors. The Directive provides many options and routes to conformity (modules), inappropriate choice can lead to significant third party inspection costs.



## ATEX Directive

The "ATEX" Directive 94/9/EC is a so-called "New Approach" Directive which provides the technical requirements to be applied to equipment intended for use in potentially explosive atmospheres. It is named after the French "ATmosphere EXplosible".

The Directive covers a surprisingly large range of equipment, potentially including equipment used on fixed offshore platforms, in petro-chemical plants, mines, flour mills and other areas where a potentially explosive atmosphere may be present.

In very broad terms, there are three pre-conditions for the Directive to apply:

- The equipment must have its own source of ignition
- Be intended for use in a potentially explosive atmosphere (air mixtures)
- Be under normal atmospheric conditions.

The Directive also covers components essential for the safe use and safety devices directly contributing to the safe use of the equipment in scope. These latter devices may be outside the potentially explosive environment.

## Work Equipment Directive

**Scope**

The Provision and Use of Work Equipment Regulations 1998 (PUWER) requires users of work equipment to carry out risk assessment and provide work equipment that is suitable for its intended task and can be used without putting persons at risk.

The Regulations cover any machinery, appliance, apparatus, tool or installation for use at work (whether exclusively or not) - effectively it is anything used at work. The 1998 regulations (updating the original 1992 Regulations) introduce requirements to ensure that, for reasons of health and safety, inspections are carried out:

- After installation and before being put into service for the first time; or after assembly at a new site or in a new location to ensure that it has been installed correctly and is safe to operate.
- After work equipment has been exposed to any conditions causing deterioration, which is liable to cause a dangerous situation.
- At suitable intervals; and
- Each time that exceptional circumstances have occurred that are liable to jeopardise the safety of work equipment. The results of these inspections have to be documented and kept.

The regulations make it an offence to allow work equipment to leave an employer's undertaking, or if obtained from another undertaking, be used, unless it is accompanied by physical evidence that the last inspection has been carried out.



## EN Standards

By definition a standard is "A document established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results aimed at the achievement of the optimum degree of order in a given context" (ISO/IEC guide 2 (1986).

Three organisations are mandated by the European Commission to produce standards, with each organisation being responsible for specific standards.

Once a standard has been produced through the process as detailed by CEN and CENELEC they become known as transposed harmonised standards. European member states will then remove any existing national standards which conflict with the new standard and add the relevant country prefix.

For example, EN designates that the standard is a full, harmonised standard. The process of transposition adds the country prefix hence a standard will become BS EN in the UK. A DIN EN standard in Germany will be exactly the same.

## Why Use Standards?

The use of standards is not mandatory, however, if a standard is applied correctly, conformance with the relevant EHSRs of a directive may be presumed, hence they represent the surest way to compliance. The user though, must still ensure that the equipment complies with the Directive and is in fact safe.

## Maritime specifics

November 2006 saw a major change with PUWER. Up to this date, work equipment on ships was outside of the scope of PUWER because there were other maritime regulations that took precedence (these have now been revoked). In September 2006, a new maritime version of PUWER was published. The Merchant Shipping & Fishing Vessels (Provision & Use of Work Equipment) Regulations 2006 impose the minimum health and safety requirements for the provision and use of work equipment by workers at work.

The regulations require that employers shall ensure that the work equipment made available to workers on board a ship, is suitable for the work being carried out and safe to use.

Alongside the maritime PUWER regulations is a maritime version of LOLER (Lifting operations, Lifting Equipment Regulations), which applies LOLER to ships in the same manner that PUWER has now been applied.

## Linkspans and Passenger Walkways

These, in simple terms, are the bridging between ship and port that allows for tidal movements. They have always been considered machinery due to the latent energy in the hydraulic systems that balance them. At a recent meeting of Notified Bodies for the Machinery Directive, it was discussed whether linkspans should actually fall under Annex IV of the Machinery Directive as they effectively lift people, and devices for the lifting of people are Annex IV machines. The discussion concluded that linkspans should be considered as Annex IV machinery and so maritime architects and builders will now have to use a Notified Body when building linkspans in ports.

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# Risk Assessment

section three



**Guidance on carrying out risk assessment can be found in many places. EN ISO 12100 is the main standard for risk assessment for machinery as it sets down the principles for the process.**

Risk assessment is fundamental to any health and safety process and in particular machinery safety. Because of this, anyone involved in dealing with machinery safety issues should be competent in risk assessment and be well aware of the types of hazards that may occur across their working environment.

Risk Assessment is subjective therefore the information in this section gives help and advice on risk assessment. It has to be stressed that it is only a guide and the onus remains firmly with the person carrying out the assessment to comply with all the relevant regulations.

## Issues to consider

## Hazard Identification

## EN ISO 13849-1

## EN ISO 12100

## EN 62061

## Common hazards

# Risk Assessment and Hazard Analysis



## Issues to consider when assessing Machinery Safety

### Emergency Stops

- Are they fitted correctly?
- Do they all work correctly?
- Are they accessible?
- Are they correct type?

### CE Marking

- Does the machinery fall under the Machinery Directive?
- Have all the Directives been considered i.e. EMC, Low Voltage, ATEX and PED?
- If so, has it been CE Marked?
- Has it been altered in a way that could affect the original CE Marking?

### Environment

- Is there adequate lighting?
- Is the floor area free from slip and trip hazards?

### Electrical Enclosure

- Is the enclosure locked?
- Are all enclosures fitted with electrical warning signs?
- Are they free from debris and foreign objects?

### Guarding

- Is guarding fitted?
- Is it adequate?
- Are interlocks fitted where required and are they positively acting?
- Do fixed guards require tools for their removal



## Hazard Identification

**A hazard is:**

Anything that has the potential to do harm, a source of possible injury or damage to health.

**A risk is:**

The likelihood of someone coming into contact with a hazard and the degree of injury or damage to health that could be caused should contact occur.

**A hazardous situation is:**

Any situation where a person or persons are exposed to a hazard.

**Examples:**

A moving belt on a conveyor would be a hazard. The risk would be the likelihood of someone coming into contact with an in-running nip or being drawn along the belt by a protrusion and the severity of injury or damage to health that could be caused. An electrical enclosure containing voltages above 50v AC and 75v DC that has uncovered terminations is a hazard even though the enclosure may be kept locked and strict key control enforced. The reason for this is that if an electrician had to carry out diagnostic testing on a live enclosure they could inadvertently touch an adjacent terminal with a tool etc. The risk would be the likelihood of that happening and the severity of injury or damage to health that could be caused.

## Risk Assessment Definition

A comprehensive estimation of the probability and degree of possible injury or damage to health in a hazardous situation in order to select appropriate safety measures.

## Risk Assessment Objective

To achieve adequate safety according to the state of the art and technical and economic requirements. There are numerous ways of assessing risk involved with a hazard, one of which is the hazard rating number system. (HRN). The practical risk assessment method that is used by Laidler Associates is Preliminary Hazard Analysis, which uses the HRN system. **A sample risk assessment form can be found in the appendices at the end of this guide.**

Numerical values are assigned to descriptive phrases relating to-

- The likelihood of occurrence (LO)
- The frequency of exposure (FE)
- The degree of possible harm (DPH)
- The number of persons at risk (NP)

A key to the number system is detailed on the risk assessment form in the appendices.

The hazard description is vital in understanding those risk assessments, unless otherwise stated, the risk assessment relates to the hazards in the normal operation of the machine. Where a specific risk is associated with that equipment, a separate risk assessment will be provided.

Where there is no control over the frequency of exposure, a worst-case scenario must be assumed, and a constant frequency is assigned.



## Risk Assessment Example

Injury due to access to dangerous parts of machinery. The present guarding, partially fitted, allows access to the moving parts.

LO FE DPH NP=H.R.N.
2 X 5 X 4 X 1=40
Degree of risk: = Significant

Clearly from this example we can see that the existing guarding, whilst offering a certain amount of protection, is not adequate and the degree of risk can be reduced further by fitting a guard that completely prevents contact with the hazard but does not affect the production.

