

Paper and Board

Industry

Advisory

Committee

.....

Part 6: Making paper safely

Managing safety in the papermaking process



Members of the Paper and Board Industry Advisory Committee

.....

Mr A D Porter	HSE (Chair)
Mr G Beattie	GPMU
Mr M Bonnett	AEEU
Mr C Britchford	Arjo Wiggins Fine Papers Ltd
Mr M Eede	TGWU
Mr C Griffiths	St Regis Paper Co Ltd
Mr A Harvey	AEEU
Mr P Hiatt	GPMU
Mr R A Hudspith	GPMU
Mr T Mellish	TUC (Observer)
Mr P Planet	Bridgewater Paper Co Ltd
Mr T Watts	Paper Federation of Great Britain
Mr K Willis	GMB
Mr M Wilcock	HSE (Secretary)

Members of the PABIAC Working Group

.....

Mr Mike Wilcock	HSE (Chair)
Mr Alan Barber	Fort James UK Ltd
Mr George Dews	SCA Hygiene Products UK Ltd
Mr David Gillett	Paper Federation of Great Britain
Mr R Gipp	Sittingbourne Paper Company
Mr P Hiatt	J R Crompton Ltd
Mr G McSkimming	Inveresk plc
Mr Denis Pimblett	GMBATU
Mr Tony Stratton	Kappa SSK Ltd
Mr Alan Timms	James Cropper plc
Mr P Walmsley	Shotton Paper Company plc
Ms Maureen Kingman	HSE (Secretary)

PABIAC would like to thank the various organisations and individuals who contributed to the development of this publication and provided photographs.

Extracts from British Standards are reproduced with permission of BSI under licence number 2000SK/0497. Complete standards can be obtained by post from BSI Customer Services, 389 Chiswick High Road, London W4 4AL.
Tel: 020 8996 9001.

Paper and Board

Industry

Advisory

Committee

.....

**Part 6: Making
paper safely**

**Managing safety
in the
papermaking
process**

.....

© Crown copyright 2001

First published 2001

Reprinted 2005

Formerly sold as a single item ISBN 0 7176 1907 9.

Now available only as part of the PABIAC binder

ISBN 0 7176 2942 2

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without the prior written permission of the copyright owner.

Applications for reproduction should be made in writing to:
Licensing Division, Her Majesty's Stationery Office,
St Clements House, 2-16 Colegate, Norwich NR3 1BQ
or by e-mail to hmsolicensing@cabinet-office.x.gsi.gov.uk

This is guidance prepared, in consultation with the Health and Safety Executive (HSE), by the Paper and Board Industry Advisory Committee (PABIAC) which was appointed by the Health and Safety Commission as part of its formal advisory structures. The guidance represents what is considered to be good practice by members of the Committee. It has been agreed by the Commission. Following this guidance is not compulsory and you are free to take other action. But if you do follow this guidance, you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

CONTENTS

Preface v

Introduction 1

Section 1: General guidance 4

Principles of machinery guarding 4

Safety-related control systems 10

Safe systems of work 14

Removing broke 16

Fabric changing 18

Web feeding systems 20

Safe access to plant 22

Safe work in confined spaces 27

Housekeeping 30

Section 2: Stock preparation 33

Manual de-wiring 33

Wire balers 35

Conveyors feeding pulpers 36

Pulpers 40

Ragger ropes 43

Section 3: Papermaking machine - wet end 45

Head box 45

The wire 47

Transfer to press section 52

Section 4: Papermaking machine - press and dryer sections 53

Press section 53

Dryer section 56

Sizing and coating units 60

Calenders and supercalenders 62

Yankee cylinders 65

Section 5: Reel-ups 68

Appendix 1: Updated information on design and implementation of safety-related electrical control systems 73

References 85

Further reading 88

Further information 89

.....



.....

PREFACE

WHO IS THIS GUIDANCE FOR?

If you use papermaking machinery, this guidance will help you carry out a risk assessment, compare what you have now with the control measures recommended, and decide what more you need to do. It will also be useful when carrying out workplace inspections.

WHY IS THIS GUIDANCE NEEDED?

It replaces the long-standing *Safety in paper mills*, more commonly known as the 'Fourth Report'. The law, technology and safeguarding philosophy have moved on since the report was first published in 1979 and PABIAC considered the information available on this subject needed updating.

Also, the paper industry has a poor accident performance record which partly stems from a lack of knowledge about standards of safeguarding. This guidance is intended to fill that knowledge gap.

HOW TO USE THIS GUIDANCE

This guidance gives practical advice to users of papermaking machines on how to comply with the law. The 'General guidance' section covers broad topics which apply to all papermaking processes. It includes a part on 'Principles of machinery guarding' which sets out the general requirements on guarding. In the following sections, which deal with hazards on the papermaking machine, appropriate levels of safeguarding are selected from these general requirements. You can also refer to 'Principles of machinery guarding' to help you decide on guarding standards for machines not specifically covered by this guidance.

The 'General guidance' section also covers safe systems of work, together with other general systems-related issues such as safe access and work in confined spaces. These are NOT repeated in detail in the rest of this publication to save space, but reference is made throughout to these general sections to ensure mills remember that achieving a satisfactory standard of risk control is usually a matter of both technological control AND safe systems of work.

WHAT IS NOT COVERED BY THIS GUIDANCE?

It does not include information on ionising radiations, control of fire risks (except in relation to housekeeping), or hazardous substances.¹

.....

STATUS OF THIS GUIDANCE FOR THE SELF-EMPLOYED

Although only the Courts can give an authoritative interpretation of the law, in considering the application of this guidance to persons working under your direction, you should consider the following:

If you have people working under your control and direction who are self-employed for tax and/or NI purposes, they are nevertheless treated as your employees for health and safety purposes. You may therefore need to take appropriate action to protect them. If you are in any doubt about who is responsible for the health and safety of a person working for you this could be clarified and included in the terms of the contract. However, remember, you cannot pass on a legal duty that falls to you under the Health and Safety at Work etc Act 1974 (HSW Act) by means of a contract and you will still retain duties towards others by virtue of section 3 of the HSW Act. If you intend to employ such workers on the basis that you are not responsible for their health and safety, you should seek legal advice before doing so.

MEANING OF TERMS USED IN THIS GUIDANCE

Where you see the word '**must**' in this guidance it means a legal obligation, ie you are breaking the law if you do not comply. Terms such as '**should**' and '**need to consider**' do not indicate a legal obligation, but do indicate good practice. There may be other legally acceptable ways of achieving the same objective. Others terms such as '**you may**', '**you are recommended to**' give general pointers on the way an objective may be met.

When you see the term 'mills' in the context of what is required, for example 'mills have duties to', 'mills should work towards' etc, it refers to employers and other duty holders (including employees) in mills.

INTRODUCTION

WHAT DOES THIS GUIDANCE INCLUDE?

- 1 This guidance includes advice on hazards arising from the papermaking process, not only on guarding but also on matters such as housekeeping, safe access and systems of work.
- 2 The advice on guarding of machinery applies to existing machinery which is not 'CE' marked. New machines² are covered by the Machinery Directive, and a European Standard on papermaking machines BS EN 1034-1: 2000³ will help manufacturers comply with the Directive. (BS EN 1034-3 *Winders and slitters, plying machines* is also available⁴).
- 3 In preparing this guidance PABIAC has tried to follow the European Standard to avoid different levels of protection applying to machines of different ages - in particular certain dimensions have been altered from the original Fourth Report to reflect current standards and practice. However, where well-established UK levels of protection are significantly higher than in the European Standard, we have tried to maintain these. This approach may need to be reviewed in the future.
- 4 In law, mills have duties to ensure the health and safety of their employees and others under the Health and Safety at Work etc Act 1974 (HSW Act sections 2 and 3). They also have certain duties under the Provision and Use of Work Equipment Regulations 1998 (PUWER 98).⁵ However, where the Supply of Machinery (Safety) Regulations 1992 applied to the equipment at the time of supply, the manufacturer or supplier has the primary duty to ensure the machinery is safe and complies with the Essential Health and Safety Requirements (EHSRs). Relevant standards (eg BS EN 1034) will be helpful.

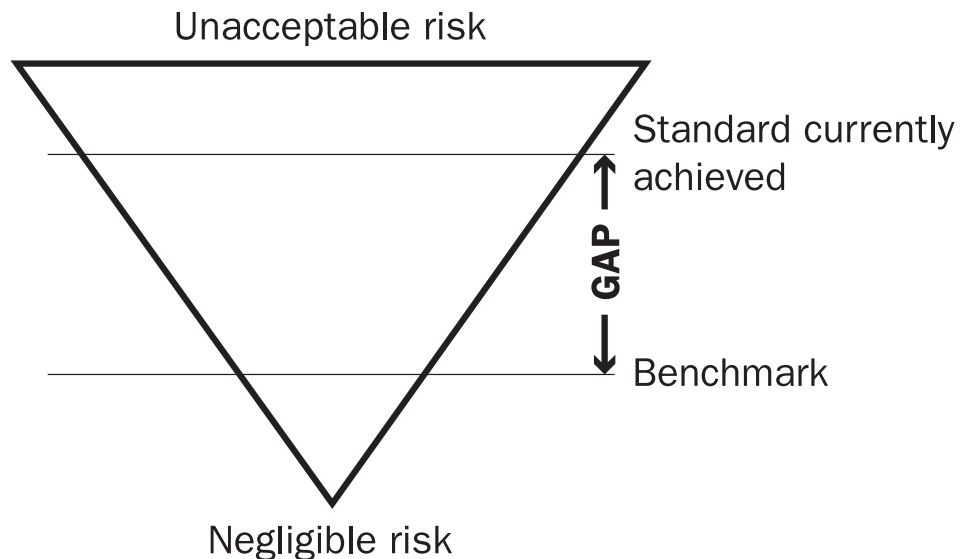
RISK ASSESSMENT

5 This guidance is not intended to be a substitute for your own risk assessment.^{6,7} You will still have to ensure that the levels of safeguarding recommended here deal adequately with the risks arising from your papermaking processes. However, it does provide a benchmark that PABIAC believes all mills **can** achieve and that all mills should work towards achieving by a phased programme of work. To do this mills need to know:

- where they are now;
- where they should be; and
- what is the difference and why.

.....

Figure 1 The 'Risk gap' triangle



6 Mills should close the gap between where they are and where they should be by using the technical standards in this publication and BS EN 1034. They will also need to introduce safe systems of work and operating procedures to effectively control risks. Where mills feel unable to achieve the standards in this document they will have to satisfy themselves using their own risk assessments that they are achieving an equivalent or better standard. Mills should also be aware that the photographs used in this publication are illustrative only, and that, where necessary, they may have to adapt the guarding shown to their own circumstances. The Confederation of Paper Industries has more details of the safeguarding systems shown and others that are currently being developed (see 'Further information' for address and telephone number).

.....

WARNING!

Remember - proper control of risks should involve technical controls AND safe systems of work. These can only be delivered by a company with the right safety culture that really believes health and safety matters. Refer to the machinery-specific sections for guidance on particular safeguarding issues and the general sections for more on safe systems of work.

While PABIAC has tried to include as much as possible in this guidance, it does not cover every hazard and risk on your machine or in your mill. It does not take into account detailed design differences between machines, processes or differences in working methods. Mills should therefore be conscious of different or additional hazards and risks around their factory and take appropriate action to identify and control them.

Also, PABIAC has suggested separation distances throughout this guidance based on normal practice and processes - where necessary taking into account the use of rubberised or coated rolls. There may be circumstances where, for process reasons, mills have used additional clothing on rolls, ie that converts a normally smooth roll into a 'tacky' roll. In these circumstances PABIAC would advise caution with the separation distances in this publication and urge mills to ensure that the guards provided prevent access to these rolls or any in-running nip created at all times they are in motion.

SECTION 1: GENERAL GUIDANCE

PRINCIPLES OF MACHINERY GUARDING

7 Authoritative guidance on principles of safeguarding dangerous parts of machinery is set out in various European Standards which have been adopted as British Standards and supersede former British Standards which dealt with the same subjects. The levels of safeguarding recommended in this guidance take their lead from the European Standards but PABIAC recognises that these standards may not always be practicable on existing papermaking machinery.

Hierarchy of safeguarding measures

8 Safeguarding measures fall into a hierarchy of four levels:

- fixed (enclosing) guards;
- other guards or protection devices, eg interlocking guards, nip guards;
- protection devices, eg trip nip bars which do not prevent access but stop the movement of the dangerous part before injury occurs and preferably before contact is made, use of crawl speed and hold-to-run control devices; and
- provision of information, instruction, training and supervision.

9 Your risk assessment is the starting point for choosing safeguarding measures. Consider each level in turn, making use of the measures as far as practicable. You may need to combine measures from more than one level to reduce the risk. However your preference should always be to adopt the highest level of safeguarding possible.

Fixed (enclosing) guards

10 A guard is 'fixed' if it needs a tool to remove it.

11 Lift-off guards, which have been used on older papermaking machines, are generally of poor design and encourage misuse. **PABIAC now considers that lift-off guards do not provide a suitable standard of protection and if you have these guards you should plan to replace them.**

12 Fixed guards which guard the dangerous parts but which are designed to allow limited access, eg for clearing broke, cleaning etc, are more effective in preventing danger. These guards can have openings in them, eg for feeding the paper, as long as the size of the opening and its distance from the dangerous part complies with the safe reach distances in BS EN 294: 1992⁸

.....

(see 'Distance guards'). If a fixed guard has to be removed more than once a week, for example for maintenance, it is often better to replace it with an interlocked guard (see 'Interlocking guards').

Distance guards

13 The height of the guard, its distance from the danger point (eg an in-running nip), and how far it has to extend to stop someone reaching around it to the danger point, can be worked out from tables in BS EN 294: 1992. If it is not practicable to achieve these reach distances, there is a duty to provide alternative safeguarding (from the safeguarding hierarchy) which achieves an equivalent level of safety.

14 Distance guards should generally be at least 1.4 m high to reduce the likelihood of someone climbing over them. A gap of up to 200 mm can be left underneath the guard to allow for cleaning.

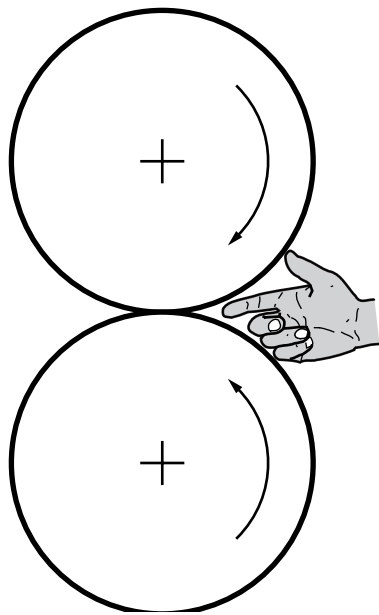
Guarding for transmission machinery

15 Eliminate entanglement hazards on machine drives by enclosing the dangerous parts with fixed guarding. Rotating shafts present a particular risk of entanglement - particularly if they are slotted or have projections, eg bolts or screws for counting devices. Enclosing guards or loose sleeves can be provided which effectively eliminate the risk. If there are projections, then enclosing guards should be provided.

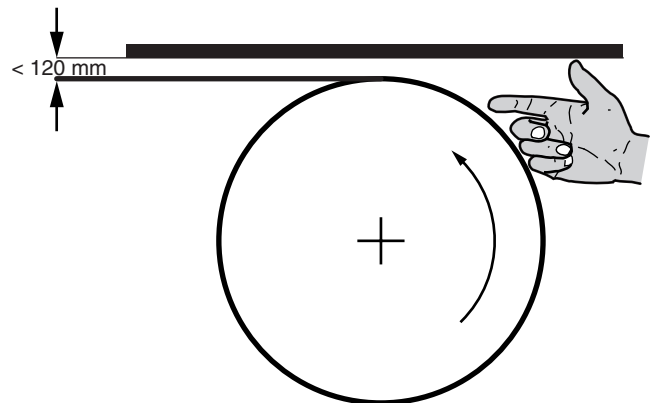
16 It is not acceptable to rely solely on lockable gates at either end of the drive side to guard the transmission machinery of a papermaking machine; experience has found that this type of guarding is impracticable because of the frequent need for access, particularly by maintenance personnel, while the machine is running. If access to moving machinery is required, enclosed guarding for the dangerous parts of each drive should be provided.

Guarding for in-running nips

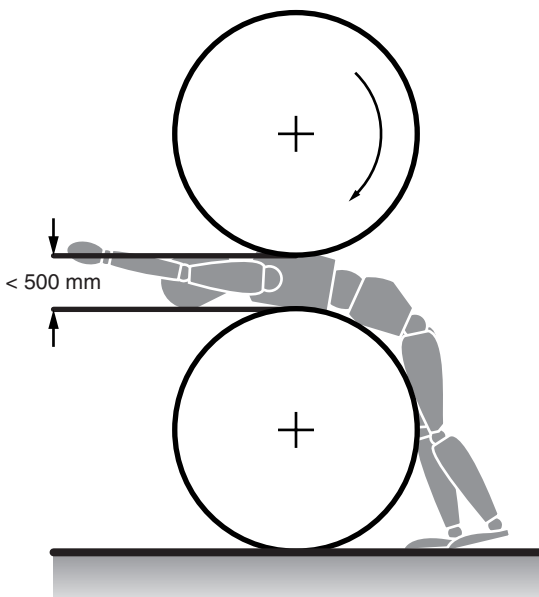
17 In-running nips are the main hazard on a papermaking machine. They arise between rolls rotating in different directions, between rolls and fixed parts, between Sheahan ropes and pulleys and between felts/wires and rolls. There is also a drawing-in hazard between rolls and heavy grades of paper and board where the material is unlikely to tear. This can be designed out by having a large enough gap between the rotating and fixed parts. See Figure 2 for examples of in-running nips.



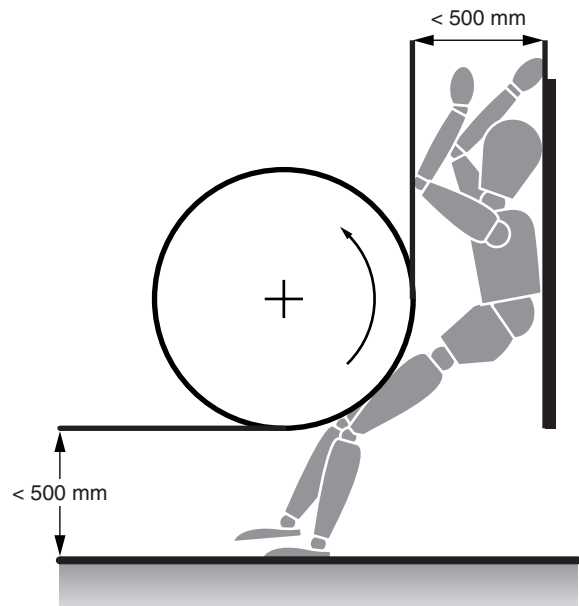
Two counter-rotating rolls



Roll and fixed part



Body reaching between two rolls



Body between roll with felt at right angles and a fixed part

Figure 2 Examples of in-running nips

18 Where an in-running nip between two rolls (such as a drying cylinder and a felt roll), or between a roll and a fixed part, can be reached by an outstretched arm, guarding is unnecessary if the gap at the nip point is at least 120 mm.

However, if the whole body can get close to the in-running nip the gap needs to be at least 500 mm (see Figure 2). Your risk assessment should take into account that certain machinery is designed to open so-called 'protected nips' for operational reasons, creating a different risk and creating an 'unprotected' situation. Where nips cannot be safeguarded in this way, the next best option is to fit a guard directly on the nip.

.....

19 Nips which are only accessible from the sides of the machine can have fixed guards. The guard should extend far enough to prevent someone reaching round it to the nip. BS EN 294: 1992 calls for a reach distance of 850 mm (but see 'Distance guards').

20 Nips which can be reached from passageways, decking, catwalks or gangways through the machine must be guarded across their whole width. Examples of nip bars are shown in Figure 3, but alternatives, such as interlocked gates or fixed guarding, may be equally effective (see 'Distance guards' and 'Interlocked guards'). Round section nip bars are not suitable because they create new in-running nips.

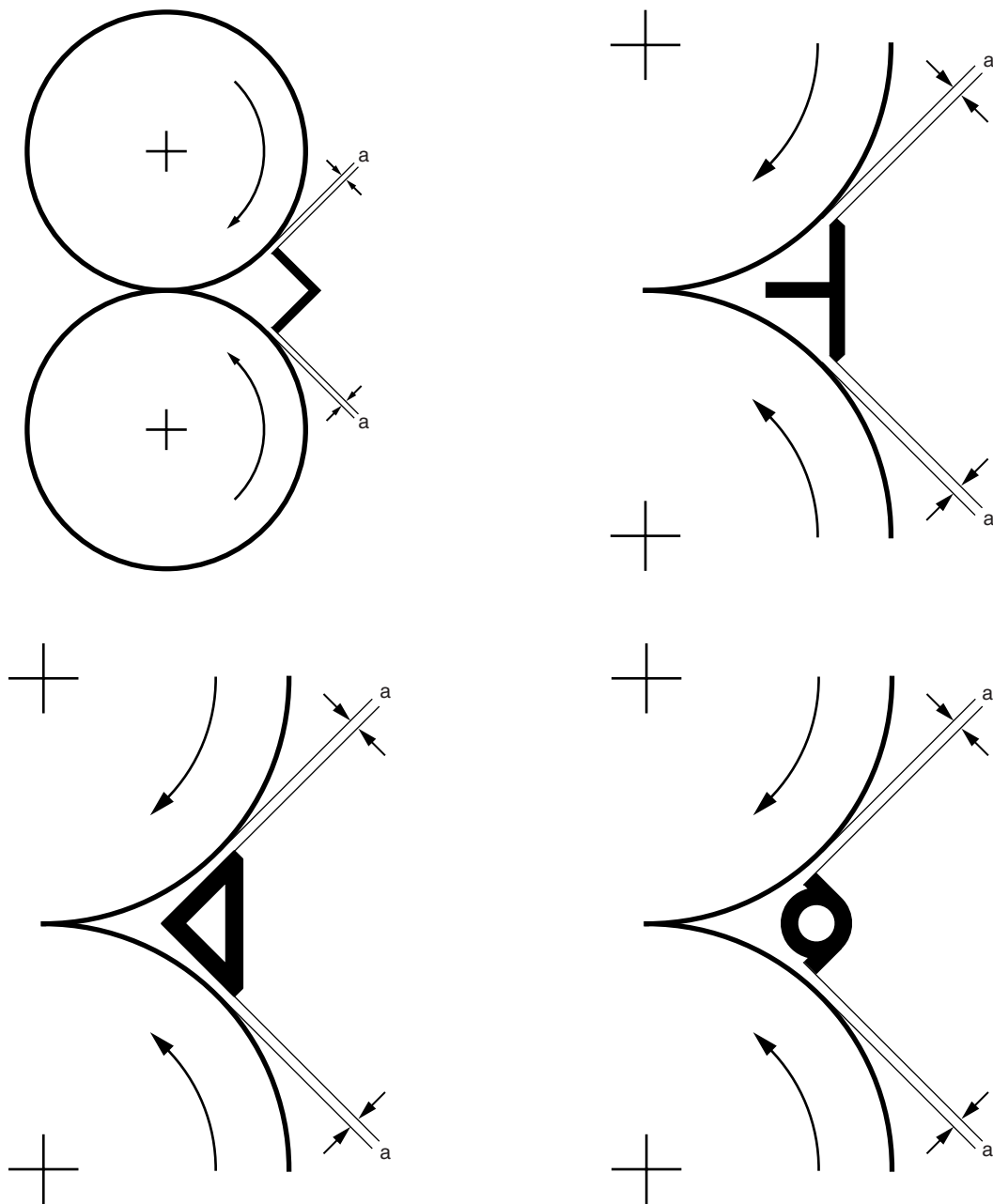


Figure 3 Examples of nip guards
($a \leq 8$ mm)

.....

21 The gap between the nip guard and the rotating machine part should be as small as practicable, at no point be more than 8 mm and allow for deflection under operating conditions.

22 It is not acceptable to leave an accessible nip without appropriate safeguarding. Mills should pay particular attention to providing safeguards for nips in areas away from 'normal' working areas where access is required only infrequently and provide either local safeguards at these nips or prevent access to the areas concerned using fixed or interlocked fencing.

Interlocking guards

23 An interlocking guard has a device - usually a switch - which prevents the hazardous machine parts covered by the guard being started up until the guard is closed. Opening the guard will also stop the machine movement.

24 The higher the risk of injury, the more dependable the interlocking system has to be. Two basic designs of interlocking system are normally used on papermaking machinery:

- a system with a single actuator (switch) on the guard and a single control channel; and
- a system with two independent actuators (switches) on the guard with separate control channels to each so that if one fails, the other will continue to work.

25 The second type is used in higher-risk situations. A trapped key exchange system is also suitable for higher-risk applications. (For very high-risk situations, dual-control channels with cross-monitoring are required for the interlocking system; this is a requirement, for example, on the front face guard of a large reeler slitter.)

26 Interlocking with guard locking is required if, on opening the guard, the dangerous parts take some time to run down. Guard locking ensures that the guard cannot be opened until motion has ceased. As a rough guide, guard locking is necessary if the time taken for the dangerous parts to come to rest is more than 10 seconds.

Crawl speed

27 This is the slowest speed at which the machine can run, and should be no more than 15 m/min. (NB on reeler-slitters the maximum crawl speed should be 10 m/min.)

28 There are some jobs, such as inspection, setting up, removing broke and felt straightening, which cannot always be done with the machine stopped. Operating the machine at crawl speed is only regarded as a risk-reduction

.....

measure as long as it is combined with a safe system of work, instruction and training to reduce the risks to which the workers are exposed.

Hold-to-run control

29 This is an actuator which has to be held depressed to allow the machine to run at no more than crawl speed; if the actuator is released, motion ceases. Running machine sections under hold-to-run control is recommended for removing broke, but must be provided if the machine can be run in reverse. The operator should be able to see the danger points from the position of the hold-to-run control actuator.

Routine maintenance, inspection and testing

30 Various types of safeguarding may be found in paper mills and it is essential that these are maintained in working order and checked to ensure they are still in place and functioning properly. In addition, the Provision and Use of Work Equipment Regulations 1998 (PUWER 98) require any checks carried out in-house to be recorded. Further guidance on PUWER can be found in Part 1 of the PABIAC loose-leaf *Guide to managing health and safety in paper mills*.⁹

.....

SAFETY-RELATED CONTROL SYSTEMS

IMPORTANT NOTE

The information in the following paragraphs 31-47 is superseded and updated by Appendix 1: Updated information on design and implementation of safety-related electrical control systems.

The new Appendix provides a technical framework that can be used by mill engineers for the design and implementation of safety-related electrical control systems that are used to carry out safety functions at papermaking machines. This is drawn from published standards and other sources that take a systematic approach towards the specification, design, installation and operation of safety-related electrical control systems so as to achieve safety performance requirements derived from a risk assessment.

What is a control system?

31 A **control system** responds to input signals from the machine, or from the operator, and generates output signals which make the machine operate in a desired manner. So if, for example, an operator presses a start button, the control system may respond by closing a contactor and energising a motor.

32 A part of a control system is said to be 'safety-related' if it has a role in the safeguarding of the machine, operators and others. So if, for example, an operator opens an interlocked gate, the control system responds by bringing the machine to a stop or by preventing it from being started while the gate is open.

33 The more critical the role played by the safety-related part of the control system, the more resistant to faults it must be. BS EN 954: 1997¹⁰ classifies systems according to their ability to resist the occurrence of faults and whether they will continue to perform their safety function after a fault has occurred. Fault resistance may be achieved by the reliability of the parts and the way the parts are combined in the design of the control system.

Categories of control systems

34 There are five main categories of performance of control systems in accordance with BS EN 954-1 which are broadly:

Category	Basic requirements
B	Use of good engineering principles
1	Use of well-tried components and principles
2	Incorporates a safety function check at machine start-up and may also be checked periodically
3	A single fault will not cause the safety function to fail
4	Two or more faults will not cause the safety function to fail

.....

How to apply BS EN 954-1

35 The categories should only be used as 'benchmarks' of performance. It is important to bear in mind that safety-related parts of control systems may not neatly fit into a single category, particularly if they use different energy sources - a control system can incorporate electric, electronic, programmable electronic, pneumatic or hydraulic devices.

36 The categories should **not** be regarded as hierarchical with regard to safety. For example, a single mechanical link will meet the requirements of Category 1 but not the criteria for Categories 3 and 4, but its level of safety performance may be considered at least as reliable or even more reliable than technologies that meet Categories 2, 3 and 4. Therefore, the selection of categories is a matter of judgement which should be part of a risk assessment.

Steps in a risk assessment process for selecting a category for a control system

37 The following list aims to help you carry out a risk assessment on existing machinery to determine the level of performance you need from safety-related control systems.

- Assess the risks on the machine, taking into account the hazards which occur in normal operation (eg cleaning, clearing broke, webbing up etc) and in foreseeable abnormal conditions (eg persistent misfeeds, machine break-down).
- Select appropriate risk-reduction measures, eg fixed guards, nip bars, interlocked guards, trip devices, photoelectric devices, crawl speed, emergency stops.
- Determine which of the measures for risk reduction will be achieved by a safety-related control system.
- What contribution do the safety-related parts of the control system make as part of the safety function in achieving the necessary level of risk reduction? What would be the consequences of failure?
- How often will demand be placed on the machine's safety functions? For example, the control system for an electro-sensitive safety system on a guillotine is called into use every time the operator puts a hand through the light curtain and so needs to give a higher level of safety performance than a gate interlock system which is only used occasionally and where the result of failure may not be serious.
- Select a category to assess the safety-related parts of the control system against, taking account of the factors above on how to apply BS EN 954-1.

.....

Selecting a category for safety-related parts of a control system at a refurbished machine

38 If the work is being done by in-house personnel, follow the steps in a risk assessment process as set out above.

39 There are also a number of questions which the designer needs to address.

- What is the rationale for the design, ie what levels of risk are assumed, and what are the design objectives?
- What assumptions have been made about the way the machine will be used, cleaned, set up etc?
- How and why does the system meet the design objectives?

Guidance on performance categories of safety-related parts of control systems used on papermaking machines

40 The following paragraphs deal with examples of control systems which implement safety functions and will comprise safety-related parts: emergency stop, pre-start warning device, overspeed control and protection, interlocking and guard-locking systems, control system to infrared dryers, temperature and pressure control systems and prevention of unexpected start-up. They describe the minimum requirements for the safety function in terms of system behaviour and the principles by which an acceptable level of safety performance can be achieved.

Emergency stop

41 The emergency stop function should be designed in accordance with BS EN 60204-1: 1998 *Safety of machinery. Electrical equipment of machines Part 1: General requirements* and BS EN 418: 1992 *Safety of machinery. Emergency stop equipment, functional aspects. Principles for design*. See Appendix 1 for more information.

42 Those parts of the pneumatic and hydraulic system used in the emergency stop function may be allocated as Category 1.

43 An emergency stop circuit can remain inactive for long periods of time and it is important that, when required, it functions effectively to avert danger. The best advice is to design the system with simplicity and reliability in mind rather than with redundancy and monitoring.

Pneumatic and hydraulic systems

44 The safety-related parts of the control systems for pneumatic and hydraulic systems may be to Category 1. This would apply, for example, to the control systems for raising and lowering suspension type dryers.

Speed control system

45 The risks that occur in the event of overspeed at a machine arising from control system failure are significant. See Appendix 1 for updated information.

.....

.....

Pre-start warning device

46 Failure of a pre-start warning device could result in the machine being started before the waiting time has elapsed (ie people would not have enough time to leave a hazardous area on hearing the alarm) or the machine could be started up without a warning being sounded.

47 The timing functions should be monitored during the start-up sequence when the machine is energised to ensure that failures which give rise to danger are detected and the starting sequence is disabled. See Appendix 1 for updated information.

.....

SAFE SYSTEMS OF WORK

48 Safe systems of work are formal procedures or methods of working. They are needed when guarding of dangerous parts cannot eliminate all of the hazards and some element of risk remains. **Safe systems of work should not be used as a substitute for guarding.** (See also Parts 1 and 2 of the loose-leaf PABIAC Guide.^{7, 9})

49 Before a safe system of work can be drawn up, you have to examine the task to identify all of the hazards. You need to take account of:

- *What* is used, eg the plant and substances, what mechanical things can go wrong, what the consequences of failure might be, toxic hazards, electrical hazards, design limits.
- *Who* does what, eg delegation, whether contractors might be involved,¹³ training, foreseeable human errors, short cuts, need for co-operation and co-ordination of others, ability to cope in an emergency.
- *Where* the task is carried out, eg in a confined space,^{14, 15} at height, in hot and humid conditions,¹⁶ in close proximity to people doing other work, such as contractors.
- *How* the task is done, eg whether under pressure of time, whether regular or infrequent, the consequences of failing to follow the procedures.

50 It is important that the people who will be doing the work and those who supervise the work, are involved in drawing up systems of work; they have practical knowledge of unusual risks and help to avoid systems of work which are based on false assumptions about the job.

51 Systems of work commonly fail for one or more of the following reasons:

- the system is irrelevant or impractical - it was drawn up as a paperwork exercise, without consultation, by someone who will not be involved in managing or using the system;
- failure of communication - the system is introduced without people being trained in it or having it explained to them;
- failure of supervision - those in charge are not familiar with the system or they do not enforce it;
- following the system takes too long - if the time and effort involved is out of proportion to the time the job would take, people working under pressure are strongly tempted to take the easier and quicker option of a short cut.

.....

52 You need to monitor a system of work to make sure that employees (particularly new ones) and contractors are familiar with it, that they still find the system workable, that it is actually being followed, and that nothing has changed which would require it to be amended. It is recommended that systems of work are specifically covered by site inspections or management audits.

.....

REMOVING BROKE

53 Removing broke accounts for a significant number of accidents every year. (Broke includes 'wads', also known as 'plug-ups', and 'wraparounds'.) Operators get injured, for example, when broke hooks they are holding get taken into in-running nips, they are hit by a falling 'slab' of broke while trying to direct it from the reel into the under-machine pulper, or they try to reach into a nip to remove broke or pulp.

Hazards

- Trapping or entanglement in moving machinery.
- Musculoskeletal injuries due to pulling heavy loads of broke from the machine.
- Being struck by tools used to remove broke while a machine is moving.
- Ignition from static electricity discharges.

Action

54 The safety of those involved in broke removal relies on training and strictly following safe systems of work. The following are some of the issues which you need to consider in deciding whether your systems of work are adequate.

- Unless the machine is designed to permit broke to be removed safely while it is running or automatic systems have been fitted, you should only remove broke from the machine when it is stopped.
- In principle all rolls on a machine should be capable of being stopped and this should be the aim if any close access is required.
- When the machine is stopped, you can use suitable tools such as a broke hook, air knife, or similar to reach into the machine from the side to completely avoid the need for entry.
- If you have to enter a machine section, isolate and lock-off that section and the sections either side of it. (See section on isolation in *The application of the Provision and Use of Work Equipment Regulations to the paper and board industry*⁹ in the loose-leaf PABIAC Guide for guidance on disconnection of control systems for short-term interventions.)
- Only if the machine cannot be stopped and/or automatic cleaning equipment cannot be fitted should cleaning take place on moving rolls. If a roll or cylinder has to be rotated to remove broke this should either be with the machine running at crawl speed (ie no more than 15 m/min) or preferably under hold-to-run control. The hold-to-run control should be sited in a place where the operator can see the danger zone. Movement should stop as soon as the control is released. At all other times access should be prevented by local fixed or interlocked guarding.

-
- In all cases where access is proposed to moving machinery, a thorough and effective risk assessment should have been carried out and the outcome recorded. All **additional** measures that are required to further reduce the risks, such as those arising from manual handling, static or tools being dropped, should be identified, set out in operating instructions and implemented.
 - If the machine section can be reversed, this should only be possible under hold-to-run control.
 - Do not unwind broke paper from a reel which is suspended from a crane. Cranes are not designed to withstand dynamic loads.
 - Removing broke from under low felts/fabrics in basements or at high level can be extremely hazardous due to the design of the machine. Mills should be aware of the need to provide safe means of access and carry out effective risk assessments taking into account the confined nature of some working areas. In no circumstances is it acceptable for operators to crawl into confined parts of machinery unless the machine is stationary, has been properly isolated and an effective safe system of work is in place, that includes consideration of the precautions needed for entry into confined spaces where necessary (see 'Safe work in confined spaces' in this section for more information).

FABRIC CHANGING

Hazards

- Entanglement in moving machinery.
- Entanglement in the fabric or other material being removed or fitted.
- Falling from a height.
- Being struck by tools or materials falling from above.
- Musculoskeletal injury due to handling large, awkward or heavy materials or equipment.
- Hot and humid conditions.
- Failure of lifting equipment used.
- Cuts from sharp tools used to seam or trim fabrics.
- Failure of communications between team members.
- Slippery or wet conditions.

Action

- Fabric changing should be carried out under the control of an experienced, competent person. A thorough risk assessment should be carried out and a written safe system of work developed as a result. The system of work should consider all aspects of the work including how to deal with stress and exhaustion and shift changeovers - particularly the problems associated with communication.
- Fabric changing should only take place on a stationary, isolated machine. However, if absolutely necessary for the fabric changing process, the machine should only be allowed to move under strictly controlled conditions that should be defined within the system of work, and even then under slow crawl or, preferably, hold-to-run control.
- Whenever a machine is moving, all operators involved must be in line of sight of the person operating the controls or an effective system of signals should be used to maintain communications.
- All lifting equipment should be maintained and examined in accordance with the Lifting Operations and Lifting Equipment Regulations 1998.¹⁷ If jacks or winches are used it is preferable that these are purpose-built or designed into the machine and are fit for the purpose intended. If rolls need to be suspended for any length of time then additional supports in the form of stands or blocks should be inserted.

-
- Suitable means of support should be provided for felts and wires as they are unrolled ready to be put into place.
 - Appropriate precautions should be taken to prevent cylinders rotating freely while being worked on.
 - Safe means of access should be provided to every place operators are required to work - where necessary, temporary access platforms should be built. Only if absolutely necessary should work be carried out from ladders and then additional fall arrestor devices ('safety or full-body harnesses' with a maximum fall of 2 m and shock absorbing devices) should be used. If fall arrestor devices are used, mills should ensure that they cannot snag on parts of the machine frame or other equipment.
 - Only those sections of walkways and handrails necessary to allow access for the fabric replacement shall be removed. Where openings have to be left unattended then appropriate temporary barriers and signs should be erected. All handrails and walkways should be replaced after work is completed and before normal operations recommence. Walkways and floors should also be checked for tools, materials or spillages.
 - Where manual handling is unavoidable,¹⁸ those involved should be properly trained to lift safely. See guidance on manual handling in the loose leaf PABIAC guide.¹⁹ See also the section on housekeeping in this booklet and the PABIAC publication on heat stress.¹⁶

55 For information about rope changing see 'Dryer section'.

-
- Manual feeding using tail carrying devices or air knives to keep hands away from in-running nips. This should only be done by fully trained, experienced operators at the slowest practicable machine speed. The aim should be to eliminate hand feeding throughout the industry.
 - Hand feeding - but not directly into roll-nips or where access to roll-nips is possible. Hand feeding into machine roll-nips is dangerous and should be eliminated. Where hand feeding is unavoidable, this should only be done by fully trained, experienced operators at the slowest practicable machine speed.

Stress caused by web feeding

57 Webbing up a machine can be one of the most stressful jobs in a mill. Operators feel under perceived pressure to 'get the machine away' which increases as misfeeds continue. Accidents at this time are probably more likely than at any other. Also, if it has taken a long time to get the sheet through the machine, there is pressure not to stop it for short-term interventions, such as removing broke. Operators can take chances rather than risk having to go through the feeding process again.

58 If the culture of the mill is perceived to be 'production first' then it will be demonstrated in the practices used (or condoned) during webbing-up and in the risks taken to avoid stopping a machine. Set out your policy in this area. Make it clear in both words and actions.

59 Some mills have recognised the pressures from persistent misfeeding and have empowered supervisors to give the crew a break. In other mills, relief operators from other machines are brought in to take over.

'Operators confronted by abnormal situations will be guided not just by instructions but by what they understand are the real risks and by the attitudes of supervisors or managers. In this, nothing is so pervasive or damaging, particularly if a complex or unusual situation arises, as a culture in which a 'macho' attitude to safety has been implicitly encouraged or if departures from safe practice are winked at. Most people wish to 'get on with it'. Few wish to appear timid or to refer to possibilities of danger that are not clear or visible. If these natural attitudes are not to dominate at critical times, positive steps to encourage the attitude of 'stop and think' and the asking of 'what if . . . ?' questions must be an inherent part of training objectives and of what management say and do.'

.....

SAFE ACCESS TO PLANT

60 Safe access should be provided to all places where people are expected to work. This guidance follows BS EN 1034: Part 1 and sets out recommended requirements but, where necessary or practicable, mills may need to go further to provide safe access. In particular, mills should examine where access is required on a regular basis and consider the means of access in conjunction with the job(s) operators are expected to undertake.

Hazards

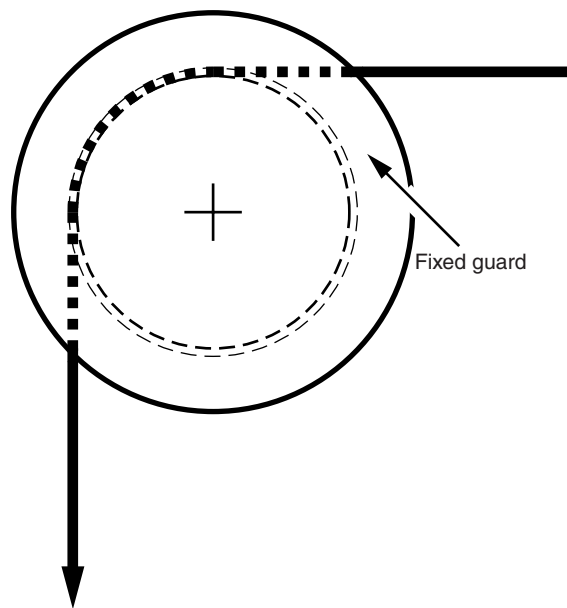
- Slips, trips and falls.
- Complete absence of proper walkways to places where people are expected to work.
- Excessive physical effort needed, eg to climb a series of ladders.
- Falling materials or objects.
- Hazards generated by the machine, such as entanglement on adjacent machinery, hot surfaces and a hot, humid environment.

Action ***Selection of means of access in order of preference:***

- Access directly from floor level is preferred whenever possible. It is especially important that frequently operated controls can be reached from ground level.
- If this is not possible or practicable, a stairway as illustrated in Figure 5 may be used. A stairway should be regarded as the norm for reaching elevated plant.
- If a stairway is not possible, a stepladder as illustrated in Figure 6 or, as a lesser alternative, a ladder as illustrated in Figure 7 may be considered. The selection should be made on the basis of risk assessment, which will include an assessment of ergonomics. One or more of the following conditions will need to be satisfied to justify the use of a stepladder or ladder in preference to a stairway:
 - short vertical distance;
 - the means of access will be used infrequently;
 - the user will not be carrying large tools or equipment when using the means of access;
 - only one user at a time is likely to use the means of access;
 - the structure of the machine does not make stairs possible.

WEB FEEDING SYSTEMS

Figure 4 Inadequately guarded Sheahan rope pulleys have been responsible for many accidents



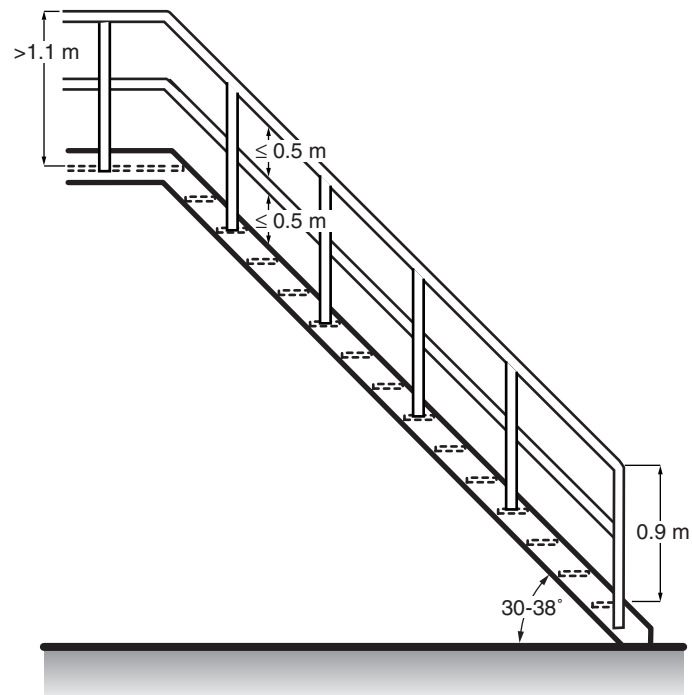
Hazards

- In-running nips between ropes and pulleys of Sheahan rope system.
- Hand-feeding into machine roll nips.
- Hand-feeding into reel-ups.
- Pressure to take short cuts.
- Fire from friction on broke build-up around nip bars.

Action 56 The following web-feeding methods are listed in order of preference, with the safest first:

- Automatic web feeding systems which remove the need for any manual intervention, eg air chutes to Sheahan rope systems, tail conveyors, turn-up devices etc. Automatic feeding is now common and should be the goal for the whole industry.
- Sheahan rope systems with manual tail feeding.
- Manual feeding into Sheahan rope nips should be at the slowest practicable machine speed. Identify the places on the Sheahan rope system, eg at the beginning of a dryer section, where manual tail feeding is permitted. (Accidents tend to happen when misfeeds keep happening and operators, usually through frustration, try to re-feed the tail from the break-point.) Where access for feeding the tail is not essential, guard the intake between the rope and pulley - for example see Figure 4.

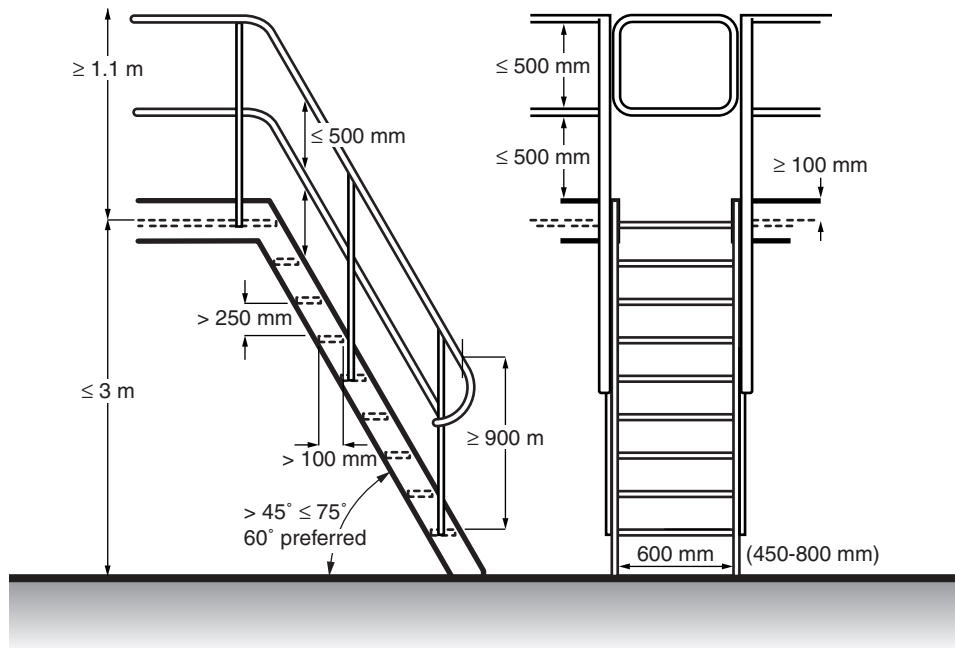
Figure 5 The main recommended requirements for a stairway access



Stairways

- In addition to the requirements in Figure 5, the climbing height of individual flights should not exceed 3 m without a landing. An exception is permitted in the case of a single flight only, which may have a climbing height of not more than 4 m.
- Where the height of possible fall is more than 500 mm, the stairway should have a handrail and intermediate rail.
- If a headroom of 2.3 m cannot be achieved along the whole length of the stairway, fit padding to the protruding objects and provide warning signs - remember to provide guarding to prevent entanglement if necessary.
- The width of the stairway should be increased to 1 m if several people will usually cross on the stairs.
- Stairways and handrails are not designed as lifting equipment! Do not allow them to be used for slinging or as anchor points for lifting equipment.
- Where stairways give access to a working area and operators are liable to fall down the stairs, then mills have found, through experience, that a spring-loaded barrier that drops into place at the top of the stairs can be very effective to prevent falls.

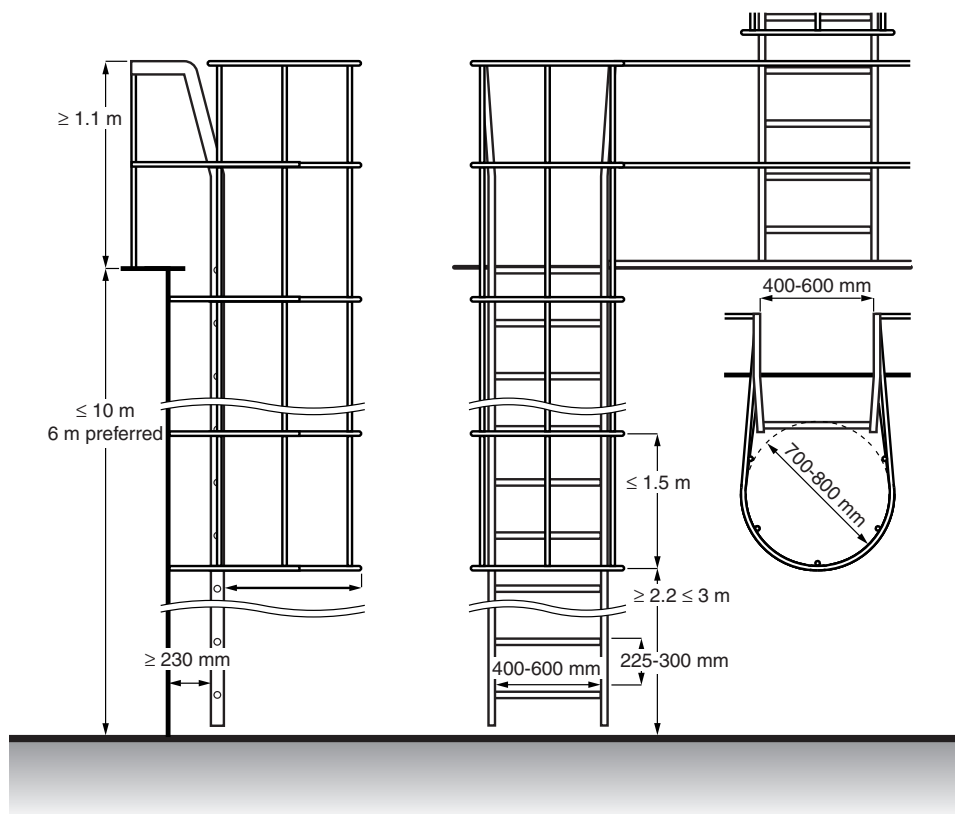
Figure 6 The main recommended requirements for stepladder access



Stepladders

- In addition to the requirements in Figure 6 where the height of possible fall is more than 500 mm, handrails and intermediate rails shall be provided on both sides. On the same flight, the riser height should be constant. If unavoidable, the riser height of the first step may be reduced by up to 15%.

Figure 7 The main recommended requirements for ladder access



.....

Ladders

- In addition to the requirements in Figure 7, the spacing between the floor level and the first rung shall be the same as the spacing between the rungs.
- The top rung should be at the same level as the walking level in the arrival area. If the gap between the walking level and the ladder is more than 200 mm, the floor should be extended to reduce it. There should be a minimum of 230 mm behind each rung to allow room for the foot and provide a firm foothold.
- A safety cage (hoops) or other type of anti-fall device should be provided where the height of the ladder is more than 3 m. At the arrival area, the safety cage should extend up to the height of the guard-rail on the platform served by the ladder (ie 1.1 m above the platform level).
- The length of intermediate platforms between two flights of the ladder should be at least 700 mm.
- The opening at the arrival area should be provided with an inward-opening, self-closing gate. The gate should have a handrail at 1.1 m and intermediate rail.

Work platforms and walkways

- The headroom over platforms and walkways should be 2.1 m.
- As a guide, platforms and walkways should be at least 600 mm wide and preferably 800 mm wide. However, the width and clear length should be determined by such factors as the need for unrestricted work-movements when using tools, the number of operators likely to be on the walkway or platform at the same time, the frequency and duration of the tasks undertaken, people passing each other etc.
- Where you could fall 500 mm from a platform or walkway, provide handrails at a minimum height of 1.1 m above the platform with an intermediate rail and toe board. The maximum gap between the handrail and intermediate rail, and between the intermediate rail and toe board, should be 500 mm.
- Do not allow handrails or intermediate rails to be used as a means of access to a higher level.
- Securely fasten open-grid flooring to the framework.
- If a section of flooring in a working platform or walkway has to be removed, for example, when changing a felt, erect temporary protection around the opening and put up a warning notice. Make sure that there is a system of work for replacing the flooring when the job is completed and that the person(s) responsible knows that it is their job to do it.

-
- If temporary access platforms are required, ie for non-routine maintenance work, then a competent access contractor should be used to provide scaffolding or supply a mobile elevating work platform ('Cherry Picker').

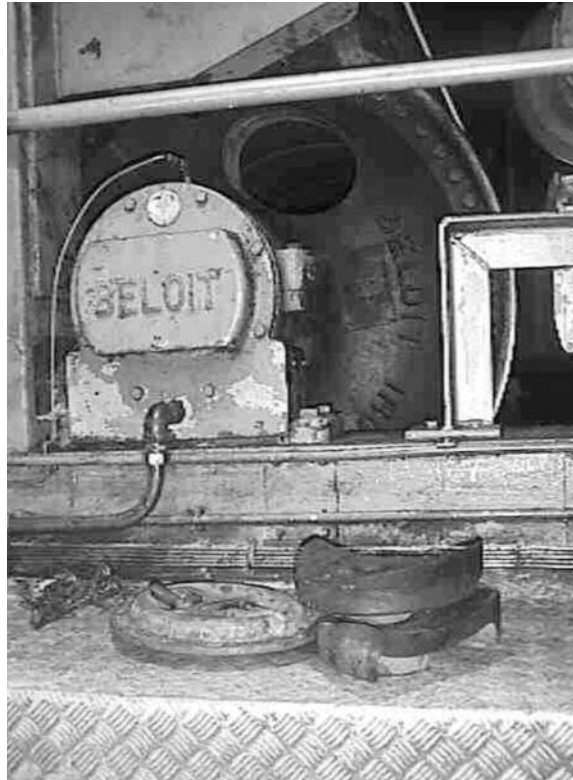
Hot surfaces and humidity

61 Further guidance on working in a hot environment can be found in the PABIAC guidance *Prevention of heat stress in paper and board mills*.

SAFE WORK IN CONFINED SPACES

Figure 8 Drying cylinder with access hatch open.

The legal definition of 'confined spaces' includes places where hot conditions may lead to a dangerous increase in body temperature.



Hazards

- Lack of oxygen (eg arising from rust forming in tanks when unused for a time).
- Entry of poisonous gas, fume or vapour from connecting pipes.
- Water, stock or other liquid suddenly filling the vessel.
- Hot and humid conditions leading to a dangerous increase in body temperature and heat stress.
- Fume and gas from welding carried out inside the confined space.
- Vapours/gases/fumes, eg from coating or cleaning process.
- Access and egress from restricted openings - particularly in an emergency.
- Mechanical hazards from plant unexpectedly starting up.

Action

- Identify the plant in your mill which falls within the definition in the Confined Spaces Regulations 1997.¹⁴ This will include, not only plant with limited openings, such as drying cylinders, head boxes and closed-top pulpers, but also open-topped vessels where, for example, there is a risk of drowning from the failure to isolate the infeed of liquid.

-
- Decide which tasks can only be done by someone going in to the confined space. (Remember that the Regulations prohibit entry to a confined space if it is reasonably practicable for the work to be done by other means. For example, could remote-controlled cameras be used for inspection?)
 - Identify and assess all the risks, as well as the specific risks which bring the confined space within the Regulations - these may be mechanical, electrical and other risks, such as falls from height. Do not forget to identify situations that could involve a risk of heat stress - further specific information and guidance on this problem can be found in the PABIAC guidance *Prevention of heat stress in paper and board mills*.
 - Use a safe system of work for entry to confined spaces and support this with a permit-to-work to ensure that safeguards to deal with the risks are in place before the work can start.
 - Emergency arrangements for getting someone out of the confined space must be in place before work begins. Rescuers will need to be trained in procedures and the use of rescue equipment. They will also need to take part in regular emergency exercises to test the arrangements.

Consider the following points when drawing up a permit-to-work system/safe system of work for entry into confined spaces:

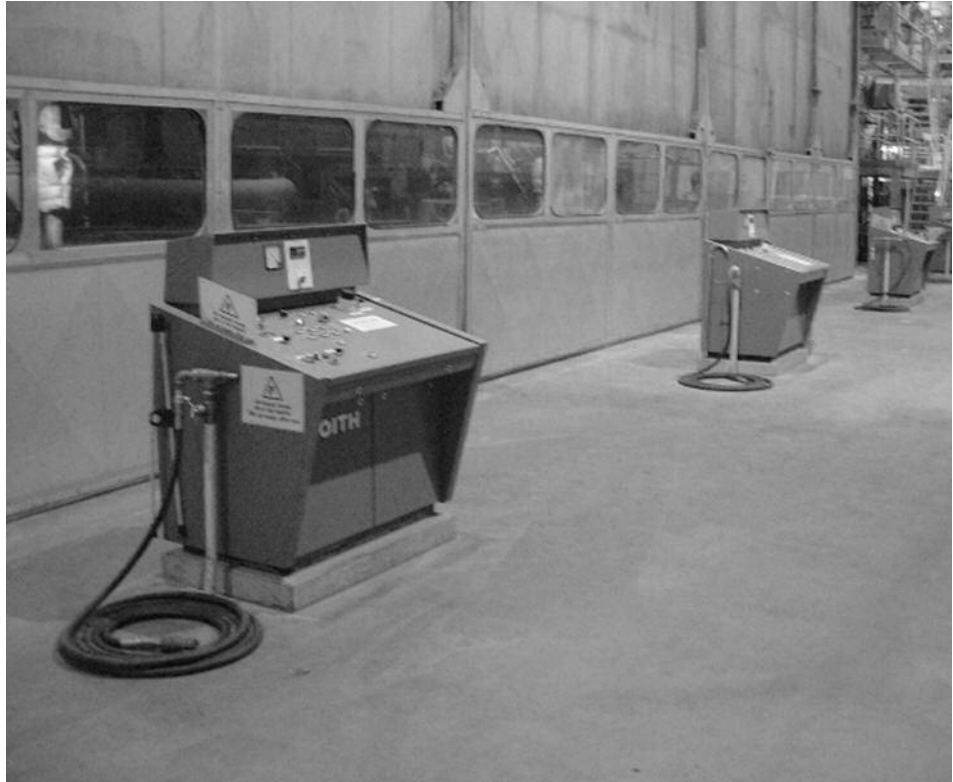
(See also the section on 'Safe systems of work' in 'General guidance'.)

- Appoint a competent person to take control and be in charge. Set out their responsibilities so that they know exactly what they have to do. State the precautions that have to be taken before the work starts, and how often and at what stages they have to carry out checks. Decide the level of supervision required.
- Not just anyone can go into a confined space - you have to consider their age, size, fitness and general medical condition. You should train them and provide an annual medical examination.
- Establish what isolations are needed before entry. Remember that all sources of energy - not just electrical sources - and infeed of liquids etc need to be isolated.
- Where people entering the confined space may be exposed to heat stress, the system of work should also set out the length of time a person may remain inside and the frequency of rest periods. This will depend on the amount of physical effort involved in the work.
- In the case of entry to drying cylinders, establish the means for securing the cylinders to prevent them turning under their own inertia with someone inside.

-
- Decide the procedure for testing the air.
 - Consider whether any risks will arise from the work being done, eg fumes from welding.
 - Decide whether ventilation should be improved, eg by opening other access doors or providing mechanical ventilation.
 - Electrical lighting and tools inside metal tanks and cylinders need to be extra-low voltage (typically 25 V). Consider the use of air tools instead.
 - Decide how communications will be maintained between people inside the confined space and those outside, especially in an emergency.
 - Remember that you will need to ensure that contractors follow your safe systems of work!

HOUSEKEEPING

Figure 9 What your mill should look like



Remember that slips, trips and falls account for a third of all accidents in paper mills and represent a huge personal and financial cost.

Hazards Slips, trips and falls due to:

- Inadequate cleaning.
- Hose reels/trailing cables.
- Poorly maintained floors and stairways.
- Wet floors - particularly in combination with paper dust and chemicals.
- Spillage of chemicals, eg oil, starch, retention agents.
- Fire from the accumulation of dust and debris, especially tissue dust.

Action **Housekeeping policy^{20, 21}**

Remember that cleaning operations can expose operators to other risks, for example those associated with safe access and moving machinery - refer to the relevant sections of this guidance for additional advice. Cleaning on a machine should be carried out with the machine stationary and isolated unless access to dangerous parts is prevented.

-
- Draw up a housekeeping policy. Good housekeeping depends on clear standards and a commitment to maintain those standards at all levels, from boardroom to shop floor. The policy should set out the standards you want to achieve on housekeeping and how you intend to achieve them. Most importantly, it should allocate resources. The policy should also state who is responsible for managing housekeeping, for day-to-day housekeeping activities, for inspection and maintenance of floors, for actioning reports of defects etc.
 - The housekeeping policy should not conflict with the environmental policy, eg on clearing oil spillages.
 - Make sure that contractors follow your policy or get them to take their own rubbish away!

Cleaning

- You have to have a regular regime to keep on top of cleaning. The frequency of cleaning will depend on the product being made and the amount of dust produced. It is also helpful to prioritise areas and activities which you know from previous accidents or from risk assessment will need to be cleaned more often. These will include machine hoods, ductwork, ledges on buildings etc.
- Clarify responsibilities to ensure that cleaning regimes are maintained. For example make individuals or teams responsible for checking that designated areas are clean before shift changeovers.
- Vacuum cleaning is the best method for cleaning dust, especially tissue dust - air lines just disperse the dust. Air lines may be used after vacuum cleaning to remove coagulated deposits. Fit proprietary trigger-controlled blow guns with safety nozzles to air lines - these reduce the risk of eye injury from particles blown into the atmosphere and the dangers from close skin contact - however mills should remember to consider the provision of eye protection against any dust that may be blown into the air.
- Site air and water hoses close to where they need to be used to avoid long lengths of pipe.
- Keep hoses coiled or off the floor when not in use - preferably fit automatic retraction systems.
- Overalls and clothes should not be cleaned with an air line. Serious injuries, sometimes fatal, have been caused when an airline has been pointed towards the anus, even at some distance. More commonly, eye injuries result from dust and debris on the clothes being blown at high velocity.²²

-
- Give careful consideration to safe access requirements, particularly building ledges and suspended services at high level. A mobile elevating working platform is often the most practical solution.

Those mills which have made a commitment to the reduction of slips, trips and falls have seen the benefits of their efforts in fewer accidents and reduced costs. Managers achieved results by showing commitment in their actions - by making sure that employees and supervisors understood the importance they attached to the prevention of slips and trips and by not condoning bad housekeeping.

Supervisors, in particular, were recognised as having a key role. It is they who have to juggle the day-to-day demands on their staff, and standards tend to suffer without a clear steer on where housekeeping falls in the list of priorities. Supervisors were 'empowered' to use their resources on housekeeping and agreed with management on what they could realistically deliver.

Crucially, managers showed that they were prepared to take prompt action on hazard reports from employees and this, in turn, encouraged better reporting.

Maintenance and cleaning of floors

- Check floors for loose finishes, holes and cracks etc, and deal with defects promptly. Provide adequate drainage to prevent standing water and growth of slime.
- Mark out through-routes which take people away from slippery areas.
- Warn of changes in floor-level, particularly at the beginning of a ramp, eg by painting a hatched area on the floor, and make sure the area is clearly lit.²³
- The cleaning regime has to be right for the floor surface - incorrect cleaning techniques can reduce the slip-resistance of the floor.
- Cleaning methods will also differ according to what has been spilled - make sure operatives are properly trained in the right method. For example, cleaning a spillage of starch with water will make the slipping hazard worse - spillages of starch should be contained and cleaned up by dry sweeping. Oil collecting in basements can be vacuumed out before using absorbent material.
- If in doubt, consult a reputable flooring or cleaning product manufacturer for the cleaning method most suitable for the floor and type of contamination expected.

SECTION 2: STOCK PREPARATION

MANUAL DE-WIRING

Figure 10 Pneumatic cutters are easier to use than manual cutters



Hazards

- Wire whipping when cut and causing severe injuries to face, hands and arms.
- Musculoskeletal injuries from repetitive movements during cutting or twisting to remove wire.
- Cuts, puncture wounds from discarded baling wire.
- Tripping on loose wire.
- Vehicle movements in bale delivery area.
- Bales falling.

Action

- Provide full-face visors, preferably with chin guards to prevent wire whipping underneath, and gauntlets (or gloves with additional forearm protection) for cutting wires around bales of waste or pulp.²⁴ Gloves are not adequate by themselves.
- Train operators in the correct sequence for cutting wires to reduce the risk of wire whip.

-
- If possible, mark out a danger zone in which wire cutting can be confined. Keep untrained, unprotected people away from the danger zone.
 - If the wires are removed put them in a bin or wire baler. Make sure that the ends of the wire do not stick out.
 - Pulling wires from under a bale is a manual handling hazard. Where possible, provide devices which lift the bale clear of the conveyor, to remove the risk of back injury. Alternatively, some mills have fitted cleats on the side of the conveyor to wrap the wire around - as the bale proceeds up the conveyor, the wire is pulled clear.
 - Precautions should be taken to reduce the risk of injury due to vehicle movements^{25, 26} in the bale delivery area and from people being injured by falling bales. These depend on the geography of the mill and the type of bale handled, but will include, for example:
 - segregation of vehicles and pedestrians;
 - the provision of high-visibility clothing;
 - clearly marked pedestrian walkways;
 - training for all drivers that includes regular refresher training;
 - crash protection bars for both machinery and people;
 - good lighting; and
 - the prohibition of all unauthorised personnel in the area.

WIRE BALERS

Hazards

- In-running nips on wire drawing rollers.
- Shearing hazards from wire cutting tool.
- Puncture wounds and cuts from stray wires.
- Coil ejection under pressure and subsequent entanglement.
- Manual handling of coils.

Action

- Suitable and effective training should be provided for all operators of wire baling machines. Operators should be provided with and wear suitable protective equipment, including full-face visor with chin guards and strong gauntlets that extend to cover the wrists.
- The feed point should be safeguarded to prevent access to the drawing rollers, and access to all other dangerous parts should be prevented by means of fixed or interlocked panels.
- The machine should be stopped and isolated when access is required for maintenance or cleaning.
- If regular access is required for operational or cleaning purposes then the relevant sections should be interlocked. Where the wire is baled under pressure then no access should be possible until pressure at the ram/plate has been released.
- The door for coil removal should have a two-stage release mechanism so that if excess pressure has been produced in the coil, the door is not forced open, with the potential to hit the operator.
- Mechanical aids to move the completed coil from the machine to the disposal point should be considered.

CONVEYORS FEEDING PULPERS

Figure 11 It is important to fit the right sort of emergency stops to a conveyor in the right place



Hazards

- People going onto the conveyor.
- Falling onto the conveyor or getting clothing or footwear snagged, for example on baling wire or between slats of the conveyor, and being carried into danger.
- Conveyor starting up while someone is on the belt, for example when clearing blockages or retrieving contraries.
- Bales falling from, or back down, an elevated conveyor.
- Falling off the conveyor or into the pulper when clearing blockages, or carrying out maintenance, eg on 'magic eyes' at the top of the conveyor.
- Damaged or missing slats.

Action **Access onto conveyors**

- The starting point for thinking about conveyor safety is how to keep people off them. If anyone is having to go onto the conveyors frequently or routinely, then you need to find out why and tackle the causes. For example, if blockages keep happening, then maybe you need to change the way the conveyor is fed - some redesign of the conveyor might be the answer - or simply to give the operators better training. If the reason is to remove contraries, then you should provide arrangements for pre-sorting.

-
- **Going onto a moving conveyor should not be permitted in any circumstances.**
 - Clearing of blockages at the top of the conveyor should be done from a working platform (with fixed access) - not from the conveyor itself.
 - If you cannot avoid going onto a conveyor then the conveyor itself, any associated feed conveyor and any pulper being fed, must be isolated, **regardless of the length of the job.**
 - **Never** rely on the locking-in of an emergency stop button to prevent the conveyor being started up when going onto it. Use a full-body harness fixed to a suitable, tested, anchorage point above the working position. Make sure that the lanyard is as short as possible and in all cases sufficient to prevent the wearer reaching the surface of the pulp should they fall into the pulper! The lanyard should not exceed 2 m and include a shock absorbing device. All fall arrestor equipment should be regularly checked for damage. A simple safety belt is not considered suitable.
 - Consider an additional drop-down guard or door for the entrance to the pulper which can be bolted in place for the period of the work to prevent someone on the conveyor falling into the pulper. (A harness is still required to protect people from falling off or through the conveyor.)
 - Some conveyors can be reversed to help clear blockages. You should only be able to start the reverse motion under hold-to-run control and the control should be in a place where the operator can see the whole of the conveyor. Make sure that any in-running nips created between the belt and rolls when the conveyor is reversed are guarded.

Emergency stops on conveyors feeding pulpers

- The purpose of the emergency stopping system is to stop the conveyor in the event of danger. It is not intended as a means of preventing unexpected start-up while someone is on the conveyor.
- The system used must be easy to operate by a person who, for example, has fallen over on the conveyor or is trapped, or by someone seeing someone else in danger on the conveyor.
- You need to test the emergency stop devices regularly. You should be aware that self-monitoring emergency stop relays will not check, for example, that the actuators work. Physical checks and regular testing are still needed to make sure that emergency stop devices are not, for example, clogged up with paper dust.
- The control system for the emergency stop system on conveyors feeding pulpers should meet the performance levels of Category 3 of BS EN 954-1: 1997. (See 'Safety-related control systems' in 'General guidance' section.)

-
- **Note:** Personnel detection systems which, for example, rely on a signal receiver over the conveyor and transmitters which are worn on a belt, are only acceptable as additional safeguards; they should not be used as alternatives to emergency stop devices.
 - There should be at least one emergency stop button close to the feed point of the conveyor.
 - On the conveyor itself, any of the following emergency stop systems may be used. They are listed in order of preference:
 - A trip wire fitted along the top edge of one, but preferably both, of the conveyor side panels.
 - A single trip wire hung centrally up the length of the conveyor with pull cords suspended from the trip wire to make it easy to operate (see Figure 11).
 - Trip wires arranged like 'goal posts' over the conveyor. The first goal post should be at the start of the inclined section. The maximum recommended distance between sets of 'goal posts' is 3 m. They will also need to have suspended pull cords to make them easy to operate.

Whichever of the above systems is used, the trip wire should either have a switch at both ends or have a single switch at one end and tension spring anchors at the other so that the emergency stop system will work if the wire is pulled from any direction and from any position along it. The system should also stop the machine if the wire breaks.

- Push buttons along the top edge of one of the conveyor side panels, but preferably both. The recommended interval between push buttons is 3 m or less.

Additional requirements for horizontal conveyors feeding pulpers

- The main risk with horizontal conveyors is from people falling on them. If horizontal conveyors feeding pulpers are less than 1.1 m high, they should be provided with fencing at least 1.1 m high along the sides. Provide fencing of the type which does not allow people to climb on it, eg shear sided, vertical slats etc.
- There is also a risk of people falling into the pulper, for example, while clearing blockages or carrying out maintenance, close to the entry point to the pulper. Provide fixed tunnel guarding at the entry point, extending at least 1 m along the sides of the conveyor. Where a 'goal post type' emergency stopping system is used, or emergency stop buttons are provided along the sides of the horizontal conveyor, the fixed tunnel guarding should extend from the last goal post or emergency stop button to the entry point of the pulper.

.....

Falling bales

- The sides of the conveyor should be high enough to prevent bales falling off. If necessary, you can fit a horizontal bar across the conveyor at its lower end to knock over bales standing on end.
- Keep the carrier bars (flights) on your conveyors maintained in good order.

Safe systems of work

- In addition to safe systems of work for normal operating procedures at the conveyor, safe systems will also be needed to cover isolation procedures, clearing blockages and maintenance of the conveyor.

A typical conveyor accident

An operator broke his forearm when he fell from an elevated conveyor, attempting to clear a blockage caused by wet bales.

Frequently, the conclusion of an accident investigation is to make sure that operators wear a harness in future. The investigation fails, however, to look for the underlying causes of the problem. A thorough investigation would look for answers to the following types of questions:

- *What did the risk assessment have to say about this?*
- *Why were the bales wet? Do wet bales cause regular blockages?*
- *What can be done about it?*
- *Have the operators who load the conveyor been trained to avoid blockages?*
- *Is the design of the conveyor suitable for the material used?*
- *If blockages are inevitable, what other ways could they be cleared besides the operator having to go on to the conveyor? For example, could they be cleared from a walkway on the side of the elevated conveyor?*
- *Were the procedures for clearing blockages adequate?*
- *Do people have to go onto the conveyor for other reasons?*
- *What about the arrangements for supervision - were responsibilities clearly set out and understood? Did the supervisor have enough time to do the job properly?*
- *Why wasn't a harness being used? Was it readily available? Was it working properly? How difficult was it to use? What training had been provided? Where was the anchor point?*

If you don't try to uncover the real reasons for the accident, it may happen again.

PULPERS

Figure 12 Pulper with fixed grille on hatch to prevent people falling through



Figure 13 The fencing around open-topped pulpers should be designed so that people cannot climb onto it



Hazards

- Drowning in a loaded pulper - if you fall in, your chances of getting out alive are negligible, even with the rotor stationary.
- Drowning in a pulper if water is turned on while working inside.
- Contact with rotors/impellers.
- Burns from hot stock splashing from openings.

- Contact with chemicals while manually dosing the pulper - remember reactions in the pulper can give off toxic gas.
- In-running nip between ragger rope and capstan.
- Entanglement in motor drive.
- Contact with guillotine for ragger rope.
- Struck by material falling from the feed conveyor.
- Falls from height while entering or working in pulper.
- Toxic fume or oxygen deficiency while working inside.
- Lifting of replacement parts.

Action ***Preventing falls into pulper***

- The feed opening must be at least **1.1 m** above floor level. Keep the floor area around the feed opening clear of raw material to maintain the effective height of the guarding.
- Where pulpers are fed by a horizontal conveyor, fit a tunnel guard which extends at least 1 m from the opening. (For further requirements see 'Conveyors feeding pulpers'.)
- Under no circumstances should you use boxes or steps to reduce the level of protection below 1.1 m.
- The fencing around open-topped pulpers should be designed to prevent people climbing on it, for example, it could be sheer sided or have vertical bars, so as not to give a foothold. If you currently have guard rails and toe boards around your pulper you are strongly recommended to replace these with the type of guarding described.
- Inspection hatches or other openings in the pulper which are large enough for a person to fall or be drawn through, should have fixed grilles.

Access to pulpers

- All pulpers, including open-topped ones, are confined spaces as defined in the Confined Spaces Regulations 1997 and all entry should be in strict conformity with these Regulations. (See 'Safe work in confined spaces' in 'General guidance'.)
- No one should be allowed to go into a pulper unless ALL sources of energy (not just electrical power), the conveyor feeding it, the infeed of

.....

water and other raw materials, have been ISOLATED, purged where necessary and a permit-to-work has been issued.

- Extra-low voltage lighting should be used inside the pulper (typically 25 V).
- You need to provide a safe means of access for people working inside the pulper. Do not leave the arrangements to the people doing the job. For example, you need to consider how ladders are to be secured when working on the rotor. If the job is likely to take some time, a proper working platform will be needed. Scaffolding will almost certainly be needed for working on the pulper sides or pipework.
- Fix a notice to the pulper warning that people are working inside.

Lifting aids

- Provide a mechanical means for lifting above the pulper. However, you should remember that it will be in a corrosive atmosphere and take this into account when making arrangements for inspection, examination and testing.

RAGGER ROPES

Figure 14 An unguarded ragger rope capstan and guillotine

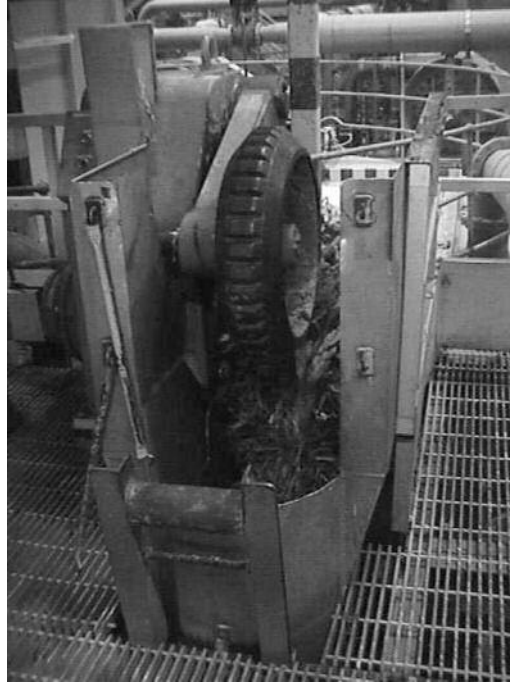
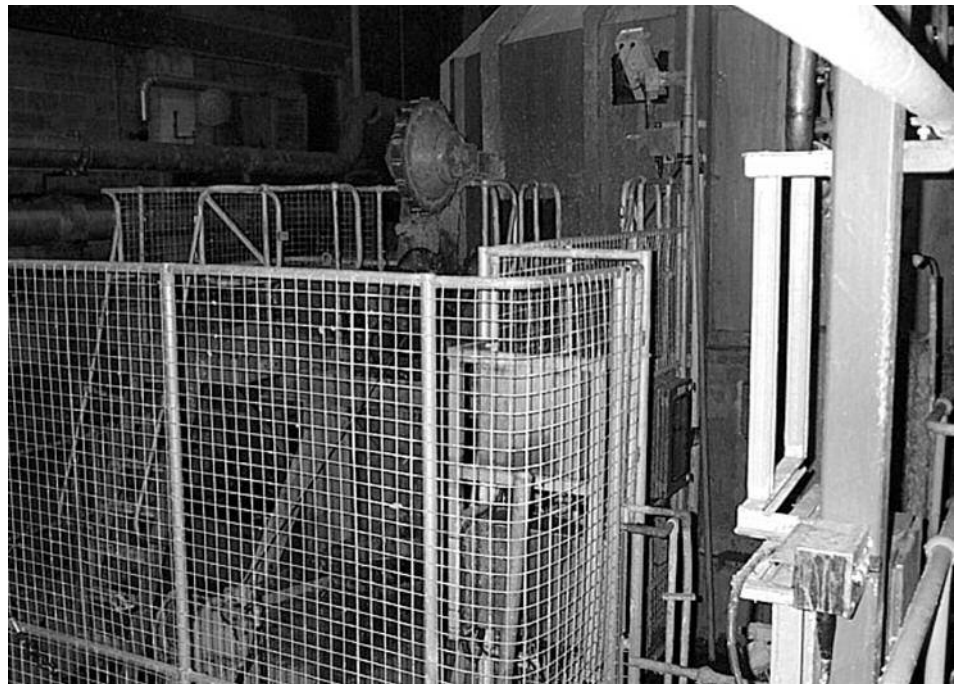


Figure 15 Ensure the guard is interlocked with both the movement of the capstan and the pneumatic system for operating the guillotine



Hazards

- Nip between the rope and capstan.
- Contact with the guillotine.

Action

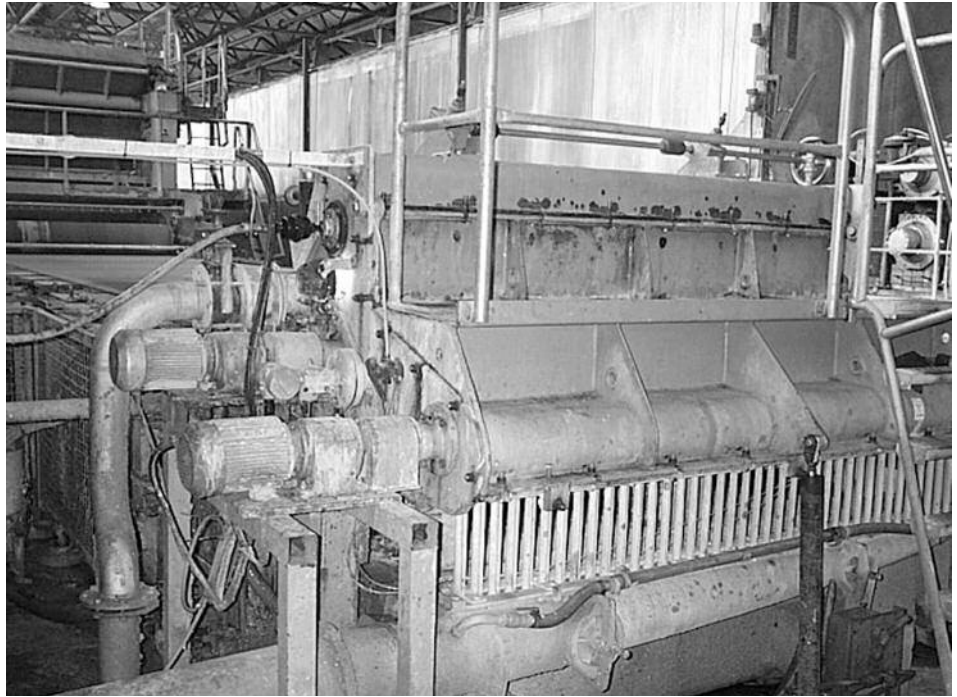
- You must guard the intake between the ragger rope and capstan and access to the guillotine. A fence-type guard with interlocked access gate is suitable. An override facility may be provided to allow the capstan only to operate under hold-to-run control at crawl speed (**no more than 5 m/min**) to allow for feeding new ropes.

-
- The safety-related control system for the interlock on the gate should be to Category 3 of BS EN 954 - see 'Safety-related control systems' in 'General guidance'.
 - The capstan and guillotine must be isolated when changing blades. Accidents have occurred during maintenance because the electrical system has been isolated but not the pneumatic supply to the guillotine blade which normally operates on a timer. Make sure your isolation procedure is written down, clearly detailed and operators are trained to use it.

SECTION 3: PAPERMAKING MACHINE - WET END

HEAD BOX

Figure 15 Head box showing guarding for evener roll drives



Hazards

- Entry into confined space - being overcome by toxic chemicals during cleaning of the box.
- Entanglement on drive shafts.
- Falling into open breast box - danger of coming into contact with agitators, or baffle rolls inside the box.
- Being struck by unsecured head box lid.
- Falling from top of head box, particularly where access required to adjust 'the slice'.
- Inadvertent start-up during entry into the box for maintenance or cleaning.
- Adjacent slippery floor surfaces.

.....

Action **Confined spaces**

- Head boxes are confined spaces as defined in the Confined Spaces Regulations 1997 and all entry should be in strict conformity with these Regulations. (See 'Safe work in confined spaces' in 'General guidance' and 'Access to pulpers'.)

Guarding

- Exposed drive shafts, agitators, baffle rolls etc should be enclosed by guards. A slot may be provided in the guard to allow tool access for adjustments. The slot should not be big enough to allow a hand or loose sleeve to reach the rotating parts.

Safe access

- Access is needed for cleaning and adjustment. Provide platforms and walkways which meet the requirements in 'Safe access to plant' in the 'General guidance' section.
- Provide a means to secure the head box lid when open to make sure it is not dislodged.

Cleaning

- The area around the head box should be a priority area for cleaning - see 'Prevention of slips, trips and falls' in the 'General guidance' section.

Clothing

- Provide operators with appropriate, close-fitting workwear to further reduce the risk of entanglement.

Systems of work

- Apply a permit-to-work system to ensure isolation of all power (electrical, hydraulic and/or pneumatic) and isolation and blanking of all stock valves before entry for maintenance or cleaning. Train all relevant personnel, including contractors, in the permit-to-work system and isolation procedures.

THE WIRE

Figure 17 Provide a guard to prevent access to the underside of the wire and the couch pit if there is a risk of drowning or contact with agitators

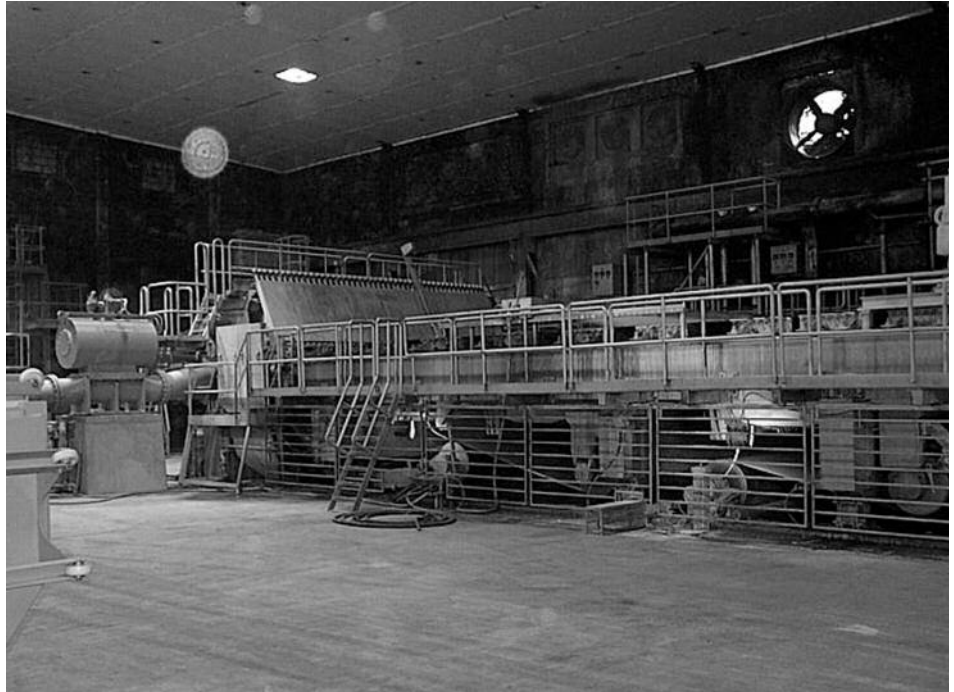
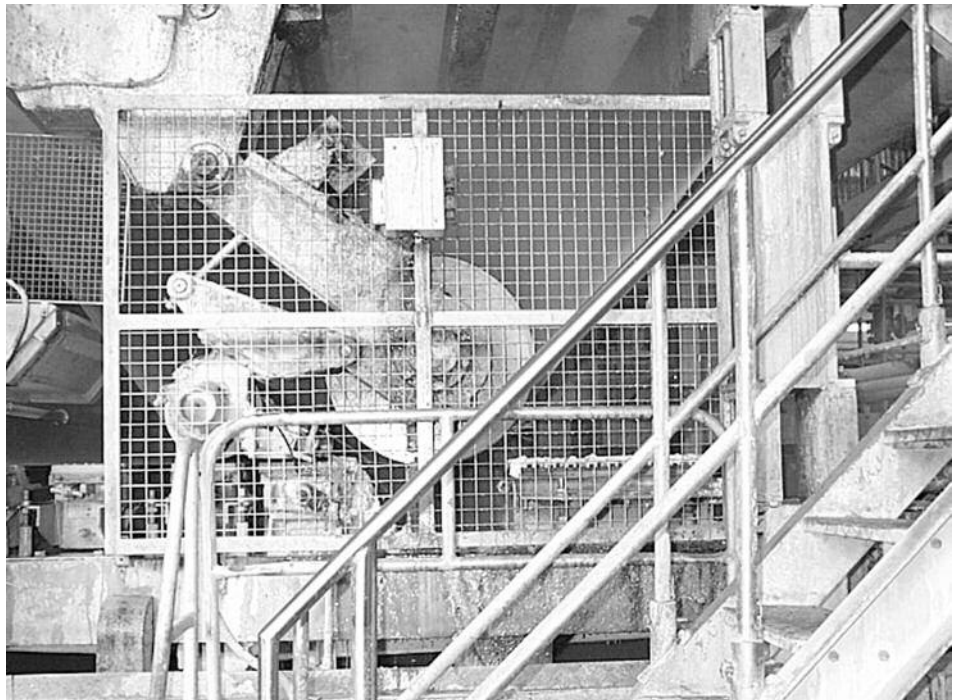


Figure 18 Any guarding should conform to BS EN 294: 1992



Hazards

- Noise from couch roll.
- Manual handling and falling during wire changing.
- In-running nips between wire and rolls.
- Entanglement with drive and couplings to the shake mechanism and the wire drive rolls.
- In-running nip between dandy roll and the wire.
- In-running nip with other wires.
- High-pressure showers for cleaning wires.
- Cutting hazard from edge of wire.
- Falling from platform and cross-machine walkways.
- Falling into the underwire pit and either drowning or coming into contact with paddle or auger.
- Chemical cleaning with the machine running.

Action **Noise reduction**

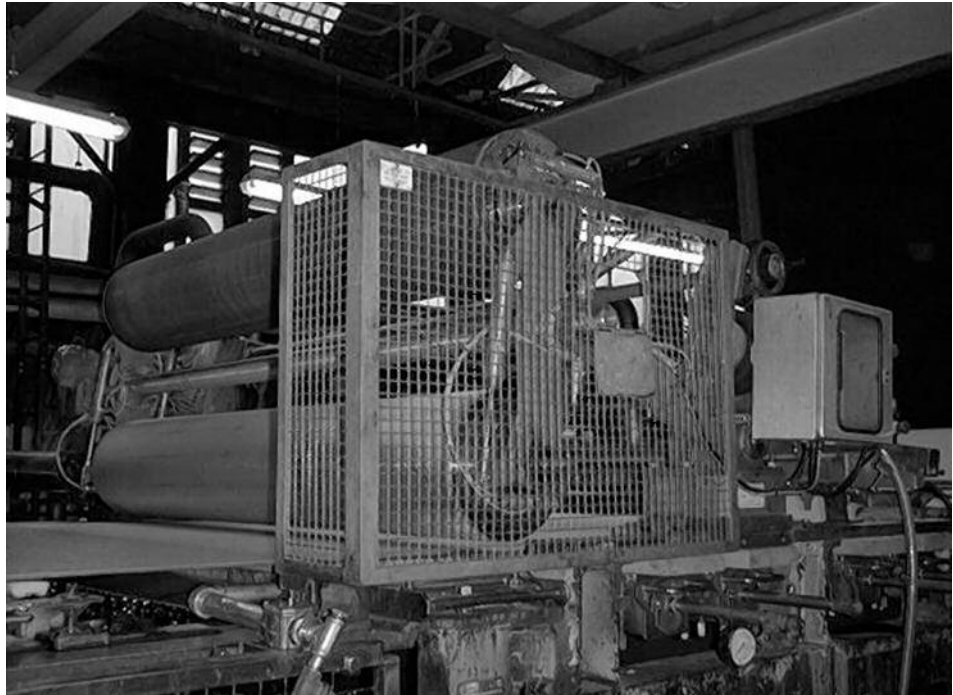
- Significant noise reductions of around 3 dB have been achieved by altering the pattern of the holes in the couch roll and regular maintenance of the seals.^{27, 28} (See also PABIAC Noise Information sheets.^{29, 30})
- Keep the vacuum system properly maintained to control noise emission.

Changing a wire

- A written safe system of work, which addresses the manual handling issues, is needed for changing a wire - see 'Fabric changing' section for further advice.
- Provide a safe means of access and working platforms (preferably permanent) for changing wires.
- Radio communication between the people involved in wire changing has been found to make the job easier and safer.
- Make sure that personnel have been trained in safe slinging.

Guarding

Figure 19 An example of a specialised dandy application illustrating the principles of safeguarding

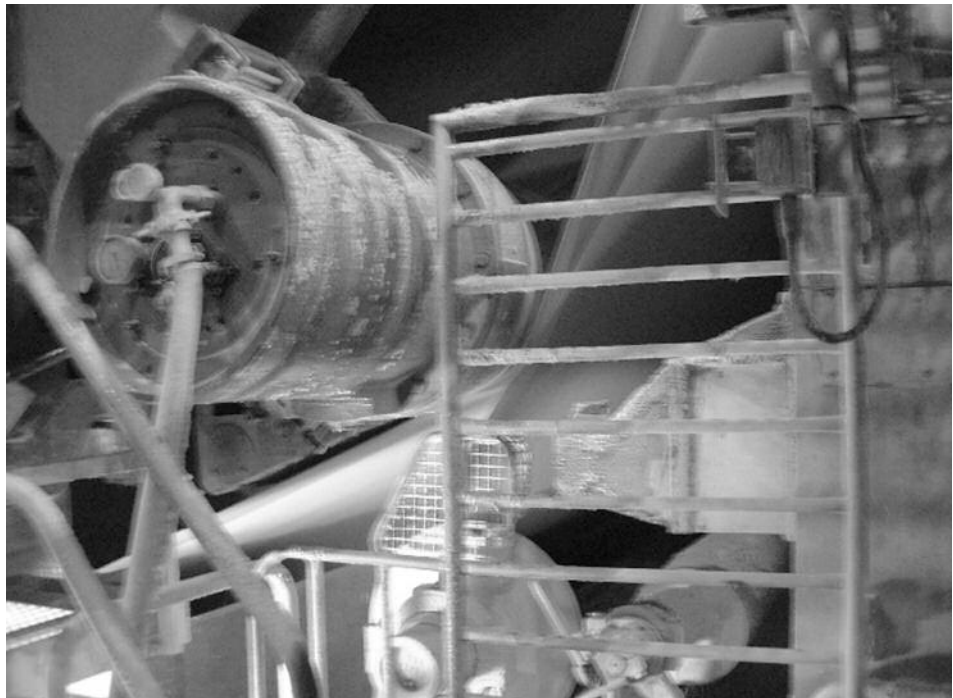


- Guard in-running nips between the wire and wire rolls and between wire and couch. Fixed side-guards, which you cannot reach around, fitted close to the nip are most effective.
- On multi-wire machines, provide guarding extending 850 mm from each side of the nip at each accessible station where two wires meet. The design of the guard should take into account the need for removal for wire changing and should not impede visibility.

There is a risk of drowning from slipping and falling into the under-wire pit, particularly if the pit is deep or has an auger. Provide a barrier around the wire (front and back side) to prevent someone falling into the pit. The design of barrier should permit cleaning with hoses but not allow people to reach dangerous parts.

- Drives to the wire shake, couch or other rolls must be completely enclosed with fixed guarding.
- Provide guarding at the front and back sides to prevent access to the in-running nip between driven dandy rolls and the wire (see Figure 19). Guarding is not necessary on undriven dandy rolls mounted in loose bearings which would lift if someone became drawn in.
- Provide guarding to prevent people coming into contact with the edge of wires, particularly at head and neck height, it could easily cut flesh or propel a person into another hazard. It is not sufficient to rely on warning notices - you can't read them if you slip!

Figure 20 Pick up guard.
Note that guards should comply with BS EN 294: 1992. It should not be possible to access dangerous parts through the guard or use it as a climbing frame



Showers

- If access to high-pressure needle showers is possible, particularly from underneath the machine, then you will need to provide fixed guarding to prevent approach.
- Provide a readily accessible means of isolation and lock off for carrying out maintenance.

Access to the wire

- Platforms crossing the wire should have handrails, intermediate rails and kick plates on both sides. (See also 'Safe access to plant' in the 'General guidance' section.)

Chemical cleaning

Cleaning requires a safe system of work that will include:

- restricting the area to those involved in the operation using suitable barriers and warning signs;
- appropriate personal protective clothing - usually this will be a full chemical suit for those involved;
- proper training for all those involved;
- exhaust ventilation of the area to a safe place;

-
- proper consideration of other risks, including safe means of access and isolation of mechanical, or electrical power. Machines should only be moved at crawl speed during cleaning if absolutely necessary under a proper system of work;
 - a proper system for dealing with chemical spills.

TRANSFER TO PRESS SECTION

Hazards

- In-running nip between couch and carrying roll (also known as lead or wind roll).
- In-running nip between wire and pick up roll/felt.
- In-running nip between first felt and felt roll.
- In-running nip at first press roll, particularly if the transfer of the web is done by hand.
- Falling into underwire (couch) pit.

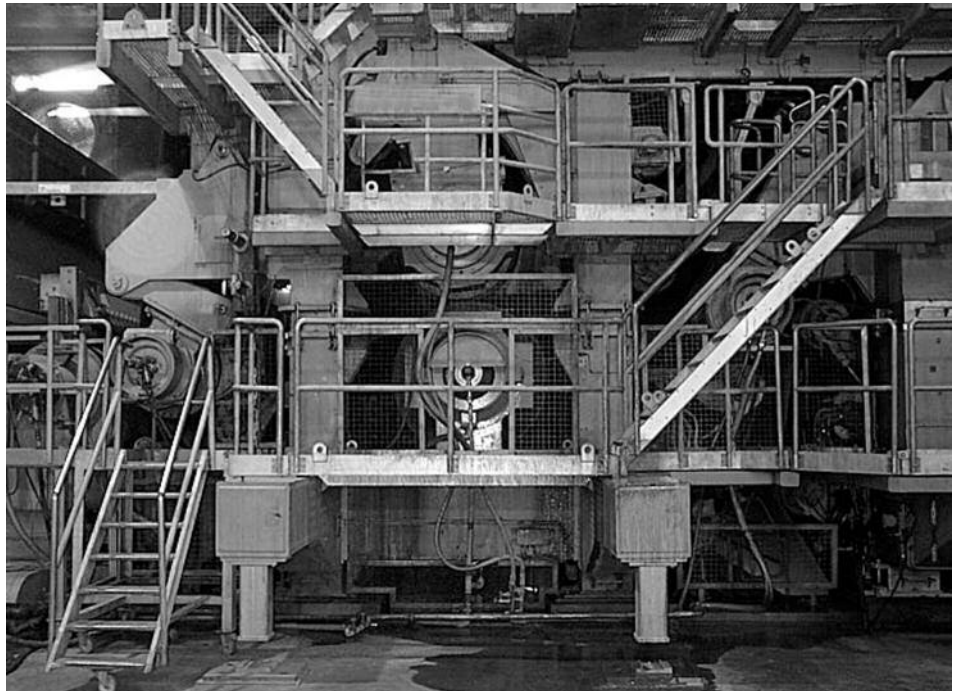
Action

- Avoid hand transfer of the web from the couch to the felt. Use an air 'blower' if practicable. (See also 'Web feeding systems' in the 'General guidance' section.)
- Guard the in-running nip between the wire and pick up roll/felt.
- The paper carrying roll and couch roll should be at least 120 mm apart. If not, fit a guard to prevent access to the nip.
- Guard the in-running nip between the first wet felt and roll. (Accidents at this point can occur when carrying out manual straightening of felts.)
- Provide fixed fencing to prevent anyone from falling into the pit.

SECTION 4: PAPERMAKING MACHINE - PRESS AND DRYER SECTIONS

PRESS SECTION

Figure 21 Where practicable guards should be extended to at least 850 mm from nip and prevent access from both above and below the felt



Hazards

- In-running nips at the press rolls.
- Intake between the doctor blade and roll when doctor is raised out of position.
- Falling onto felt and being carried into press rolls.
- In running nips at felt stretch or bow rolls.
- Entanglement on protrusions, eg nuts or capscrews on ends of press rolls.
- Manual handling problems while changing press rolls and felts.
- Slipping on oil emissions.
- Splashes from felt showers.
- Falling from cross-machine walkways and platforms during normal running and during felt changing.
- High levels of heat and humidity towards the top of the press section.

.....

Action **Guarding**

- Guard the in-running nip between the press rolls at both the front and back of the machine. The guard should, where practicable, extend at least 850 mm from the nip and prevent anyone reaching up to the nip from either above or below the felt.
- Provide a guard with a smooth surface over any parts sticking out from the ends of rolls to prevent clothing being caught up.
- If stretch rolls and felt carrying rolls are accessible, you need to guard the in-running nip from the sides or, if they can be reached from under the machine, across the whole of the nip.
- Prevent access to high-pressure showers.
- Remember - where do people go to work and what do they do when they get there?

Figure 22 Provide safeguards to prevent access to dangerous parts



Safe access

- Provide slip-resistant flooring around extended nip presses. Make the area around the nip press a priority area for cleaning. (See 'Housekeeping' in the 'General guidance' section.)
- Provide working platforms across the machine to make the cleaning and changing of doctor blades easier.
- If walkways are removed when changing felts and rolls, make sure that temporary barriers are provided. Chains are not sufficient.

.....

Safe systems of work

- Provide a written safe system of work for changing press rolls. This should cover the procedures for isolation, safe lifting, access arrangements, replacement of guards and cleaning (particularly with caustic washes).

Heat and humidity

- Carry out an assessment and adopt working practices in accordance with the PABIAC guidance *Prevention of heat stress in paper and board mills*.

DRYER SECTION

Figure 23 In some mills, interlocked distance guarding is being developed



Figure 24 Guarding should be as close as practicable to the machine to prevent whole body access between the guard and machine frame



Hazards

- Confined space inside cylinders.
- In-running nips between cylinders and felts/felt carrying rolls and Sheahan ropes and pulleys.
- Burns from contact with cylinders.
- Falling into machine or under-machine pulper from cross-machine passageways.

- Heat stress working inside machine hoods.
- Failure of lifting mechanism for machine hood.
- Lacerations from doctor blades.
- Hazards associated with clothing changes.
- Replacing Sheahan ropes.
- Safe access/working in pits.

Action **Confined space**

- Drying cylinders are confined spaces as defined in the Confined Spaces Regulations 1997 and all entry should be in strict conformity with these Regulations. (See 'Safe work in confined spaces' in 'General guidance'.)

Guarding

- Safeguarding against the arm being drawn into the in-running nips between cylinders and felt rolls (and between any other pairs of counter-rotating rolls) is achieved if there is a gap between the rolls of at least 120 mm. If a nip can be reached by the whole body, then the safety distance between the rolls must be at least 500 mm. (See 'Principles of machinery guarding' in the 'General guidance' section.)
- The same safety distances apply to running nips between rolls and fixed parts of the machine. Safety distances can be used, for example, to safeguard the gap between the first drying cylinder and the hood.
- If the safety distances cannot be achieved (as may be the case on old machines) you will need to prevent access to the nips from the front and back sides of the machines with fixed guards. The guards need to be carefully designed to allow for broke removal and for cleaning and changing doctor blades.
- A recent development on newer machines is the use of interlocked guards on drying cylinders. A distance guard, 2.5 m high, is fitted along the drying section with hinged gates at each point where access is needed. The gates are either interlocked using a trapped key system or have guard locking; both of these systems ensure that the gates can only be opened when the machine is stopped. A facility is provided to permit the machine to be operated at crawl speed, for example for removing broke. However, while the machine (or machine section) is running in this mode, only one guard may be open and the operator must be able to see whether there is someone inside the guarded area. This system has long been in use for newspaper printing presses and the technology is well known.

-
- Nips between felts and felt rolls accessible from the front and back sides of the machine should be guarded by fixed guards mounted close to the wrapping point.
 - If nips on rolls can be reached from cross-machine passageways, provide guarding across the machine.

Safe access

- If there is a risk of falling into a machine pit or basement from a passageway across the machine, provide railings 1.1 m high with intermediate rails and kick plates. (See 'Safe access to plant' in the 'General guidance' section.) Where dangerous parts could be reached by someone standing on the railings, provide fencing which does not permit a foothold. If it is foreseeable that people will still be able to reach up and make contact with dangerous machinery then additional guarding should be provided.
- Sheer-sided fencing, or other fencing which does not give a foothold, must be provided for passageways above under-machine pulpers, to a minimum height of 1.1 m. Any gaps in the fencing at floor level for feeding broke should be as narrow as possible, but should not exceed 300 mm. (You should be aware that new machines may be provided with feed gaps of up to 400 mm.)
- Provide working platforms where necessary for cleaning and changing doctor blades.

Pit access

- Where a machine is sitting over a pit, access to the pits is by means of steps or ladders located within the area of the machine. In these cases the provision of individual guards may be impractical and some form of gate, preferably interlocked, but at least locked, should be provided. If a lock is used then the key should be under the control of a responsible person and only released under a strict isolation procedure.

Machine hood

- The distance from any location under the hood and the nearest door should be no more than 15 m.
- Failure of the lifting mechanism for the machine hood should not allow the hood to fall under gravity; provide devices which limit the fall.
- An audible pre-start warning should be given before the hood is lowered.
- Any trapping points between the hood and first machine roll should be

.....
eliminated by design, eg by maintaining a gap of at least 500 mm.

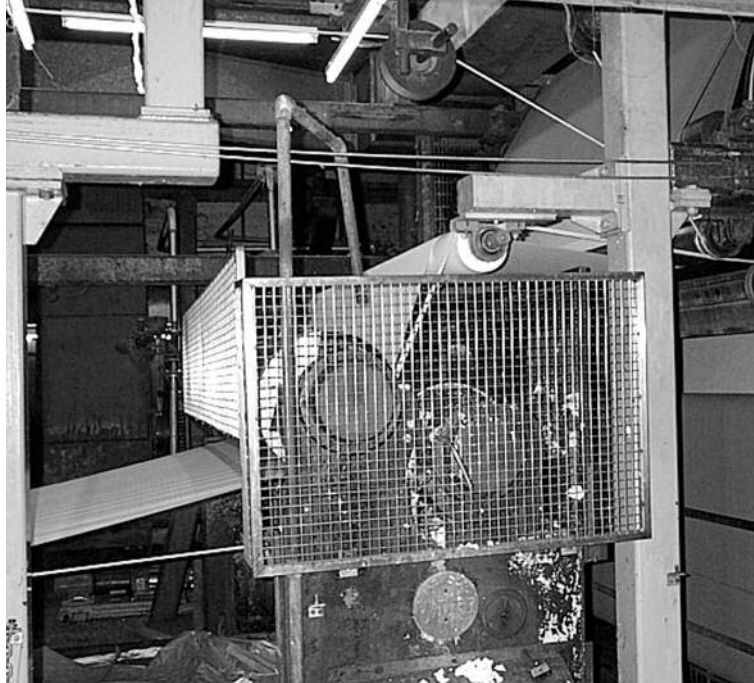
- Any work inside the machine hood is liable to expose operatives to heat stress. See also 'Safe work in confined spaces' in the 'General guidance' section.

Replacing Sheahan ropes

- Replacing ropes should only take place under a safe system of work that is strictly enforced - wherever possible the work or parts of it should be carried out with the machine stationary. Only if it is necessary for the machine to be in motion should work be allowed on a moving machine - and then only at a maximum of crawl speed.
- Safe access will be required to all pulleys to re-feed the ropes, and guarding provided should be replaced after the operation has been completed and before the machine is run up to full speed.
- Ropes that have failed should be replaced before the next web-feeding operation. It is NOT acceptable to manually feed a machine designed to be rope-fed.

SIZING AND COATING UNITS

Figure 25 An example of a size press



Hazards

- In-running nips between coating/sizing rolls.
- Entanglement and drawing-in during inspection and cleaning.
- Burns from splashes of hot or caustic size press mixes or coating colours.
- Automatic opening of roll nips when a break occurs, increasing the drawing-in hazard.
- Cuts from doctor/coating blades.
- Slips, trips and falls.

Action **Guarding**

- Guard accessible in-running nips between the coating rolls. On size presses, provide guarding to prevent someone reaching the ends of the nip from the front and back of the machine. If the nip can be reached from a cross-machine passageway, it must be guarded across its whole width.
- Fixed nip bars are acceptable. Interlocked (trip) nip bars tend to impede feeding up and are not usually appropriate. (Trip bars are also unlikely to be able to stop the machine before nip is reached.)
- If fixed nip bars are impracticable, one method of guarding is to fit interlocked gates with guard locking at the cross-machine walkway to ensure that operators can only get access when the machine is stopped. The actuators for the interlock and the control system should meet the

.....

performance criteria of Category 3 of BS EN 954: 1997. (See 'Safety-related control systems' in the 'General guidance' section.)

- Where roll nips are designed to open when a web break occurs, beware of additional in-running nips which this can create. Design nip bars so that they protect the nip created by the rolls in both the open and closed positions. (Also, make sure that the gap between the nip bar and open rolls does not exceed 8 mm.) Check that the distance between the rolls in their open position and any other rolls or fixed part is not reduced to less than 120 mm. If so, guarding for the nip created by opening the rolls will need to be provided.

Safe access

- Make the area around the press a priority area for cleaning. (See 'Housekeeping' in the 'General guidance' section.). Eliminate the need for close access to moving rolls during cleaning by either stopping the rolls concerned or providing automated mechanical cleaning devices. In principle, all rolls on a machine should be capable of being stopped and this should be the aim if close access is required. However, stopping machines for cleaning may create additional hazards or problems, such as moving the rolls by hand. In these circumstances, automatic cleaning devices or remote cleaning methods such as water jets should be examined to distance the operator from the moving machinery.
- Only if the machine cannot be stopped and/or automatic cleaning equipment cannot be fitted should cleaning take place on moving rolls. Under all circumstances, roll speed should be reduced to a minimum - preferably crawl speed. Even so, reducing the speed is only a risk reduction technique. In all such cases a thorough and effective risk assessment should have been carried out and the outcome recorded. All additional measures that are required to further reduce the risk should be identified, set out in operating instructions and implemented. Examples of such additional measures might include using water jets, long-handled tools, a written safe system of work - including details of the speed at which the activity will take place, effective and recorded training, supervision and regular review.

Doctor/coating blades

- Use proprietary devices for removing doctor blades. Suitable gauntlets should be provided to prevent cuts and the edge covered as soon as the blade has been taken out of the machine and the whole blade placed in a storage box. Do not leave them on walkways!

Protective equipment

- Suitable protective clothing should be provided and worn. Consideration should be given to eye protection or a full-face visor, and other suitable clothing to reduce the risk from splashing.

CALENDERS AND SUPER CALENDERS

Machine calenders

Hazards

- In-running nips between rolls.
- Open nips at lifted rolls.
- Entanglement in drive shafts.
- Entanglement in sheet between last rolls and the reel-up.
- Pressure loss at hydraulic lines.
- Cuts from doctor blades.
- Burns from hot surfaces.
- Entanglement during cleaning.
- Static discharges.
- Falling down under floor openings.
- Strains due to manual handling.

Action **Machine feeding and guarding**

- