Risk analysis

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Most of us probably harbour a variety of fears. Some are beneficial to us while others are not. It is beneficial to be afraid of adventures that we have reason to believe will end badly. For example, it is wise to feel fear if hanging over a cliff in a meagre string and unwise not to do so. The fears that are problematic, in contrast, are those that give a greater malaise than what is reasonable regarding the risk or consequences. I would imagine that almost everyone hosts unjustifiable fear for something. Among children, the proportion of unjustifiable fear higher is than among adults (for example, they are often afraid that there are monsters under the bed). While they may be less often than adults afraid of things that are really dangerous (like running across the street).

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MÄKLAR CENTRUM

In the past we were, among other things, very afraid of fire, which judging by this promotional messages from a real estate dealer, is completely gone today.

Probably most of us have a latent fear of dying. A fear that flares up in the event that something serious happens. To prevent death at a too early age, we are constantly taking action, such as to look right and left before we go across the street, and by not eating whatever we find. Which on a group level seems to work pretty well, since the majority of everyone in Sweden die after the age of 75 (in 2010, for example, 46 601 women and 43 920 men in Sweden died, 36 497 of the women and 28 312 of the men were 75 years or older, according to the Welfare Board (Socialstyrelsen 2011, Causes of Death 2010)). Of those who died before the age of 75 years, more than half died from cancer or diseases in the circulatory system. Which organs affected by the deadly cancer seems, judging by the statistics, vary quite a lot and thus presumably the underlying reasons why the cancer occurred. Diseases of the circulatory system however is, of course, less scattered and ischemic heart diseases (mainly acute myocardial infarction: women 5.44%, men 9.41%) dominate as the cause of death.

The most well documented[1] risk factors for ischemic heart disease are:

- Age. From 35-44 to 55-64 years of age the risk of ischemic heart disease increases 15 times for men and 30 times for women.
- Gender. In the age group 50-59 the discussed heart disease are five times more common among men than among women.
- High proportion of saturated fatty acids in the diet. They who eat a lot of such as butter and/or meat has a higher risk than those who eat a lot of olive oil and/or fish. Wilhelmsen does, However, not quantify the difference in risk.
- High blood cholesterol. Men who have high cholesterol are at a 3.4 times higher risk than those with low levels.
- High blood pressure. A systolic pressure (the lower pressure, from when the blood returns to the heart) greater than 105 mm Hg doubles the risk compared to a pressure of 91 mm Hg. High blood pressure is considered, in addition to hereditary factors, be due to including overweight, sedentary, salt and/or alcohol consumption, and possibly also stress.
- Smoking. Smoking appears to double the risk (given that everything else is equal).
- Diabetes. The risk doubled for men with diabetes and it increases even more for ditto women.
- Heredity. Those who have a family history of such diseases are at a higher risk. Wilhelmsen does, however, not quantify the difference in risk.

[1.] According to Lars Wilhelmsen and Michael Marmot's chapter: Ischemic heart disease: risk factors and prevention, in Diseases of the Heart, second edition, edited by Desmond G Julina et al., WB Saunders Company Ltd., London, 1998.

Despite all these factors many appears to, in the current situation, focus on a few: smoking, high blood pressure and obesity. Even though Wilhelmsen says that there is not any substantial support for that the latter is a risk factor. Regarding the two previous risk factors, Wilhelmsen writes that they seem to be less important for ischemic heart disease in countries where the population has low cholesterol content in the blood. Furthermore, he writes elsewhere that there is evidence to suggest that an elevated level of cholesterol in the blood is necessary for the development of such diseases. I do not know what is true, though it seems likely that many of us, in this context exaggerates the dangers of smoking, obesity and high blood pressure and that we overlook the dangers of high cholesterol levels. If so, it could to some extent be due to that those who smoke or have an overweight are sinful. The same is true, to some extent, regarding high blood pressure because it can be caused by overweight (i.e. gluttony and other sinful things).

It might suggest that different routes to the same danger are more or less scary. There are other indications suggesting that it is true, as some who have had sex with someone in a brothel in Thailand may harbour greater anxiety about that they have been infected with HIV, compared to if they had met the sex partner on a beach. Although they used a condom at the brothel, while they at the beach practiced unprotected sex and thus ran a far greater risk to actually becoming infected. Generally, the reasoning may be summarized in:

The risk of injury causes fear, but different paths to the same injury is more or less scary.

Those who are afraid to do something that they intend to do, probably often make some sort of risk analysis before the action, it could be for instance:

- The lonely footpath through the park to be crossed on the way home late at night: it is sufficiently illuminated, it seems to hang some freaks at the benches?
- The man who offers a last drink at his home when the pub has closed: is he okay?
- The ladder leaning against the wall: is it realiable?

All risk assessments are, presumably, basically the same way:

1. What is the danger?
2. How could the dangerous thing happen?
3. Where can the dangerous thing happen?
4. What are the chances that it happends?
5. What precautions can/should I take to reduce the risk?
6. Is the risk worth taking?

For the woman who hesitates to go through the park in the evening, the result of the analysis could be:

1. Someone rapes me.
2. He forces me away from the path into the darkness, tearing off my dress and panties.
3. In the most dark and lonely place in the park?
4. Not so high because it’s very cold outside.
5. I walk fast and do not stop even if I am spoken to.
6. The detour takes half an hour extra and I am too tired.

It is likely, however, that we rarely carry out even a rudimentary risk analysis before we do an action that we do not fear.

These everyday risk analyzes will not be further discussed in this text. For it is from now on focused on risk analysis in technical systems. This is because there is authorities[23] requiring that manufacturers of technical systems, or those representing the manufacturers, perform risk assessments before the systems are delivered to the customers. The forms of these risk analyzes are to some extent prescribed by the relevant authority.

2. Machinery Directive applies to machines in which there is some kind of movement that is not driven by hand as well as their accessories. Also various lifting equipment and safety components are included. But there are exceptions. The most common exceptions are:

   - Motor vehicles.
   - Household appliances intended for domestic use[3].
   - Audio and video equipment[3].
   - Information technology equipment[3].
   - Ordinary office machinery[3].
   - Low-voltage switchgear and control gear[3].
   - Electrical motors[3].

3. Electrical/electronic devices are regulated primarily by the Low Voltage Directive. It regulates the design from an electrical point of view of virtually all products to be used with a voltage between 50 to 1 000 V. However, with some exceptions, such as electrical parts to elevators and medical devices.

The Machinery Directive and Low Voltage Directive enshrines that the products shall undergo a CE-marking procedure. The purpose of the rules is that the products sold in Europe are as harmless as possible for the users.

For products that fall under the Machinery Directive, the manufacturer shall ensure that they are safe by carefully analyzing them and if possible eliminate the risks he then finds. If it is not possible to eliminate the hazards, he shall warn for them on the products.
The product must also be accompanied by instructions, and their design is to some extent defined by the Directive. See the excerpt from the directive below.

"1.7.4.2 Contents of the instructions
Each instruction manual must contain, where applicable, at least the following information:
(a) the business name and full address of the manufacturer and of his authorised representative;
(b) the designation of the machinery as marked on the machinery itself, except for the serial number (see section 1.7.3);
(c) the EC declaration of conformity, or a document setting out the contents of the EC declaration of conformity, showing the particulars of the machinery, not necessarily including the serial number and the signature;
(d) a general description of the machinery;
(e) the drawings, diagrams, descriptions and explanations necessary for the use, maintenance and repair of the machinery and for checking its correct functioning;
(f) a description of the workstation(s) likely to be occupied by operators;
(g) a description of the intended use of the machinery;
(h) warnings concerning ways in which the machinery must not be used that experience has shown might occur;
(i) assembly, installation and connection instructions, including drawings, diagrams and the means of attachment and the designation of the chassis or installation on which the machinery is to be mounted;
(j) instructions relating to installation and assembly for reducing noise or vibration;
(k) instructions for the putting into service and use of the machinery and, if necessary, instructions for the training of operators;
(l) information about the residual risks that remain despite the inherent safe design measures, safeguarding and complementary protective measures adopted;
(m) instructions on the protective measures to be taken by the user, including, where appropriate, the personal protective equipment to be provided;
(n) the essential characteristics of tools which may be fitted to the machinery;
(o) the conditions in which the machinery meets the requirement of stability during use, transportation, assembly, dismantling when out of service, testing or foreseeable breakdowns;
(p) instructions with a view to ensuring that transport, handling and storage operations can be made safely, giving the mass of the machinery and of its various parts where these are regularly to be transported separately;
(q) the operating method to be followed in the event of accident or breakdown; if a blockage is likely to occur, the operating method to be followed so as to enable the equipment to be safely unblocked;
9.6.2006 L 157/48 Official Journal of the European Union EN (r) the description of the adjustment and maintenance operations that should be carried out by the user and the preventive maintenance measures that should be observed;
(s) instructions designed to enable adjustment and maintenance to be carried out safely, including the protective measures that should be taken during these operations;
(t) the specifications of the spare parts to be used, when these affect the health and safety of operators;
(u) the following information on airborne noise emissions:
— the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated,
— the peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 µPa),
— the A-weighted sound power level emitted by the machinery, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

These values must be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced. In the case of very large machinery, instead of the A-weighted sound power level, the A-weighted emission sound pressure levels at specified positions around the machinery may be indicated. Where the harmonised standards are not applied, sound levels must be measured using the most appropriate method for the machinery. Whenever sound emission values are indicated the uncertainties surrounding these values must be specified. The operating conditions of the machinery during measurement and the measuring methods used must be described.
Where the workstation(s) are undefined or cannot be defined, A-weighted sound pressure levels must be measured at a distance of 1 metre from the surface of the machinery and at a height of 1,6 metres from the floor or access platform. The position and value of the maximum sound pressure must be indicated.
Where specific Community Directives lay down other requirements for the measurement of sound pressure levels or sound power levels, those Directives must be applied and the corresponding provisions of this section shall not apply;
(v) where machinery is likely to emit non-ionising radiation which may cause harm to persons, in particular persons with active or non-active implantable medical devices, information concerning the radiation emitted for the operator and exposed persons."

To achieve the requirements of many of the items such as: "**e**", "**h**" and "**l-t**", it is required that the author, in addition to having the necessary knowledge of the machine, and the documentation of it, also has a risk analysis as the basis for this work.
The actual risk analysis could be done much in the same way as for the woman who is about to go through the park. But, probably to ensure that the analyst thinks through all types of risks, no matter what he or she fears, the authorities have created a checklist with suggestions regarding potential risks. Below are comments on and description of risk analysis according to the Machinery Directive, and general advice on the application of the regulations. The text in *italics* is quoted from Annex 1 in the directive:

"1.1.2 Principles of safety integration
(a) Machinery must be designed and constructed so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen but also taking into account any reasonably foreseeable misuse thereof.
The aim of measures taken must be to eliminate any risk throughout the foreseeable lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping.
(b) In selecting the most appropriate methods, the manufacturer or his authorised representative must apply the following principles, in the order given:
— eliminate or reduce risks as far as possible (inherently safe machinery design and construction),
— take the necessary protective measures in relation to risks that cannot be eliminated,
— inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.
(c) When designing and constructing machinery and when drafting the instructions, the manufacturer or his authorised representative must envisage not only the intended use of the machinery but also any reasonably foreseeable misuse thereof. The machinery must be designed and constructed in such a way as to prevent abnormal use if such use would engender a risk. Where appropriate, the instructions must draw the user's attention to ways — which experience has shown might occur — in which the machinery should not be used.
(d) Machinery must be designed and constructed to take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protective equipment.
(e) Machinery must be supplied with all the special equipment and accessories essential to enable it to be adjusted, maintained and used safely."

This means that in the first place, the manufacturer shall aim to construct the device so that users can not be hurt, even if they have no personal protection and also, for example, have poor vision and are clumsy. If, despite these efforts, there are risks associated with the use of the device, which is not likely

to eliminate with safety devices, the manufacturer may and must warn for those hazards with signs on it and information about them in the manual.

"1.1.3 Materials and products
The materials used to construct machinery or products used or created during its use must not endanger persons' safety or health. In particular, where fluids are used, machinery must be designed and constructed to prevent risks due to filling, use, recovery or draining."

Are any liquids or gases in any stage involved in the use of this device? No = OK, go to 1.1.4.

Yes = What ikind of liquid/gas? Isit dangerous (check the material safety data sheets) and to ensure that the safety precautions requirements are met by the design and the manual.

"1.1.4 Lighting
Machinery must be supplied with integral lighting suitable for the operations concerned where the absence
thereof is likely to cause a risk despite ambient lighting of normal intensity.
Machinery must be designed and constructed so that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects on moving parts due to the lighting. Internal parts requiring frequent inspection and adjustment, and maintenance areas must be provided with appropriate lighting."

Is there any point/area on the device that the user needs to see particularilly well (eg. an indicator or a processing tool)?

Yes = is the lighting there not stronger there than on the surrounding areas?
Are there areas there irritating glare when looking on the spot?
Shadows?
Can these deficiencies result in that operators are forced to use awkward postures to see properly and/or that they do wrong manouvres = redo.

"1.1.5 Design of machinery to facilitate its handling
Machinery, or each component part thereof, must:
— be capable of being handled and transported safely,
— be packaged or designed so that it can be stored safely and without damage.
During the transportation of the machinery and/or its component parts, there must be no possibility of sudden movements or of hazards due to instability as long as the machinery and/or its component parts arehandled in accordance with the instructions. Where the weight, size or shape of machinery or its various component parts prevents them from being moved by hand, the machinery or each component part must:
— either be fitted with attachments for lifting gear, or
— be designed so that it can be fitted with such attachments, or
— be shaped in such a way that standard lifting gear can easily be attached.
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Where machinery or one of its component parts is to be moved by hand, it must:
— either be easily moveable, or
— be equipped for picking up and moving safely.
Special arrangements must be made for the handling of tools and/or machinery parts which, even if lightweight, could be hazardous."

Is the unit a large, difficult to grasp, heavy or are there any other risk to harm someone when moving the device? No = OK, go to 1.1.6.

Yes = consider the specific issues raised in the text above and, if necessary, read more in the chapter The ergonomics of tools.

"1.1.6 Ergonomics
Under the intended conditions of use, the discomfort, fatigue and physical and psychological stress faced by the operator must be reduced to the minimum possible, taking into account ergonomic principles such as:
— allowing for the variability of the operator's physical dimensions, strength and stamina,
— providing enough space for movements of the parts of the operator's body,
— avoiding a machine-determined work rate,
— avoiding monitoring that requires lengthy concentration,
— adapting the man/machinery interface to the foreseeable characteristics of the operators."

Is there someone that, at times, will work directly with the device (eg, load it with work-pieces or starts it)? No = OK, go to 1.1.7.

If yes, this step is important, especially if it is intended to be maouvered frequently or if it is handheld. This is because mosculoskeletal disorders are probably the most common type of damage that modern devices generate. For guidance and advice on the ergonomic design, see the chapter The ergonomics of tools.

"1.1.7 Operating positions
The operating position must be designed and constructed in such a way as to avoid any risk due to exhaust gases and/or lack of oxygen. If the machinery is intended to be used in a hazardous environment presenting risks to the health and safety of the operator or if the machinery itself gives rise to a hazardous environment, adequate means must be provided to ensure that the operator has good working conditions and is protected against any foreseeable hazards.
Where appropriate, the operating position must be fitted with an adequate cabin designed, constructed and/or equipped to fulfil the above requirements. The exit must allow rapid evacuation. Moreover, when applicable, an emergency exit must be provided in a direction which is different from the usual exit.

1.1.8. Seating
Where appropriate and where the working conditions so permit, work stations constituting an integral part of the machinery must be designed for the installation of seats. If the operator is intended to sit during operation and the operating position is an integral part of the machinery, the seat must be provided with the machinery. The operator's seat must enable him to maintain a stable position. Furthermore, the seat and its distance from the control devices must be capable of being adapted to the operator. If the machinery is subject to vibrations, the seat must be designed and constructed in such a way as to reduce the vibrations transmitted to the operator to the lowest level that is reasonably possible. The seat mountings must withstand all stresses to which they can be subjected. Where there is no floor beneath the feet of the operator, footrests covered with a slip-resistant material must be provided."

Does the device have controls that must be manouvered often? No (common) = OK, go to 1.2.1.
If yes, but the device is supposed to be indoors on the floor or on on a bench and the controls are accessible in a convenient way for someone which is outside the boundaries of the device= OK, go to 1.2.1.

Note that most devices with controls/control panel, as well known, neither have a cab or a seat.

"1.2 CONTROL SYSTEMS

1.2.1. Safety and reliability of control systems
Control systems must be designed and constructed in such a way as to prevent hazardous situations from arising. Above all, they must be designed and constructed in such a way that:
— they can withstand the intended operating stresses and external influences,
— a fault in the hardware or the software of the control system does not lead to hazardous situations,
— errors in the control system logic do not lead to hazardous situations,
— reasonably foreseeable human error during operation does not lead to hazardous situations.
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Particular attention must be given to the following points:
— the machinery must not start unexpectedly,
— the parameters of the machinery must not change in an uncontrolled way, where such change may lead to hazardous situations,
— the machinery must not be prevented from stopping if the stop command has already been given,
— no moving part of the machinery or piece held by the machinery must fall or be ejected,
— automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,
— the protective devices must remain fully effective or give a stop command,
— the safety-related parts of the control system must apply in a coherent way to the whole of an assembly of machinery and/or partly completed machinery. For cable-less control, an automatic stop must be activated when correct control signals are not received, including loss of communication."

Does the apparatus have a control system? No = OK.

All devices that is only operate with some kind of switch that is directly connected to the power source are not affected by this point.There are, however, a lot of equipment from simple ones with a relay between the control and the power source, through those who are started/stopped by some form of sensor, to advanced machinery with a variety of movements controlled via a control system.

Please note that all items are "must", i.e. This is considered to be particularly important, and if the device has some form of control, all points must be considered. But in reality, the analysis is prefereably done with the other issues related to the same risks, see the paragraph 1.4.3.

"1.2.2 Control devices
Control devices must be:
— clearly visible and identifiable, using pictograms where appropriate,
— positioned in such a way as to be safely operated without hesitation or loss of time and without ambiguity,
— designed in such a way that the movement of the control device is consistent with its effect,
— located outside the danger zones, except where necessary for certain control devices such as an emergency stop or a teach pendant,
— positioned in such a way that their operation cannot cause additional risk,
— designed or protected in such a way that the desired effect, where a hazard is involved, can only be achieved by a deliberate action,
— made in such a way as to withstand foreseeable forces; particular attention must be paid to emergency stop devices liable to be subjected to considerable forces.
Where a control device is designed and constructed to perform several different actions, namely where there is no one-to-one correspondence, the action to be performed must be clearly displayed and subject to confirmation, where necessary.
Control devices must be so arranged that their layout, travel and resistance to operation are compatible with the action to be performed, taking account of ergonomic principles.
Machinery must be fitted with indicators as required for safe operation. The operator must be able to read them from the control position.
From each control position, the operator must be able to ensure that no-one is in the danger zones, or the control system must be designed and constructed in such a way that starting is prevented while

someone is in the danger zone. If neither of these possibilities is applicable, before the machinery starts, an acoustic and/or visual warning signal must be given. The exposed persons must have time to leave the danger zone or prevent the machinery starting up. If necessary, means must be provided to ensure that the machinery can be controlled only from control positions located in one or more predetermined zones or locations. Where there is more than one control position, the control system must be designed in such a way that the use of one of them precludes the use of the others, except for stop controls and emergency stops. When machinery has two or more operating positions, each position must be provided with all the required control devices without the operators hindering or putting each other into a hazardous situation.

1.2.3 Starting
It must be possible to start machinery only by voluntary actuation of a control device provided for the purpose.
The same requirement applies:
— when restarting the machinery after a stoppage, whatever the cause,
— when effecting a significant change in the operating conditions.
However, the restarting of the machinery or a change in operating conditions may be effected by voluntary actuation of a device other than the control device provided for the purpose, on condition that this does not lead to a hazardous situation. For machinery functioning in automatic mode, the starting of the machinery, restarting after a stoppage, or a change in operating conditions may be possible without intervention, provided this does not lead to a hazardous situation.
Where machinery has several starting control devices and the operators can therefore put each other in danger, additional devices must be fitted to rule out such risks. If safety requires that starting and/or stopping must be performed in a specific sequence, there must be devices which ensure that these operations are performed in the correct order.

1.2.4 Stopping

1.2.4.1. Normal stop
Machinery must be fitted with a control device whereby the machinery can be brought safely to a complete stop. Each workstation must be fitted with a control device to stop some or all of the functions of the machinery, depending on the existing hazards, so that the machinery is rendered safe. The machinery's stop control must have priority over the start controls. Once the machinery or its hazardous functions have stopped, the energy supply to the actuators concerned must be cut off.

1.2.4.2. Operational stop
Where, for operational reasons, a stop control that does not cut off the energy supply to the actuators is required, the stop condition must be monitored and maintained.

1.2.4.3. Emergency stop
Machinery must be fitted with one or more emergency stop devices to enable actual or impending danger to be averted. The following exceptions apply:
— machinery in which an emergency stop device would not lessen the risk, either because it would not reduce the stopping time or because it would not enable the special measures required to deal with the risk to be taken,
— portable hand-held and/or hand-guided machinery. The device must:
— have clearly identifiable, clearly visible and quickly accessible control devices,
— stop the hazardous process as quickly as possible, without creating additional risks,
— where necessary, trigger or permit the triggering of certain safeguard movements. Once active operation of the emergency stop device has ceased following a stop command, that command must be sustained by engagement of the emergency stop device until that engagement is specifically overridden; it must not be possible to engage the device without triggering a stop command; it must be possible to disengage the device only by an appropriate operation, and disengaging the device must not restart the machinery but only permit restarting. The emergency stop function must be available and

operational at all times, regardless of the operating mode. Emergency stop devices must be a back-up to other safeguarding measures and not a substitute for them.

1.2.4.4 Assembly of machinery
In the case of machinery or parts of machinery designed to work together, the machinery must be designed and constructed in such a way that the stop controls, including the emergency stop devices, can stop not only the machinery itself but also all related equipment, if its continued operation may be dangerous.

1.2.5. Selection of control or operating modes
The control or operating mode selected must override all other control or operating modes, with the exception of the emergency stop. If machinery has been designed and constructed to allow its use in several control or operating modes requiring different protective measures and/or work procedures, it must be fitted with a mode selector which can be locked in each position. Each position of the selector must be clearly identifiable and must correspond to a single operating or control mode. The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator. If, for certain operations, the machinery must be able to operate with a guard displaced or removed and/or a protective device disabled, the control or operating mode selector must simultaneously:
— disable all other control or operating modes,
— permit operation of hazardous functions only by control devices requiring sustained action,
— permit the operation of hazardous functions only in reduced risk conditions while preventing hazards from linked sequences,
— prevent any operation of hazardous functions by voluntary or involuntary action on the machine's sensors. If these four conditions cannot be fulfilled simultaneously, the control or operating mode selector must activate other protective measures designed and constructed to ensure a safe intervention zone. In addition, the operator must be able to control operation of the parts he is working on from the adjustment point.

1.2.6. Failure of the power supply
The interruption, the re-establishment after an interruption or the fluctuation in whatever manner of the power supply to the machinery must not lead to dangerous situations. Particular attention must be given to the following points:
— the machinery must not start unexpectedly,
— the parameters of the machinery must not change in an uncontrolled way when such change can lead to hazardous situations,
— the machinery must not be prevented from stopping if the command has already been given,
— no moving part of the machinery or piece held by the machinery must fall or be ejected,
— automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,
— the protective devices must remain fully effective or give a stop command."

All these analyzes (section 1.2.2-1.2.6) are best done together with the other questions relating to the same risks, see the paragraph 1.4.3.

"1.3 PROTECTION AGAINST MECHANICAL HAZARDS

1.3.1. Risk of loss of stability
Machinery and its components and fittings must be stable enough to avoid overturning, falling or uncontrolled movements during transportation, assembly, dismantling and any other action involving the machinery. If the shape of the machinery itself or its intended installation does not offer sufficient stability, appropriate means of anchorage must be incorporated and indicated in the instructions."

Here it is, in my opinion most suitable to do an unconditional "brainstorming": What are the energies stored in the device (like high center of gravity), apart from those generated by the regular work movements, and how these could harm someone? Pay particular attention to any other operation than the usual use and do also take in account what could happened if the user was very clumsy.

"1.3.2 Risk of break-up during operation
The various parts of machinery and their linkages must be able to withstand the stresses to which they are subject when used. The durability of the materials used must be adequate for the nature of the working environment foreseen by the manufacturer or his authorised representative, in particular as regards the phenomena of fatigue, ageing, corrosion and abrasion. The instructions must indicate the type and frequency of inspections and maintenance required for safety reasons. They must, where appropriate, indicate the parts subject to wear and the criteria for replacement. Where a risk of rupture or disintegration remains despite the measures taken, the parts concerned must be mounted, positioned and/or guarded in such a way that any fragments will be contained, preventing hazardous situations. Both rigid and flexible pipes carrying fluids, particularly those under high pressure, must be able to withstand the foreseen internal and external stresses and must be firmly attached and/or protected to ensure that no risk is posed by a rupture. Where the material to be processed is fed to the tool automatically, the following conditions must be fulfilled to avoid risks to persons:
— when the workpiece comes into contact with the tool, the latter must have attained its normal working condition,
— when the tool starts and/or stops (intentionally or accidentally), the feed movement and the tool movement must be coordinated."

Here, the following analyze could be appropriate:

1. Where is the potentially dangerous parts in this device (what could be harmful if it came loose, cracked, or the like).
2. What events could lead to that the respective part becomes dangerous?
3. What could make the event occurring?
4. Which human injuries could it lead to if it occurs?
5. What is the probability that this will occur?
6. Are there structural measures to take?
7. How difficult/expensive are these measures?
8. How large is the remaining risk
9. What actions are worth doing, when taking into account the possible injuries and the risks for the injuries before and after the measures has been taken?
10. Can the remaining risks be reduced through some kind of maintenance? If so, implement appropriate maintenance requirements in the manuals.
11. Is there a residual risk after the agreed design measures? If yes, ensure that there are adequate warnings on the device and in the operating instructions.

"1.3.3 Risks due to falling or ejected objects
Precautions must be taken to prevent risks from falling or ejected objects."

This is a very important point, especially in the case of machines that perform mechanical work. In these, it is quite common that processing tools or work-pieces under processing breaks and bits are thrown out with high speed. For example, the grinding wheels shatter and parts are threwed towards the operator. Such risks are more difficult to eliminate than the risk that moving parts coming loose inside the machine, since the operator may want to see the processing and need to access the processing point. For further analysis, see the analysis scheme proposed under the paragraph 1.4.3.

"1.3.4 Risks due to surfaces, edges or angles
Insofar as their purpose allows, accessible parts of the machinery must have no sharp edges, no sharp angles and no rough surfaces likely to cause injury."

The corner edges should as far as possible be rounded. This is difficult to do in a nice way when the device is already built, but simple in the design stage.

"1.3.5 Risks related to combined machinery
Where the machinery is intended to carry out several different operations with manual removal of the piece between each operation (combined machinery), it must be designed and constructed in such a way as to enable each element to be used separately without the other elements constituting a risk for exposed persons. For this purpose, it must be possible to start and stop separately any elements that are not protected.

1.3.6 Risks related to variations in operating conditions
Where the machinery performs operations under different conditions of use, it must be designed and constructed in such a way that selection and adjustment of these conditions can be carried out safely and reliably.

1.3.7 Risks related to moving parts
The moving parts of machinery must be designed and constructed in such a way as to prevent risks of contact which could lead to accidents or must, where risks persist, be fitted with guards or protective devices. All necessary steps must be taken to prevent accidental blockage of moving parts involved in the work. In cases where, despite the precautions taken, a blockage is likely to occur, the necessary specific protective devices and tools must, when appropriate, be provided to enable the equipment to be safely unblocked. The instructions and, where possible, a sign on the machinery shall identify these specific protective devices and how they are to be used.

1.3.8. Choice of protection against risks arising from moving parts
Guards or protective devices designed to protect against risks arising from moving parts must be selected on the basis of the type of risk. The following guidelines must be used to help to make the choice.

1.3.8.1 Moving transmission parts
Guards designed to protect persons against the hazards generated by moving transmission parts must be:
— either fixed guards as referred to in section 1.4.2.1, or
— interlocking movable guards as referred to in section 1.4.2.2.
Interlocking movable guards should be used where frequent access is envisaged.

1.3.8.2 Moving parts involved in the process
Guards or protective devices designed to protect persons against the hazards generated by moving parts involved in the process must be:
— either fixed guards as referred to in section 1.4.2.1, or
— interlocking movable guards as referred to in section 1.4.2.2, or
— protective devices as referred to in section 1.4.3, or
— a combination of the above.
However, when certain moving parts directly involved in the process cannot be made completely inaccessible during operation owing to operations requiring operator intervention, such parts must be fitted with:
— fixed guards or interlocking movable guards preventing access to those sections of the parts that are not used in the work, and
— adjustable guards as referred to in section 1.4.2.3 restricting access to those sections of the moving parts where access is necessary.

1.3.9 Risks of uncontrolled movements
When a part of the machinery has been stopped, any drift away from the stopping position, for whatever reason other than action on the control devices, must be prevented or must be such that it does not present a hazard.

1.4 REQUIRED CHARACTERISTICS OF GUARDS AND PROTECTIVE DEVICES

1.4.1. General requirements
Guards and protective devices must:
— be of robust construction,
— be securely held in place,
— not give rise to any additional hazard,
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— not be easy to by-pass or render non-operational,
— be located at an adequate distance from the danger zone,
— cause minimum obstruction to the view of the production process, and
— enable essential work to be carried out on the installation and/or replacement of tools and for maintenance purposes by restricting access exclusively to the area where the work has to be done, if possible without the guard having to be removed or the protective device having to be disabled.
In addition, guards must, where possible, protect against the ejection or falling of materials or objects and against emissions generated by the machinery.

1.4. Special requirements for guards

1.4.2.1. Fixed guards
Fixed guards must be fixed by systems that can be opened or removed only with tools. Their fixing systems must remain attached to the guards or to the machinery when the guards are removed.
Where possible, guards must be incapable of remaining in place without their fixings.

1.4.2.2. Interlocking movable guards
Interlocking movable guards must:
— as far as possible remain attached to the machinery when open,
— be designed and constructed in such a way that they can be adjusted only by means of an intentional action. Interlocking movable guards must be associated with an interlocking device that:
— prevents the start of hazardous machinery functions until they are closed and
— gives a stop command whenever they are no longer closed. Where it is possible for an operator to reach the danger zone before the risk due to the hazardous machinery functions has ceased, movable guards must be associated with a guard locking device in addition to an interlocking device that:
— prevents the start of hazardous machinery functions until the guard is closed and locked, and
— keeps the guard closed and locked until the risk of injury from the hazardous machinery functions has ceased. Interlocking movable guards must be designed in such a way that the absence or failure of one of their components prevents starting or stops the hazardous machinery functions.

1.4.2.3. Adjustable guards restricting access
Adjustable guards restricting access to those areas of the moving parts strictly necessary for the work must be:
— adjustable manually or automatically, depending on the type of work involved, and
— readily adjustable without the use of tools.

1.4.3. Special requirements for protective devices
Protective devices must be designed and incorporated into the control system in such a way that:
— moving parts cannot start up while they are within the operator's reach,
— persons cannot reach moving parts while the parts are moving, and
— the absence or failure of one of their components prevents starting or stops the moving parts.
Protective devices must be adjustable only by means of an intentional action."

This (section 1.2.1-1.2.6, 1.3.3 and 1.3.5-1.4.3) is, in my experience, many times the central part of the risk analysis, as these points concerns things that we are afraid of such as clamping, crushing and amputation injuries. Therefore, these items shall be reviewed with extra thoughtfulness and it is advantageous to analyze them together because each point is part of the same thought:

1. Is a motor, pneumatic cylinder or other source of power so strong that it could cause injury (consider also the case, for example, that the pneumatic pressure is raised: No= OK!
   An electric toothbrush, for example, has a driven motion but the engine is so weak that there are no risks associated with the movement. While a mixer has the potential to injure the user.
   Yes = What is potentially dangerous movements in this device?
2. Under what circumstances could someone be injured by the motion? Brainstorm, but consider also the potential problem sources listed in paragraphs 1.2.1-1.2.6, 1.3.3 and 1.3.5-1.4.3.
3. How severe could the injury be?
4. What is the probability that it will occur?
5. Are there structural measures to take?
6. How difficult/expensive are the measures?
7. How large is the remaining risk?
8. What actions are worthy taking regarding the possible injury and the risk of injury before and after action?
9. Is there a residual risk after the agreed design measures? If yes, ensure that there are adequate warnings on the device and in the manual.

"1.5 RISKS DUE TO OTHER HAZARDS

1.5.1. Electricity supply
Where machinery has an electricity supply, it must be designed, constructed and equipped in such a way that all hazards of an electrical nature are or can be prevented.
The safety objectives set out in Directive 73/23/EEC shall apply to machinery. However, the obligations concerning conformity assessment and the placing on the market and/or putting into service of machinery with regard to electrical hazards are governed solely by this Directive."

Electric shocks are not only uncomfortable, they can also be deadly. Additionally, there are often all sorts electrical connections, et cetera, in an apparatus. On the other hand, electrical safety is an old and well-tested knowledge and there are plenty of safe devices for connections et cetera. But to be on the safe side, it should be ensured that all high voltage connections are made so as to minimize risk of injury even in the event of that a cable comes off, liquid enters, or the casing is damaged and the ground connection for some reason does not work.

"1.5.2 Static electricity
Machinery must be designed and constructed to prevent or limit the build-up of potentially dangerous electrostatic charges and/or be fitted with a discharging system."

This paragraph could be applicable when, for instance, fine dust is transported through a ventilation duct. In there static electricity could develop, which in turn causes an explosion in combination with the dust. Therefore such ducs shall be grounded.

"1.5.3. Energy supply other than electricity
Where machinery is powered by source of energy other than electricity, it must be so designed, constructed and equipped as to avoid all potential risks associated with such sources of energy."

If so, this paragraph shall be included in the risk analysis after paragraph 1.4.3.

"1.5.4 Errors of fitting
Errors likely to be made when fitting or refitting certain parts which could be a source of risk must be made impossible by the design and construction of such parts or, failing this, by information given on the parts themselves and/or their housings. The same information must be given on moving parts and/or their housings where the direction of movement needs to be known in order to avoid a risk.
Where necessary, the instructions must give further information on these risks.
Where a faulty connection can be the source of risk, incorrect connections must be made impossible by design or, failing this, by information given on the elements to be connected and, where appropriate, on the means of connection."

Another question that probably is very sutable for "brainstorming": How could anyone get hurt on the device if he/she mounts removable parts in a wrong way. Do also take into account parts that are not supposed to be removed but where disassembly is possible. This is particularly true for the driven movements in the device. If the analysis shows that there is a risk of injury if something is installed wrongly, this should primarily be avoided through redesign so that the part can not be installed wrong.

The risk that such accidents actually occur is reasonably the highest if it involves technical solutions which the users might be unfamiliar with. Which could be the case with mixers, but probably not traditional chucks on drilling machines.

"1.5.5 Extreme temperatures
Steps must be taken to eliminate any risk of injury arising from contact with or proximity to machinery parts or materials at high or very low temperatures. The necessary steps must also be taken to avoid or protect against the risk of hot or very cold material being ejected."

Is there any part of the device that gets hot? (Or, which is unusual except if there are expanding gases, extremely cold?) One common cause, and important to consider, is the frictional heating caused by mechanical processing. Since then, there is also the risk that the hot material is thrown out with high speed. Thus another reason to, as far as possible, cover spots where mechanical processing is performed.

"1.5.6 Fire
Machinery must be designed and constructed in such a way as to avoid any risk of fire or overheating posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery."

Fires are caused, as well known, by the combination of oxygen + fuel + sufficient heat= fire. Oxygen is almost always present, so if one of the other two ingredients are present one should consider whether the third may occure. If any part of the device is extremely hot: could there be some form of dust clouds, flammable vapors or gases in the environments where the device is used = serious fire hazard, extraordinary measures are required (see explosions below).
And on the contrary, it is used in such environments: are there any circumstances in which it could be hot= serious fire hazard, extraordinary measures are required (see explosions below).
In addition, one should consider the combination: bad electrical connection + high current + plastic housing= fire.

"1.5.7 Explosion
Machinery must be designed and constructed in such a way as to avoid any risk of explosion posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery. Machinery must comply, as far as the risk of explosion due to its use in a potentially explosive atmosphere is concerned, with the provisions of the specific Community Directives."

Is there such risks? See the specific directive.

"1.5.8 Noise
Machinery must be designed and constructed in such a way as to avoid any risk of explosion posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery. Machinery must comply, as far as the risk of explosion due to its use in a potentially explosive atmosphere is concerned, with the provisions of the specific Community Directives."

If the device generates noise, the noise level shall be measured, since the level has to be specified in the manual. If the level is found to be high, there are a number of simple measures to reduce it:

1. The noise level is proportional to the square of the rotational speed, so a relatively small reduction of the rotational speed gives quiet a reduction of the noise level.
2. The noise coming out of an enclosure mainly through openings, thus to seal even small openings in an enclosure can provide significant reductions in noise.
3. Major plate surfacescan function as loud speaker, particularly those that are in contact with rotating parts. Thus, such structures should be avoided by rubber machine shoes, bracing of steel surfaces, sufficient gaps between metal surfaces and rotating machine parts, and more.

"1.5.9 Vibrations
Machinery must be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to the lowest level, taking account of technical progress and the availability of means of reducing vibration, in particular at source. The level of vibration emission may be assessed with reference to comparative emission data for similar machinery."

Will a person be more than temporarily in contact with the device? If not (most common), the vibrations are not a health and safety problem, other than that it creates noise, see in this case in the point above about noise.

"1.5.10 Radiation
Undesirable radiation emissions from the machinery must be eliminated or be reduced to levels that do not have adverse effects on persons. Any functional ionising radiation emissions must be limited to the lowest level which is sufficient for the proper functioning of the machinery during setting, operation and cleaning. Where a risk exists, the necessary protective measures must be taken. Any functional non-ionising radiation emissions during setting, operation and cleaning must be limited to levels that do not have adverse effects on persons."

Is there anything in the device emitting radiation (apart from sound or thermal radiation)? This only applies to specific devices and those who use such sources in their constructions are reasonably well aware of that this is the case. And he should also be well aware of the risks that arise and how they are prevented.

"1.5.11 External radiation
Machinery must be designed and constructed in such a way that external radiation does not interfere with its operation."

Is there a risk that the device used in environments where hazardous radiation occur? Can it then affect the device so that it becomes dangerous? I'm too poorly versed in what it could mean in practice. Interference of electromagnetic fields and/or radio signals (EMC) however is quite a common error source for electronic devices. And anyone who wants to do a rudimentary test can create electromagnetic fields with a powerful transformer on high load, followed by radio signals generated by a cell phone. For real EMC tests is required, however, advanced equipment and special skills provided by special test institutes. Fortunately the electronic devices bought on the market shall be EMC tested by the manufacturer who also shall provide the approval documents. It also requires that, from a health and security point of view, that the operation is not only disturbed by external radiation, but also that the interference causes risks for human injuries. Which to my knowledge is rare. And regarding EMC, I have never been involved in that such tests has caused errors that can lead to injury, not even when it came to motor vehicle electronics.

"1.5.12 Laser radiation
Where laser equipment is used, the following should be taken into account:
— laser equipment on machinery must be designed and constructed in such a way as to prevent any accidental radiation,
— laser equipment on machinery must be protected in such a way that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health,
— optical equipment for the observation or adjustment of laser equipment on machinery must be such that no health risk is created by laser radiation."

Is there a laser? If not, the point is OK. Is there a laser (very rare): Follow the manufacturer's safety instructions.

"1.5.13 Emissions of hazardous materials and substances
Machinery must be designed and constructed in such a way that risks of inhalation, ingestion, contact with the skin, eyes and mucous membranes and penetration through the skin of hazardous materials and substances which it produces can be avoided. Where a hazard cannot be eliminated, the machinery must be so equipped that hazardous materials and substances can be contained, evacuated, precipitated by water spraying, filtered or treated by another equally effective method. Where the process is not totally enclosed during normal operation of the machinery, the devices for containment and/or evacuation must be situated in such a way as to have the maximum effect."

Are there any dangerous substances in the device, such as strong acids or the opposite? If not, the point is OK. Are there (very rare): Follow of the chemical manufacturer's safety instructions.

"1.5.14 Risk of being trapped in a machine
Machinery must be designed, constructed or fitted with a means of preventing a person from being enclosed within it or, if that is impossible, with a means of summoning help."

Is there any possibility to fit inside the device? If not the point is OK. Otherwise, ensure that the device can't be started if someone is inside it and that he always can get out.

"1.5.15 Risk of slipping, tripping or falling
Parts of the machinery where persons are liable to move about or stand must be designed and constructed in such a way as to prevent persons slipping, tripping or falling on or off these parts. Where appropriate, these parts must be fitted with handholds that are fixed relative to the user and that enable them to maintain their stability."

If there are no gangways built into the device (which is the absolutely most common), this point is OK.

"1.5.16 Lightning
Machinery in need of protection against the effects of lightning while being used must be fitted with a system for conducting the resultant electrical charge to earth."

Is the device intended for outdoor use? No = OK!

"1.6 MAINTENANCE

1.6.1. *Machinery maintenance*
Adjustment and maintenance points must be located outside danger zones. It must be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations while machinery is at a standstill. If one or more of the above conditions cannot be satisfied for technical reasons, measures must be taken to ensure that these operations can be carried out safely (see section 1.2.5). In the case of automated machinery and, where necessary, other machinery, a connecting device for mounting diagnostic fault-finding equipment must be provided. Automated machinery components which have to be changed frequently must be capable of being removed and replaced easily and safely. Access to the components must enable these tasks to be carried out with the necessary technical means in accordance with a specified operating method."

The first paragraph is mainly about large machines such as automatic processing stations in the manufacturing industry. These usually have a protective cover around the work zone and the persons operating it shall, as far as possible, not have to go into the work zone to do routine work.

The diagnostic troubleshooting on the equipment discussed in the third paragraph is usually and conveniently in the unit's software, and it is operated via the standard control panel.
Incidentally this point is considered in the analysis described after section 1.4.3.

“1.6.2. Access to operating positions and servicing points
Machinery must be designed and constructed in such a way as to allow access in safety to all areas where intervention is necessary during operation, adjustment and maintenance of the machinery."

No comments.

"1.6.3 Isolation of energy sources
Machinery must be fitted with means to isolate it from all energy sources. Such isolators must be clearly identified. They must be capable of being locked if reconnection could endanger persons. Isolators must also be capable of being locked where an operator is unable, from any of the points to which he has access, to check that the energy is still cut off. In the case of machinery capable of being plugged into an electricity supply, removal of the plug is sufficient, provided that the operator can check from any of the points to which he has access that the plug remains removed. After the energy is cut off, it must be possible to dissipate normally any energy remaining or stored in the circuits of the machinery without risk to persons. As an exception to the requirement laid down in the previous paragraphs, certain circuits may remain connected to their energy sources in order, for example, to hold parts, to protect information, to light interiors, etc. In this case, special steps must be taken to ensure operator safety."

This point is partly about risk when, for example, a repairman turns off the device to repair it and someone who does not know that turns it on again before the repairman is ready. And partly it is about the risk that there are movements with force though the device is turned off, like when a pneumatic cylinder sinks when the air pressure is lost. These risks scenarios should be considered in the analysis described under section 1.4.3.

"1.6.4 Operator intervention
Machinery must be so designed, constructed and equipped that the need for operator intervention is limited. If operator intervention cannot be avoided, it must be possible to carry it out easily and safely."

No comments.

"1.6.5 Cleaning of internal parts
The machinery must be designed and constructed in such a way that it is possible to clean internal parts which have contained dangerous substances or preparations without entering them; any necessary unblocking must also be possible from the outside. If it is impossible to avoid entering the machinery, it must be designed and constructed in such a way as to allow cleaning to take place safely."

No comments.

"1.7 Information

1.7.1 Information and warnings on the machinery
Information and warnings on the machinery should preferably be provided in the form of readily understandable symbols or pictograms. Any written or verbal information and warnings must be expressed in an official Community language or languages, which may be determined in accordance with the Treaty by the Member State in which the machinery is placed on the market and/or put into service and may be accompanied, on request, by versions in any other official Community language or languages understood by the operators."

This is a “typical European Union" point aiming at manufacturers oof products sold in large scale. Single machines constructed for a specific customer in a certain country does only need to have information and warnings in the main language spoken in the country, possibly combined with a suitable standard warning symbols for the dangers.

"1.7.1.1 Information and information devices
The information needed to control machinery must be provided in a form that is unambiguous and easily understood. It must not be excessive to the extent of overloading the operator. Visual display units or any other interactive means of communication between the operator and the machine must be easily understood and easy to use."

It is quite common that control panels and the like are difficult to understand (see the chapter About manuals), which in several respects is an abomination, and in addition, such panels create risks for human injuries. An easy way to, to some extent improve the situation, is to ask a few, on the device inexperienced people, to test it, under the supervision of the programmer.

"1.7.1.2 Warning Devices
Where the health and safety of persons may be endangered by a fault in the operation of unsupervised machinery, the machinery must be equipped in such a way as to give an appropriate acoustic or light signal as a warning. Where machinery is equipped with warning devices these must be unambiguous and easily perceived. The operator must have facilities to check the operation of such warning devices at all times. The requirements of the specific Community Directives concerning colours and safety signals must be complied with."

It can sometimes be difficult to know if a device is broken or not and that can sometimes lead to damage. For example, on a regular smoke alarm you can not see if the battery is running low. So therefore, they starts beeping until the battery is completely empty.

In the manufacturing industries with automated processing stations can be impossible to hear if a machine has stopped working, and it can lead to, for instance, that workpieces are stacked at its intake. To make the staff aware of the error there are often a beacon on the top of each machine. The beacons sends different messages depending on its status for the moment. And hopefully they follow the current directives.

"1.7.2 Warning of residual risks
Where risks remain despite the inherent safe design measures, safeguarding and complementary protective measures adopted, the necessary warnings, including warning devices, must be provided."

Here it is important to ensure that the, in the risk assessment decided, warning devices actually are fastened on the device.

In addition to the above guidelines for risk assessment of machinery/equipment in general, there are additional analysis points for certain types of devices (see extract below from the table of contents in the Machine Directive (2006/42/EC). If the object of the analysis included in the list below, the relevant points shall be analyzed, in the same way as the points in the general section (see above).

2. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR CERTAIN CATEGORIES OF MACHINERY
2.1 FOODSTUFFS MACHINERY AND MACHINERY FOR COSMETICS OR PHARMACEUTICAL PRODUCTS
2.2 PORTABLE HAND-HELD AND/OR HAND-GUIDED MACHINERY
2.3 MACHINERY FOR WORKING WOOD AND MATERIAL WITH SIMILAR PHYSICAL CHARACTERISTICS

3. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO THE MOBILITY OF MACHINERY
3.1 GENERAL
3.2 WORK POSITIONS
3.3 CONTROL SYSTEMS
3.4 PROTECTION AGAINST MECHANICAL HAZARDS
3.5 PROTECTION AGAINST OTHER HAZARDS
3.6 INFORMATION AND INDICATIONS

4. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO LIFTING OPERATIONS
4.1 GENERAL
4.2 REQUIREMENTS FOR MACHINERY WHOSE POWER SOURCE IS OTHER THAN MANUAL EFFORT
4.3 INFORMATION AND MARKINGS
4.4 INSTRUCTIONS

5. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY INTENDED FOR UNDERGROUND WORK
5.1 RISKS DUE TO LACK OF STABILITY
5.2 MOVEMENT
5.3 CONTROL DEVICES
5.4 STOPPING
5.5 FIRE
5.6 EXHAUST EMISSIONS

6. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY PRESENTING PARTICULAR HAZARDS DUE TO THE LIFTING OF PERSONS
6.1 GENERAL
6.2 CONTROL DEVICES
6.3 RISKS TO PERSONS IN OR ON THE CARRIER
6.4 MACHINERY SERVING FIXED LANDINGS
6.5 MARKINGS