**Control Measure:**
Fit a tunnel guard that prevents all access to the moving parts in accordance with

EN 953 and EN ISO 13857.
After control measures fitted:
LO FE DPH NP=H.R.N.
0.1 X0.1 X 4 X 1=0.04
Degree of risk: = Negligible

The control measure has detailed the machinery needs additional guarding, and has detailed the Standards to which you should construct that guard in accordance with. EN Standards will be used for the correct control measure where those Standards exist. The control measure is deliberately left non-specific in its description in order to allow the designer of that guard some scope of flexibility in his approach. If we detail an exact specification to a guard or control measure, we effectively tie your hands. Our assessments are one method of compliance and should you find an alternative way to achieve compliance, then we would welcome your suggestions. Our engineers are available to give specific advice to you outside of these assessments should you require it.

As mentioned at the start of this section, EN ISO 12100 is the main standard for risk assessment for machines and is harmonised to the Machinery Directive. It lays down principles for risk assessment, hazard analysis and documentational requirements.

Also included within the standard is a table giving examples of hazards, hazardous situations and hazardous events. This table gives detail as to the kind of hazards or hazardous situations that can occur. Anyone involved in a risk assessment project for machinery should refer to this list as matter of course unless they are totally confident in their knowledge and ability to carry out the assessment.



## Safety Related Control Systems

**What is a control system?**

A control system responds to input signals from the machine or from the operator and generates output signals. These make the machine operate in a desired manner. So if for example, an operator presses a start button then the control system may respond by closing a contactor and energising a motor. Control systems can be implemented in a range of technologies, but this guidance is mostly concerned with electro technical systems employing electrical, electronic and programmable electronic technologies. Electro technical control systems can range from simple electromechanical relay based systems to complex programmable systems with multiple analogue and digital inputs and outputs.

**What is a safety related control system?**

A control system in a machine should be regarded as being safety-related if it contributes to reducing the occurrence of a hazardous situation or if it is required to function correctly to maintain or achieve safety. The functions carried out by a safety-related control system are termed safety functions. Generally safety functions either prevent the initiation of a hazard or detect the onset of a hazard. Safety-related control systems should be designed and configured to be reliable enough (bearing in mind the consequences of any failure) and to perform the necessary functions to achieve or maintain a safe state or mitigate the consequences of a hazard.

To assist a designer or assessor in deciding which of the two main standards to use: BS EN ISO 13849 or BS EN 62061, a distinction is drawn between those electro technical safety related systems that use programmable technologies and those that use electromechanical components.

**BS EN ISO 13849-1**

Provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems, including the design of software. For these parts of safety-related parts of control systems, it specifies characteristics that include the performance level required for carrying out safety functions. It applies to safety related parts of control systems, regardless of the type of technology and energy used (electrical, hydraulic, pneumatic, mechanical, etc.), for all kinds of machinery.

It applies to safety-related parts of control systems, regardless of the type of technology and energy used (electrical, hydraulic, pneumatic, mechanical, etc.), for all kinds of machinery. Part 1 of BS EN ISO 13849 provides specific requirements for safety-related parts of control systems using programmable electronic system with guidance on aspects such as categories or performance levels specification. This part of ISO 13849 is intended to give guidance to those involved in the design and assessment of control systems. As part of the overall risk reduction strategy at a machine, a designer will often choose to achieve some measure of risk reduction through the application of safeguards employing one or more safety functions.

Parts of machinery control systems that are assigned to provide safety functions are called safety-related parts of control systems and these can consist of hardware and software and can either be separate from the machine control system or an integral part of it. In addition to providing safety functions, safety related parts of control systems can also provide operational functions (e.g. two handed controls as a means of process initiation).



In order to assist the designer and help facilitate the assessment of achieved PL, this document employs a methodology based on the categorisation of structures according to specific design criteria and specified behaviours under fault conditions.

**BS EN 62061**

Is a harmonised standard for the machinery sector and implements the principles of BS EN 61508. Significantly for control systems designers and systems integrators, BS EN 62061 provides the basis for the successful integration of sub-systems/parts that comply with BS EN 954-1 and IEC/EN 61508 into safety-related electrical control systems that satisfies key requirements for functional safety.

One of the limitations of EN 954-1 is that it is too simplistic, and it does not provide for evaluating common-cause system failures. In general, EN 954-1 takes a qualitative approach, whereas IEC 62061 is a risk-based standard that describes quantitative methods for evaluating statistical data such as the mean time to a dangerous failure (MTTF) and the diagnostic coverage (DC - the ratio of the probability of the detected dangerous failures to the probability of total dangerous failures). When moving from EN 954-1 to IEC 62061 for more complex control systems it is inevitable that more calculations and documentation will be required to support conformity and the design process will inevitably take longer. However, the resultant safety related electrical control system will benefit from a more thorough design process, be better documented and perform more predictably.

## Which standard now?

When evaluating which standard to use, it is important to take into consideration the type of complexity that the equipment with the safety-related parts of control system has. The table below gives some indication of the technologies which are covered by each standard. A correct implementation of a safety-related parts of control system may require the application of both standards.



## Table From IEC 62061

| | Technology implementing the safety-related control function(s) | ISO 13849 | IEC 62061 |
|---|---|---|---|
| A | Non-electrical, e.g. hydraulics | ✓ | Not covered |
| B | Electromechanical, e.g. relays,and/or non complex electronics | Restricted to designated architectures (see Note 1) and up to PL=e | All architectures and up to SIL 3 |
| C | Complex electronics, e.g. programmable | Restricted to designated architectures (see Note 1) and up to PL=d | All architectures and up to SIL 3 |
| D | A combined with B | Restricted to designated architectures (see Note 1) and up to PL=e | ✓ See Note 3 |
| E | C combined with B | Restricted to designated architectures (see Note 1) and up to PL=d | All architectures and up to SIL 3 |
| F | C combined with A, or C combined with A and B | ✓ see Note 2 | ✓ see Note 2 |

**Note 1:**
Designated architectures are defined in Annex b of EN ISO 13849-1 to give a simplified approach for quantification of performance level.

**Note 2:**
For complex electronics. Use of designated architectures according to EN ISO 13849-1 up to PL=d or any architecture according to IEC 62061

**Note 3:**
for non-electrical technology, use parts according to EN ISO 13849-1 as subsystems

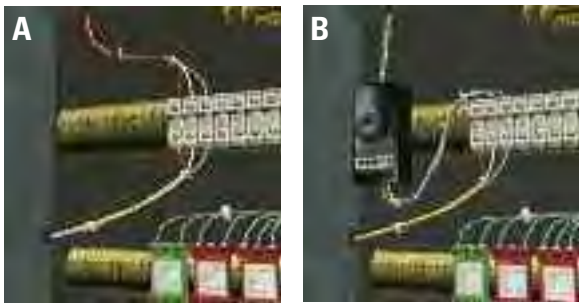


## Common Hazards

On this page, we are going to highlight common faults and hazards that are found on machinery. These examples are taken from the working experience of Laidler Associates' engineers and are illustrated using the Laidler virtual reality training model.

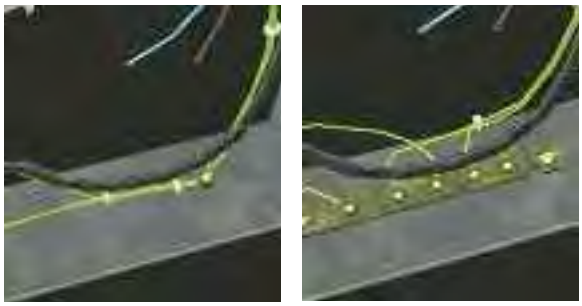
**1. Isolators**

Common faults that are found with isolators are that there isn't one fitted, the isolator is of the wrong type or is incorrectly fitted, the mains isn't terminated at the isolator. Image B is a corrected version of A.



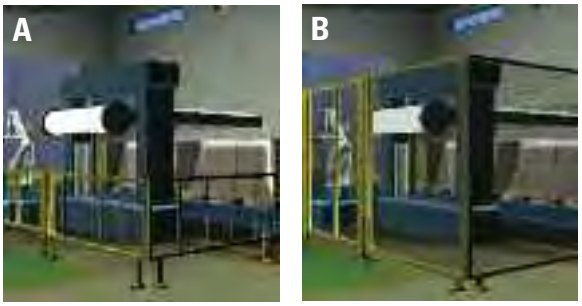

**2. Multiple Earths/ terminations**

Another common electrical fault is that of multiple terminations, in particular with earthing, onto one point.



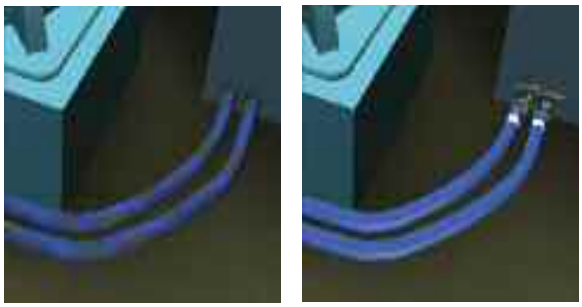
**3. Guarding**

Guarding is one of the more visual issues for machinery safety. The examples used below are extreme but the issues concerned are, is there guarding on the machine and is it adequate. Image A may have guarding but it isn't adequate. In image B, the guarding is more substantial and includes additional methods such as light curtains.




**4. Hydraulics and Pneumatics**

Where you find hydraulics and pneumatics on machinery, safety issues include the state of the pipework, whether the pipes are correctly labelled and whether they have lockable isolators or not.



# The 4 Steps to CE Marking for the Machinery Directive

Section four

4

The machinery directive is one of the widest ranging directives due to the definitions of what is machinery. According to machinery Directive 2006/42/EC, machinery is:

- An assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application
- An assembly referred to in the first indent, missing only the components to connect it on site or to sources of energy and motion
- Assemblies of machinery or partly completed machinery which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole

It also states that a manufacturer is:

- Any natural or legal person who designs and/or manufactures machinery covered by this Directive and is responsible for the conformity of the machinery with this Directive with a view to its being placed on the market, under his own name or trademark or for his own use.

So whether you are designing, manufacturing or importing machinery, you need to know what your legal duties and responsibilities are.

## Essential Health and Safety Requirements

## Technical File

## Declarations

## CE Mark

# The 4 Steps to CE Marking for the Machinery Directive

section four 4



## Step 1: The Essential Health and Safety Requirements (EHSRs)

In order to comply with the Supply of Machinery (Safety) Regulations, the machinery must be able to satisfy the EHSRs for any corresponding hazard which may apply to it. Typical examples of Essential Health and Safety Requirements are the requirements to provide adequate warning marks where there are moving parts that might trap parts of the body of personnel using the machine. Another item would be the requirement to provide safety guards to machine tools.

The requirements are wide ranging, taking into account potential dangers to operators and other persons who may be at risk. The Essential Health and Safety Requirements are mandatory. However, taking into account the state of art, it may not be possible to meet all the objectives set by them. With this in mind, the machinery must be designed and constructed with the purpose of approaching these objectives. Within the Supply of Machinery (Safety) Regulations, the Essential Health and Safety Requirements are divided into six sections:

1. EHSRs applicable to all machinery
2. EHSRs for Certain categories of machinery including Foodstuffs machinery, machinery for cosmetics or pharmaceutical products, hand-held and/or hand-guided machinery, portable fixing and other impact machinery, machinery for working wood and material with similar physical characteristics
3. EHSRs to offset hazards due to the mobility of machinery
4. EHSRs to offset hazards due to a lifting operation
5. EHSRs for machinery intended for underground work
6. EHSRs to offset hazards due to the lifting of moving of persons

The 2006/42/EC Directive made changes to a number of the EHSRs. Some of the more significant changes are as follows:

- EHSR 1.1.7 The operating position must be designed to avoid any risk due to exhaust gases/ lack of oxygen
- EHSR 1.1.8 work stations that are an integral part of the machine must be designed for the installation of seating
- EHSR 1.2.2 Manual controls must be clearly visible and identifiable; the use of pictograms is recommended
- EHSR 1.4.2.1 Fixed guards. Fixing systems must remain attached to the guards when removed
- EHSR 1.1.2 requires risk assessment to be carried out

Risk assessment is the fundamental starting point for designers of machinery under the Machinery (Safety) Regulations as well as for operators of existing machinery under the Provision and Use of Work Equipment Regulations 98.

The standard EN ISO 12100 entitled "Safety of Machinery – Risk Assessment" defines risk assessment as "a series of logical steps to enable, in a systematic way, the analysis and evaluation of the risks associated with machinery."

EN ISO 12100 goes on; "Risk assessment is followed, whenever necessary, by risk reduction. Iteration of this process can be necessary to eliminate hazards as far as practicable and to adequately reduce risks by the implementation of protective measures."

To assist manufacturers comply with the Directives and to harmonise standards throughout the EEA the European Commission charged CEN (Commission for European



Normalisation) to prepare standards which will provide a European wide scope. These Standards provide two important statements:

1. The level of safety attained in a member state must not be lowered.

2. Products or machinery manufactured in conformity with a specified published European Standard will be presumed to comply with the Essential Health and Safety Requirements covered by those standards.

**The construction of the standards is divided into three groups:**
A Type Standards apply to all machinery and are essential reading to designers and builders.

B Type Standards, these are laterally interlinked and are generally divided into B1 and B2 standards.

B1 Standards apply to all machinery and are designed to promote the essential factors of safety.

B2 Standards apply when used i.e. if a particular safety device is used it must be manufactured to the relevant standard.

C Type Standards, these will inform designers, manufacturers and users of specific safety precautions to be taken, and devices which are required to be used in particular

All standards which have been harmonised for Machinery Directive 98/37/EC will need to be at least rewritten if not fully updated to ensure compliance with the 2006/42/EC Directive.

| | | |
|---|---|---|
| **A Type Standards** | BS EN 414<br>BS EN 12100 | |
| **B Type Standards** | **B1**<br>BS EN 60204 | **B2**<br>BS EN 13850<br>BS EN 1088 |
| **C Type Standards** | BS EN 12417<br>BS EN 415<br>BS EN 693<br>BS EN 474<br>BS EN ISO 10218-1 | |

## Step 2: Technical Construction File

Under the Supply of Machinery (Safety) Regulations, any manufacturer wishing to supply machinery within the European Economic Area (EEA) must be able to assemble a file, often known as the "product file", containing technical information relative to the machinery. The file must remain available for inspection by a competent national authority, such as the UK Health and Safety Executive, for a period of ten years. The file, however, does not have to include detailed information such as the sub-assemblies of the machine, unless a knowledge of them is essential for verification and compliance with the Essential Health and Safety Requirements. For machinery it is considered this information is essential and should be provided.

**The file should contain the following:**

- The Directives applicable for design, manufacture, installation etc and with which compliance is claimed
- Any other national standards/guidance/technical specification as applicable
- An overall drawing of the machinery

- A list of the Essential Health and Safety Requirements
- Complete detailed drawings, calculation notes and test results etc, deemed necessary to endorse the conformity of the machinery, with the EHSRs
- An account of the techniques used to reduce or eliminate hazards posed by the machinery/product.
- Drawings of the operating system/control circuitry with details outlining how it works
- The standards used and any reports/test results required by these standards
- A copy of all works and site testing and commissioning reports
- If so desired a certificate or technical report obtained from a competent body in support of standards conformity
- A copy of the operator's instructions and maintenance manual

Non-European manufacturers must appoint someone within Europe to hold their Technical Files and this person's name and address must be included in the Declaration.

## Step 3: Declaration

The Declaration of Conformity is a certificate, which must accompany every machine placed on what is termed "the market" (unless a Declaration of Incorporation is issued instead). The manufacturer of a machine automatically places the machine on "the market". The Declaration is the manufacturer's assurance to the customer that the product complies with the applicable directives. The Declaration carries relevant product information and is signed by a responsible person on behalf of the manufacturer or importer.

**Declaration of Incorporation**

Partly completed machinery means an assembly which is almost machinery but which cannot in itself perform a specific application. It is only intended to be incorporated into or assembled with other machinery or partly completed machinery. The manufacturer of partly completed machinery should draw up a declaration of incorporation which should accompany the assembly instructions and the partly completed machinery when it is placed on the market. The declaration and assembly instructions will then form part of the technical file for the final machinery.

## Step 4: CE Mark

Affix the CE mark to machines which are issued with a Declaration of Conformity only. CE Marking must be affixed in the immediate vicinity of the name of the manufacturer or Authorised Representative and applied using the same technique.



## Project Management

When building machines or when combining machines to produce a 'complex assembly' of machines it is easy to get things wrong and end up with a project that requires a lot of rework and ends up going over budget or overtime. To this end, ensure that the CE marking is considered from the start.

Frequently what happens is that equipment is designed and installed with no thought as to what happens either upstream or downstream, or who takes the responsibility for which parts, and who takes responsibility for the final assembly.

This can be exacerbated when equipment is sourced from outside the European Economic Area, or existing equipment is linked to new equipment.

**The problems that we often see when CE marking is not considered at the start include:-**

- Equipment being installed before a final layout is agreed - leads to machines being moved and rework being required.
- Consideration not given to a Safety related control system at the start, leading to a number of problems when linking different machines of different performance level the machine under EN ISO 13849.
- Consideration not being given to control system functionality with feed conveyors not being stopped when a process is stopped, leading to damaged product at best, and injury at worst.
- Machinery not being inspected before installation, and then when non compliances are found, disagreements about who pays to put it right, the supplier, the contractor or the user.
- Control colours not being agreed, with different suppliers using different colours, leading to confusion. The European Standard allows for Green, White, Black or Grey for Start, and Red, White, Black or Grey for Stop! Even by complying with the Standard, errors can occur.

When starting a project, decide who is going to take the responsibility for the CE marking, and lay down the ground rules. Decide what Performance Level the machine will come under, using EN ISO 13849 and ensure all suppliers are aware of what is required.

Make sure they all understand which EN Standards to follow, and make sure they have copies of the Standards. Ask for sample Declarations before deciding on suppliers, and check to see if they have all the information on them, and the correct numbers for example.

Issue Purchase Orders, and ensure there is a clause about CE marking, and whose responsibility it is. If building a complex assembly, decide how EMC issues are to be tackled if testing is to be carried out, all suppliers should be aware of potential failures, especially if using Inverter Drives. Check that these are installed using the manufacturers guidelines.

Before accepting and paying for any machines, check that they meet the requirements of the order and also that they conform to the Machinery Directive. If there is any doubt, it should be resolved before final payment.

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# Providing peace of mind that products are safe, reliable and compliant

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:: Machinery Safety & CE Marking

:: Consulting, Certification & Training

# EMC Solutions

section five 5



The main objectives of the EMC directive, introduced in 1992 and a mandatory requirement from 1996, are twofold:

- To improve the health and safety conditions for those required to handle and operate electronic equipment and machinery.
- To harmonise technical rules and requirements for controlling interference and the susceptibility to electromagnetic noise.

## Mains Filters

## Cables

## Guidelines for installing

## Servodrives

# EMC Solutions





Electromagnetic compatibility (EMC) is an issue that many machine builders find complex and confusing, but that doesn't mean that they can ignore their legal obligation to ensure their products meet the requirements of the EMC Directive.

There can be no doubt about the need for electromagnetic compatibility (EMC). If, for example, the control system of a machine is disturbed by electromagnetic interference it may randomly malfunction, creating a potentially dangerous situation. Conversely, if the electrical and electronic systems fitted to a machine generate a high level of interference, they may cause other nearby equipment to malfunction. It is to help guard against situations like these that the EMC Directive, 2004/108/EC, was put in place. In the UK, this directive is implemented by the Electromagnetic Compatibility (EMC) Regulations 2006.

To understand the implications of these regulations for machine builders, a good starting point is to look at the "Guide to the Electromagnetic Compatibility (EMC) Regulations 2006". Section 2 of this guide, which covers essential requirements, includes statements that can be summarised as saying that equipment must be designed and manufactured so that the electromagnetic disturbance it creates is not excessive, and so that it has a reasonable level of immunity to electromagnetic disturbances. In addition, fixed installations – which includes the majority of machines – must be installed applying good engineering practices and respecting the intended use of its components.

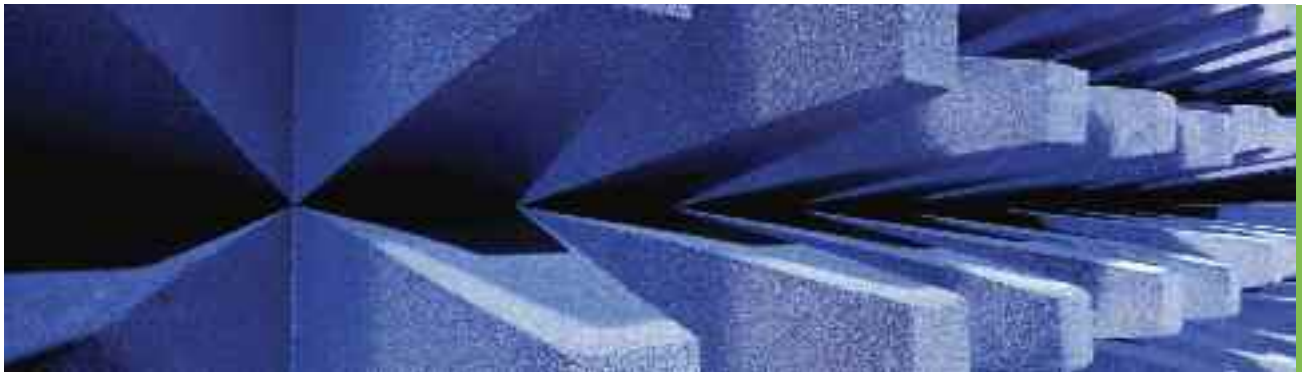
Then comes a very interesting statement, "There are no conformity assessment or CE marking requirements for fixed installations". Does this mean that builders of machines categorised as fixed installations have no need to concern themselves with the EMC performance of their products? Indeed it does not. The machines must still be designed and manufactured so that they meet the essential requirements mentioned earlier – the only relaxation of the rules relates to assessment and marking, not to performance!

But how can machine builders be sure that their products really do have satisfactory EMC performance? It's very tempting to think that the answer is to use only components that are themselves compliant with the EMC Regulations. Surely, if all of the components used in a machine satisfy the regulations, it's reasonable to conclude that the whole machine must also meet the regulations?

Unfortunately, that's not how it works and it's relatively easy to see why. Consider, for example, a variable speed drive that, for the sake of argument, produces a level of electromagnetic interference about half of that acceptable under the regulations. Clearly, there's no problem in stating that this drive complies with the regulations.

Now put four of those drives on a machine. Is it reasonable to assume that the machine complies with the regulations, simply because each of the drives is compliant? Probably not. The machine may be compliant, especially if measures to control EMC have been incorporated in its design, but the point is that it can't be assumed to be compliant. In fact, since there is no proven way of calculating or modelling the EMC performance of a machine, it is the opinion of Laidler Associates that the only way compliance can be verified is by testing. This opinion may be considered by some as rather controversial, but when the Health & Safety Executive was asked to comment on this issue, it provided the following statement:

"Section 6 of the Health & Safety at Work Act (HSW) places a duty on manufacturers to carry out or arrange for the carrying out of such testing and examination as may be necessary to ensure that the article is so designed and constructed that it will, as far as is reasonably practicable, be safe and without risks to health. In the context of EMC, in most applications it is





the electromagnetic immunity of equipment that is of interest in relation to Section 6 of the HSW. If it is reasonably practicable to carry out testing for immunity to electromagnetic disturbances, the HSW requires this to be carried out".

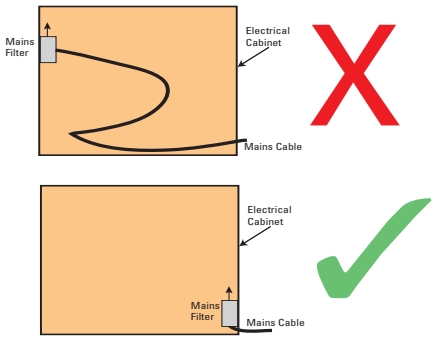
This statement leaves no room for doubt about the necessity for EMC testing of machines in the vast majority of cases – there is simply no shortcut to achieving compliance with the EMC Regulations. Unfortunately, there is also no doubt that EMC testing can be complex and time consuming, especially for the majority of machine builders that lack in-house expertise in this specialist area.

For this reason, many machine builders find it preferable to work with a specialist consultant like Laidler Associates on matters relating to EMC. Provided that they are involved with a project at an early enough stage, a consultant of this type can provide design guidance that will help to optimise the EMC performance of the machine, as well as giving invaluable advice on compliance and testing. The consultant's services may also include arranging for and supervising the tests.

The period after testing is often the time when the knowledge and ability of the consultant engineer really comes into play. Rather than walk away from a machine which has issues with EMC and hence has failed some or all of the tests carried out, Laidler engineers will work with the customer to find the source of the problem and guide the customer to find a solution. The following principles can be used to improve the machines EMC performance and help pass the testing.

## 1. Mains Filters

To reduce the conducted emissions from the machine and improve its immunity to transients, a mains filter is required. It is important to ensure that all supply cables are filtered, i.e. all live supply cables and Neutral. When fitting a mains filter it is important to ensure that it is fitted correctly, i.e. it must be mounted at the point where the mains incoming cable enters the cabinet, the body of the mains filter should be bonded to the metal work of the electrical cabinet and the bond should be metal to metal. When wiring the rest of the electrical cabinet ensure that all cables are routed away from the mains input cables.

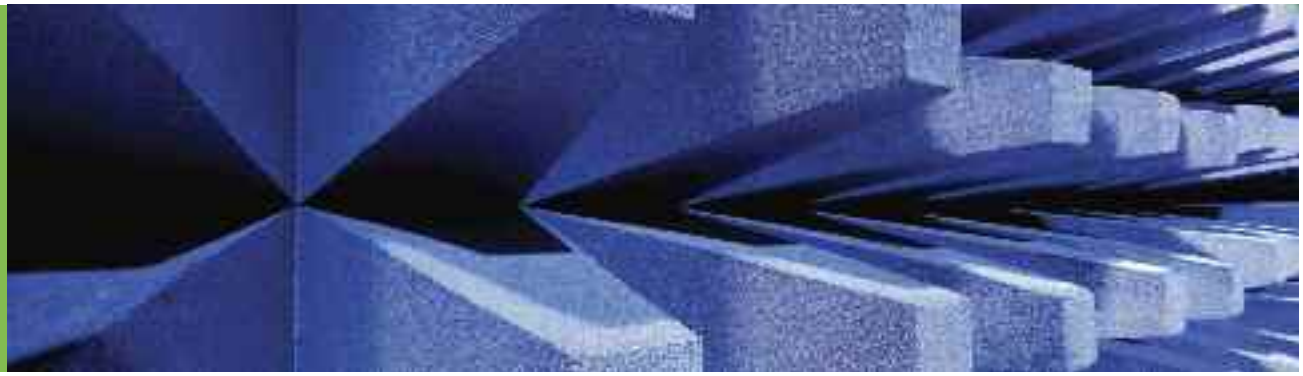



## 2. Cables

When routing cables within a machine it is important to consider the types of cables concerned. These can be broken down into the following broad areas:

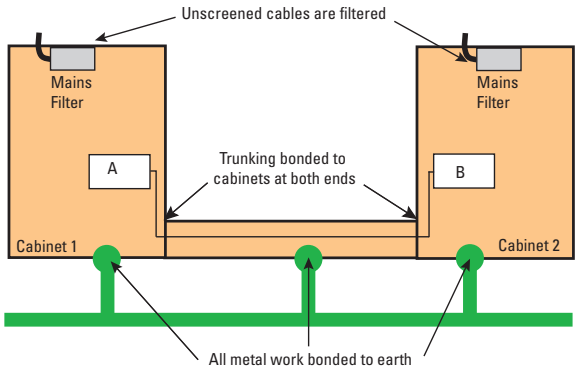
- Type 1: Sensitive analogue cables. (Measuring signals)
- Type 2: Ordinary analogue cables and digital cables. (RS422, RS458, limit switches)
- Type 3: Low voltage AC controls and DC power. (Relays, contactors, solenoids DOL motors)
- Type 4: Very noisy signals. (Inverter input / output cables, DC motors, RF generators)

It is important not to mix the different types of cable together, however when contact is unavoidable they should run perpendicular to each other. When the machine consists of a number of sub assemblies, which require interconnection via long lengths of cables, it is recommended that where possible, screened cables be used. The screens of these cables must be bonded to their local EMC earth at both ends, and it is recommended that this bonding exists around all 360 degrees of the cables (i.e. their entire periphery).





Unscreened cables entering and leaving the cabinet should be filtered. See diagram below.




When installing screened cables the screen should not be used as a signal return path. For unscreened cables all signal and return cables should be twisted, i.e. Live & Neutral, 24v and 0v. It is important not to mix signal and return cables. When bonding other parts of machinery such as doors and lids etc. ensure that the earth straps have a large cross section. Braids or thick cables are normally used for these purposes. These should be kept as short as possible.

## EMC Guidelines for Installing Servodrives

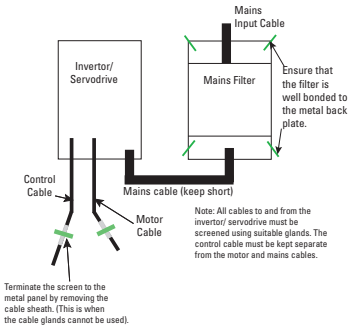
1. Ensure that all equipment is well earthed using short, thick earthing cables connected to a local earth starpoint or busbar. (This earthing is for EMC purposes only and must not replace the safety earthing system as required by EN60204). Any control equipment that is connected to the servodriver (e.g. PLC) must be connected to the same starpoint as the servodriver using a short thick link. Braids are usually the best for this situation.

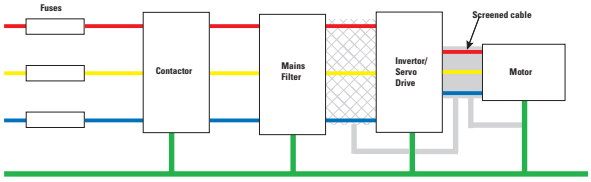
2. Use screened cables for all control circuitry connections. Terminate the ends of the cables neatly, ensuring that the unscreened portion of wire is kept as short as possible.

3. Run all control cables in separate trunking to the mains cables. If these cables must cross each other, then ensure they do so at 90 degrees to each other.

4. Suppress the coils of all contactors using RC Suppression for AC contactors and flywheel diodes for DC contactors.

5. Use screened or armoured cables for the motor connections and ground the screen at both ends. (See diagrams below)




The above diagrams are used as a guideline only. It is recommended that you follow all of the manufacturers installation instructions where available. At frequencies above a few MHz, only an unbroken metal area or volume can achieve a reliable local RF reference, and only then for cables and electronics which remain within its boundaries. In the case of a metal sheet used as a local RF reference, the cables and electronics should remain close to its surface at all times.

section six

6

# PUWER



The Provision and Use of Work Equipment Regulations 1998 (PUWER) requires users of work equipment to carry out risk assessment and provide work equipment that is suitable for its intended task and can be used without putting persons at risk.

The Regulations cover any machinery, appliance, apparatus, tool or installation for use at work (whether exclusively or not) - effectively it is anything used at work.

The 1998 regulations (updating the original 1992 Regulations) introduce requirements to ensure that, for reasons of health and safety, inspections are carried out:

- After installation and before being put into service for the first time; or after assembly at a new site or in a new location to ensure that it has been installed correctly and is safe to operate.
- After work equipment has been exposed to any conditions causing deterioration, which is liable to cause a dangerous situation.
- At suitable intervals; and
- Each time that exceptional circumstances have occurred that are liable to jeopardise the safety of work equipment. The results of these inspections have to be documented and kept until the subsequent inspection is recorded.

The regulations make it an offense to allow work equipment to leave an employer's undertaking, or if obtained from another undertaking, be used, unless it is accompanied by physical evidence that the last inspection has been carried out.

# PUWER



The primary objective of PUWER is to ensure the provision of safe work equipment and its safe use. This has several components, which are interlinked and complementary.

- Work equipment should not give rise to risks to health and safety, irrespective of its age or place of origin.
- The Regulations implement European Community (EC) Directive 89/655/EEC, amended by the non-lifting aspects of the Work Equipment Directive (AUWED).
- The Regulations are made under the Health and Safety at Work, etc Act 1974 (HSW Act), and apply to all users and the self employed covered by that Act in Great Britain except the crews of sea-going ships.
- These regulations place a requirement to carry out a Risk Assessment on all existing equipment (see section Six).
- The regulations ask that the electrical system, the guarding and other possible hazards be assessed and corrected if required.

The Health And Safety At Work Act 1974 Section 2(2) Employers must, so far as is reasonably practicable: -

Provide & maintain plant and systems of work that are safe & without risk to health.

Risk Assessments are a key part to any PUWER assessment and are cross-referenced with the appropriate section/question at all times. If a non-compliance does occur and you are asked for your reports you will probably be asked primarily for the risk assessments carried out against the equipment in question. In order to fully comply, Risk Assessments are carried out and where problems are found they are reported against a particular section/question.

## Regulations 6 Inspection

Where the safety of work equipment depends on installation it must be inspected.

**(a)** After installation and before being put into service for the first time or

**(b)** After assembly at a new site or in a new location

Work Equipment that is exposed to conditions causing deterioration liable to result in a dangerous situation must be inspected-

**(a)** At suitable intervals, and

**(b)** Each time circumstances liable to jeopardise the safety have occurred

The results of any inspection made under this regulation must be recorded. These records must be kept until the next inspection is recorded.

Every employer shall ensure that no work equipment-

**(a)** Leaves their undertaking, or

**(b)** If obtained from the undertaking of another person, is used in their undertaking unless

It is accompanied by physical evidence that the last inspection required by this regulation has been carried out.

- You should ensure that the persons who determine the nature of the inspections required and who carry out the inspections are competent to do so.
- The competent person should have the necessary knowledge and experience to decide what the inspection should include, how and when it should be carried out.
- Every employer must ensure that any work equipment complies with any European Directive that applies to it.

## The following questions highlight the types of hazards that need to be considered under PUWER and which part of PUWER they relate to.

### Reg 10 Conformity with Community Requirements
- Equipment complies with all applicable Directives

### Reg 11 Dangerous parts of machinery
- Is there access to dangerous parts of machinery
- Are all guards securely held in place
- Are guards positioned correctly
- Can the guarding be bypassed or disabled

### Reg 12 protection against specified hazards
- Is there any possibility of fire or explosion
- Is there any possibility of a discharge of hazardous material

### Reg 13 High or Very Low Temperatures
- Are there any hot/cold surfaces

### Reg 14 Controls for Starting or Making a Significant Change in Operating Conditions
- Is a start control provided
- Is there a reset facility provided
- Will the machine restart automatically after a stoppage

### Reg 15 Stop Controls
- Are normal stop controls provided
- Does the machine stop safely

### Reg 16 Emergency Stops
- Are E stops located correctly
- Do the function correctly

### Reg 17 Controls
- Can the operator see all around the machine from the operating position
- Is there a delayed start and warning system is it working

### Reg 18 Control Systems
- Is the control system fail safe
- Is it possible to be trapped in a machine
- If it is can the person summon help and stop the machine

### Reg 19 Isolation of Energy Sources
- Can all sources of energy be isolated
- Are those isolators lockable

### Reg 20 Stability
- Is the machine stable under its own weight or bolted to the floor

### Reg 21 Lighting
- Is ambient lighting of adequate intensity
- If not is the machine provided with adequate lighting

### Reg 22 Maintenance
- Can safe maintenance be carried out
- Are safe working procedures in place

### Reg 23 Markings
- Are flow directions marked
- Are rotational directions marked
- Are pipes and vessels marked
- Are permanently live circuits marked

### Reg 24 Warnings
- Are relevant PPE warnings posted
- Are electrical safety warnings posted
- Are hot surface warnings posted
- Have audible & visual warnings got a checking function

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# Pre-Purchase Audit

section seven 7



The Pre-Purchase Audit is a system designed to assist their clients to purchase machinery and equipment that is both safe and correct.

## Background

## PUWER

## The Solution

## What to look at

# Pre-Purchase Audit

section seven 7



## Background

When the Provision and Use of Work Equipment Regulations (PUWER) first came into force in 1992 it included a very simplistic view on CE Marking: the end user only has to check that the equipment concerned carried a CE Mark. If it did, they were able to presume conformity. PUWER was updated in 1998 and one of the more important, but easily overlooked, changes was that the onus was now put on the end-user to make sure that the equipment complies with all relevant legislation such as CE Marking. These changes were re-enforced with further changes in June 2002.

This point has been further backed up in other guidance from HSE including "INDG 271 - Buying new machinery". This document asks the question "Is CE Marking a guarantee of safety?" The answer given is "No. The manufacturer is claiming that the machinery complies with the law. You still need to check the machine is safe before it is used". A list of items to think about (such as do any parts look dangerous, are there guards and are they in place?) is included along with a brief checklist entitled "What do I do when I have bought new machinery?" The key in all of this is that the emphasis is on the purchaser to check that the machine is safe to use.

If this is the case, and the end-user should now check more thoroughly regarding the CE Marking of new equipment, what is the best way to do this?

## PUWER

To fully comply with PUWER, any new equipment should be inspected after installation and before it is put into use to make sure it is safe. This inspection, if carried out correctly, will highlight any safety issues, which may have an effect on the CE Marking of the equipment. Any issues that appear to relate to the CE Marking of the equipment should be raised with the manufacturer or supplier of the equipment. However, as the equipment has been installed it may be more difficult to deal with.

## The Solution

A solution to this is to use a User Requirement Specification (URS) when purchasing new equipment. This specification will outline your requirements for the equipment supplier. A URS should include statements such as:

- The machine must comply with all applicable European and UK legislation. (List all applicable Directives)
- Euro-Norm Standards should be used to achieve compliance with the Essential Safety Requirements of all applicable Directives
- Documentary evidence demonstrating compliance with all applicable Directives will be required
- A Declaration of Conformity will be required
- A CE Mark will be applied to the machine, preferably on the makers nameplate
- A full operation and maintenance manual that complies with EHSR 1.7.4 of the Machinery Directive will be required

The above is not a complete list, but is indicative of the type of information you should be asking for.

To ensure compliance with the URS, the equipment may need to be inspected or audited before it is shipped from the manufacturer or supplier. But this inspection need not be limited to only safety issues. Often a purchaser may want to



inspect his equipment to ensure the product he is receiving is indeed the product he believes he is buying. These inspections are both engineering and quality based. Often a company may lack the skill or resources to carry out an inspection of this type in one visit.

Combining the two inspections into one is a cost effective method of ensuring the machine you receive is both safe and meets your specification. Any potential issues can be raised with the manufacturer and either dealt with before it is shipped or at least be planned into the installation process once the equipment has been shipped. Retrofitting is the more difficult method of compliance; it is always advisable to deal with safety as early as possible in the purchasing process, the design stage being preferable.

So, if as a company, you decide to include such an audit in your equipment purchasing policy, what would you need to look at and who should carry out the audit? Dealing with the person first, they should have a good knowledge of the equipment type itself as well as competent understanding of PUWER and CE Marking legislation and have a sound engineering background to understand the latest developments in machine manufacture. Whilst the auditor may not go through the EHSRs as in-depth as the manufacturer, the same areas need to be covered. It may be beneficial for the auditors to create a generic checklist that can be used so that all people who are carrying out an audit for the company are looking at the same points.

**Areas to look at include:**

- Documentation, manuals etc.
- Drawings, electrical pneumatic, hydraulic etc.
- Electrical wiring and termination checks
- Hardware checks
- Utilities
- Environmental checks
- Control Systems
- Software
- Calibration, machine parameters
- Safety CE, PUWER as applicable
- Safety related control systems, interlocks etc.
- Safety, manual handling, COSHH etc.
- Safety, hazards etc
- Ergonomic Assessments
- Maintenance and cleaning procedures
- Training requirements

It may also be beneficial at this stage to collate all the relevant documentation such as manuals, drawings etc so that a file is in place when the equipment arrives on site.

## External Assistance

There may be many reasons why a company feels that a pre-purchasing audit is not feasible. It may be manpower, time, competence or a mixture of the three. Laidler Associates currently carry out this kind of audit for a number of major blue chip companies, both in the UK and abroad. Following the audit, the client will receive a full report highlighting any problem areas with a recommended corrective action. Laidler can also carry out an inspection to enable compliance with PUWER and Project Manage any retro engineering that needs to be carried out.

Laidler Associates also have experience of writing URS' for clients from amongst others, pharmaceutical and automotive companies. Laidler can also tailor the Risk Management Software system, to include the URS.

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# Hands-on engineering solutions for machinery compliance

:: Engineering Services :: Bespoke Guarding
:: ESPE Assessments :: Design, installation & project management

Safety Systems
Technology

Safety Systems Technology • TÜV SÜD Group • Email: sales@safetysys.co.uk

# Engineering Services



Safety Systems is part of the machinery division of TÜV SÜD Product Service Ltd, and provides engineering services to ensure machinery compliance, including full engineering project management of compliance solutions bespoke guarding and safety product sales. As market leaders in machinery safety compliance engineering, we have the knowledge and experience to design and install the most appropriate safety solutions using products from our wide ranging portfolio from leading manufacturers. Services include:

- Project Definition and Design Studies
- Multidiscipline Project Management
- System Specification and Design
- Electrical Design and Build including control circuits
- Guarding Design
- Commissioning and Installation
- Ongoing Support and Training
- Modifications to ensure legal compliance
- ESPE (light curtain) assessments
- Safety Product Sales

## Why Choose Safety Systems Technology Limited?

SST guarantees to provide its customers with the best possible service. We will endeavour to produce optimum solutions for your engineering requirements, using the most effective technology currently available. Our engineering personnel have experience in a vast range of industries and can use this experience in partnership with our clients to develop solutions of the highest quality.

## Engineering Design

## Electrical Engineering

## Machine Guarding

## Safety Product Sales

# Engineering Services



## Engineering Design

The initial stage of the project will be a complete Engineering Design process. In order to establish and agree the project requirements and boundaries in detail a Function Design Specification (FDS) may be generated. On FDS approval the required upgrades will be engineered in detail, producing all required documentation. A number of site surveys may be carried out as part of this design process.

On acceptance of the FDS, SST will begin the overall design process which can include the following depending on requirements:

- Physical guarding designed and built to EN 953 & EN ISO 13857
- Safety control circuitry designed to EN 954-1, EN ISO 13849 or EN 62061, depending on the system that is required
- The selection of the most suitable safety products (interlocks, light curtains etc) as appropriate for the project in question

Appropriate EN Standards will be used throughout this design stage to ensure compliance with all relevant items of legislation. Finals designs will be signed off by the end user before work begins on the production of the remedial items.

**Factory Acceptance Test (FAT)**

On completion of the works, it will be possible to carryout Factory Acceptance Testing (FAT) which will enable the system to be tested against the requirements set out in the FDS.

**Installation and Sign off**

All work will be carried out in accordance with BS 7671 (IEE 17th Edition Regulations) and EN60204-1 as appropriate. SST requires full access to all in order to carry out the installation of both the guarding and control system during the installation period of the project.

**Commissioning**

The new upgrades will be commissioned on completion of installation. The equipment will be powered up and tested in a controlled & structured manner by SST Engineers. All elements of electrical protection, shutdown, and control will be tested before any machine operations are carried out. All line functionality will then be checked and confirmed in line with the FDS. Your personnel may be required to assist in operation of the line during commissioning. SST will require complete access to the line in a fully operable state during the commissioning period.

**Documentation**

The following documentation can be generated by SST during the project, "As Commissioned" copies of which will be supplied to yourselves following the completion of the project in either/both hard copy and/or electronic format.

- Functional Design Specification (FDS)
- Relevant Diagrams
- Factory Acceptance Test
- Documentation
- Manuals relating to SST installed equipment
- Technical Construction File
- EMC and Low Voltage test results

In line with SST quality procedures and in the interest of a successful project SST require approval of the design definition documents before proceeding with detail design, build, installation, and commissioning. In respect of the purpose of the project it may be beneficial for reviews and approvals of the control system design to be carried out jointly between yourselves and Laidler Associates. Approval provider can be discussed and confirmed following order placement.



## Electrical Engineering Services

Safety Systems can design, build and install control panels and safety related control systems inconformity with all relevant European legislation including the Low Voltage and EMC Directives. Test reports and evidence of compliance to these Directives will be included within any engineering project. Standards used will include EN 60204-1, EN ISO 13849-1 and EN 62061. Safety Systems have the knowledge and experience to design systems using whichever standard is the most relevant for the application.

## Machine Guarding

Machinery Directive 2006/42/EC, which was introduced on December 31st 2009, fundamentally changed the requirements for machinery guarding. Annex V of the Directive is an indicative list of safety components and includes indent 7: "Guards and protective devices designed to protect persons against moving parts involved in the process on the machinery", hence guarding must now carry CE Marking and be issued with a Declaration of Conformity.

Safety Systems offer a full in-house machinery guarding solution including consultation, design, manufacture and installation. All guarding is designed and engineered in accordance with the latest EN standards including:

- BS EN 953: Safety of Machinery - Guards - General requirements for the design and construction of fixed and movable guards.
- BS EN ISO 13857 Safety of Machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs.
- BS EN 349 Safety of Machinery - Minimum gaps to avoid crushing of parts of the human body.

We also refer to 'Type C' standards where available for specific types of machinery.

Following these standards allows us to provide best practice solutions to guarding applications therefore providing protection to persons whilst maintaining machine functionality and productivity.

**Other Services Include:**

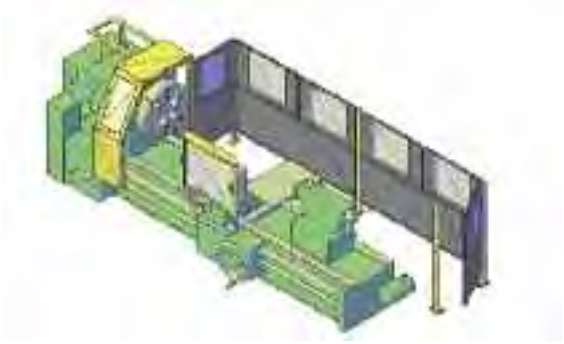
Comprehensive documentation will be generated by SST during the project, "As Commissioned" copies of which will be supplied to yourselves following the completion of the project in either/both hard copy and/or electronic format.

- Rapid CAD design and quotation service available
- National delivery and installation service to suit demanding production schedules.
- A wide range of materials to best suit the application and client needs
- Design and installation of safety controls such as door interlocks
- All guarding can be offered as a turnkey solution, or alternatively it can be sold on a supply only basis.
- All guarding supplied by Safety Systems will be in compliance with all relevant local legislation and comes with the documentation required by the Machinery Directive.



**Guarding Design Services**

Using the latest Computer Aided Design (C.A.D) we can generate accurate machinery representations in both 2D & 3D formats and then overlay the proposed guarding solution to illustrate form and function. This is a key feature of our design facility, allowing operators to see the guarding in 'virtual position' prior to installation, highlighting any potential design changes prior to manufacture.



This flexibility makes modification of the design easy at any stage of the process, ensuring that all guarding meets client expectations, operator requirements and the relevant EN standards.

**Localised Guarding**

Safety Systems can offer a wide range of localised guarding solutions for any industrial application, including:

- Process
- Pharmaceutical
- Food and drink
- Packaging
- Automotive
- Paper & board

**Machine Shop Guarding**

Safety Systems supply and install a complete range of both standard and bespoke guards to a wide range of machine tools including:

- Drilling Machine Guards
- Lathe Guards
- Chuck Guards
- Saddle Shields
- Lead Screw Guarding
- Grinder Guards
- Milling Machine Guards

**Perimeter Guarding**

Safety Systems offer flexible perimeter guarding solutions as both off the shelf or bespoke solutions for particular applications.

- Durable powder coated mild steel, stainless steel or anodised aluminium construction
- A range of heights from 1.4m to 3.0m
- A range of duty ratings for different environments and impact resistance
- Access options such as hinged or sliding single or double doors, trackless doors and vertical gates
- A variety of infill materials such as sheet steel, weld-mesh, clear or tinted polycarbonate
- Locking options such as snap locks, cylinder locks and panic locks
- Simple assembly and installation
- A wide range of colours



**Polycarbonate & PETG Guards**

Safety Systems also design, supply and install bespoke guarding in Polycarbonate and PETG sheet. Often used where greater visibility, product/liquid containment or contaminant prevention is required. These materials can be cut shaped, formed and machined allowing a huge range of possibilities for guarding.

**Permanent Means of Access to Machinery**

In addition to machinery guarding, Safety Systems can also advise upon, design and supply permanent means of access to machinery in accordance with BS EN ISO 14122 Parts 1-4.

## Safety Products

Safety Systems is an expanding company dedicated to offering clients a complete safety product solution. Through our many years of experience, we have the knowledge and expertise to select the most appropriate safety products from our wide ranging portfolio from all of the leading manufacturers. Being an independent company we are also not tied to particular suppliers of safety product's guaranteeing you an unbiased selection of safety products based around your needs, whatever they may be.

When choosing a product, Safety System's personnel will discuss the application first to ensure that the product chosen is the most relevant for the specified need. If a customer has any specific requirements such as budgetary constraints or specific site standards, these will also be taken into account. Safety Systems will always endeavour to supply the most relevant product for the customer's application.

**Typical Products**

Safety Systems are not tied to any safety product manufacturers and hence can supply the most relevant product for a customer's needs. Products that are supplied regularly include:

- Safety Switches
- Safety Relays
- Interlocks
- Light Curtains

Products can be supplied from manufacturers such as:

- Castell
- Datasensor
- Dold
- Fortress
- Idem
- Leuze Electronic
- Pilz
- Schmersal
- SICK
- Smartscan

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# Bespoke Machine Guarding

Safety Systems guarding design and installation engineers have decades of experience in the design and fabrication of guard systems to produce a complete solution for increased machine safety.

Safety Systems
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TÜV SÜD
Product Service

section nine

09

# Appendices

The following pages consist of forms, charts and checklists that can be used to make-up a machinery safety inspection. Please feel free to photocopy before using.

Please note the use of the checklists does not guarantee compliance, they should be used as aide memoires as part of an inspection.

# Appendices



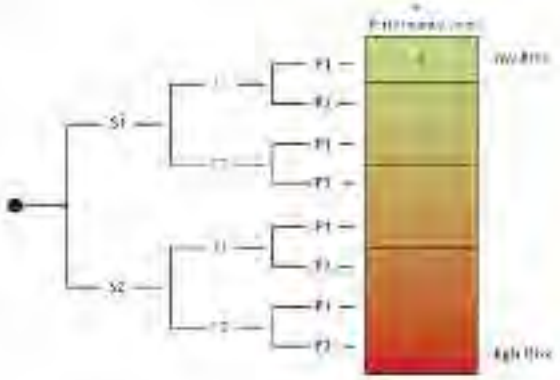
## Safety Related Control Systems

### EN ISO 13849-1

Severity of Injury
S1 - Slight injury
S2 - Severe injury

Frequency of Exposure
F1 - Less frequent or short duration
F2 - Frequent or long duration

Possibility of Avoidance
P1 - Possible
P2 - Less possible




### EN 62061

| Consequences | Severity (S) | Class (Cl) | | | | |
|---|---|---|---|---|---|---|
| | | 3-4 | 5-7 | 8-10 | 11-13 | 14-15 |
| Death, losing an eye or arm | 4 | SIL 2 | SIL 2 | SIL 3 | SIL 3 | SIL 3 |
| Permanent, losing fingers | 3 | | SIL 1 | SIL 1 | SIL 2 | SIL 3 |
| Reversible, medical attention | 2 | | | SIL 1 | SIL 1 | SIL 2 |
| Reversible, first aid | 1 | | | | SIL 1 | SIL 1 |
| | | | | | | |

| Frequency, Fr (duration > 10min) | | Probability of Hazard Event, Pr | | Avoidance, Av | |
|---|---|---|---|---|---|---|
| ≤ 1 hour | 5 | Common | 5 | | |
| > 1 hr - ≤ 1 day | 5 | Likely | 5 | | |
| > 1 day - ≤ 2 wks | 4 | Possible | 3 | Impossible | 5 |
| > 2 wks - ≤ 1 yr | 3 | Rarely | 2 | Possible | 3 |
| > 1 year | 2 | Negligible | 1 | Likely | 1 |

Calculate Class first, Cl (Class) = Fr + Pr + Av, then the consequence defines the SIL level.

# Risk Assessment Sheet Number

Company: .....

Type: ..... Make: .....

Model: ..... Serial No.: .....

Location: ..... Power Supply: .....

## Nature of Hazard

## Risk Assessment

| LO | FE | DPH | NP | HRN | | |
|---|---|---|---|---|---|---|
| | | | | | Degree of Risk | |

## Recommended Control Measure

## Re-Assessment

| LO | FE | DPH | NP | HRN | | |
|---|---|---|---|---|---|---|
| | | | | | Degree of Risk | |

| Further risk reduction required? | |
|---|---|

Assessment by: .....

Position: .....

Date: .....

| LO Likelihood of Occurrence | | | FE Frequency of Exposure | |
|---|---|---|---|---|
| 0 | Impossible | cannot happen | 0.1 | Infrequently |
| 0.1 | Almost unlikely | possible in extreme circumstances | 0.2 | Annually |
| 0.5 | Highly unlikely | though conceivable | 1 | Monthly |
| 1 | Unlikely | but could occur | 1.5 | Weekly |
| 2 | Possible | but unusual | 2.5 | Daily |
| 5 | Even chance | could happen | 4 | Hourly |
| 8 | Probable | not surprised | 5 | constantly |
| 10 | Likely | to be expected | | |
| 15 | Certain | no doubt | | |

| DPH Degree of Possible Harm | | NP Number of Persons | |
|---|---|---|---|
| 0.1 | Scratch or bruise | 1 | 1-2 persons |
| 0.5 | Laceration or mild ill health | 2 | 3-7 persons |
| 1 | Break of a minor bone or minor illness (temporary) | 4 | 8-15 persons |
| 2 | Break of a major bone or minor illness (permanent) | 8 | 16-50 persons |
| 4 | Loss of Limb/ eye/ serious illness of a temporary nature | 12 | 50 + persons |
| 8 | Loss of Limbs/ eyes/ serious illness of permanent nature | | |
| 15 | Fatality | | |

| RISK | Negligible | Very Low | Low | Significant | High | Very High | Extreme | Unacceptable |
|---|---|---|---|---|---|---|---|---|
| HRN | 0-1 | 1-5 | 5-10 | 10-50 | 50-100 | 100-500 | 500-1000 | Over 1000 |

## Comments / Control Measures Implemented

## Review Dates

# Technical File Inclusions

| Section One : Risk Assessments | | Signature |
|---|---|---|
| 1A | Safety Related Control Circuit Assessment | |
| 1B | Risk Assessment | |
| 1C | Support Documentation For Assessments | |
| **Section Two : Essential Requirements** | | |
| 2A | Essential Health & Safety requirements | |
| 2B | Complete detailed drawings showing conformity with the EHSR | |
| 2C | Calculation notes, test results showing conformity with EHSR | |
| 2D | Electrical Checklist | |
| 2E | Pneumatic Checklist | |
| 2F | Hydraulic Checklist | |
| **Section Three : Standards** | | |
| 3A | The Standards used | |
| 3B | Reports and test results required by the Harmonised Standards | |
| **Section Four : Certification and Specifications** | | |
| 4A | Any Technical specifications | |
| 4B | Certificates or Technical Reports obtained from a competent body supporting conformity (optional) | |
| **Section Five : Drawings** | | |
| 5A | Overall Drawings | |
| 5B | Drawing of Control Circuitry | |
| 5C | Specific Drawings | |
| **Section Six : Manuals** | | |
| 6A | Instruction Manual in the language of the country of intended use | |
| 6B | Maintenance Manual | |
| 6C | Other Manuals | |
| **Section Seven : Series Manufacture** | | |
| 7A | For series manufacture internal measures implemented to ensure machinery remains in conformity with the Directive | |
| **Section Eight : Other Documentation** | | |
| 8A | Any Other Documentation Showing Support For Product | |
| **Section Nine : Declarations/ inclusions** | | |
| 9A | Declaration of Conformity/Incorporation | |

Product Service

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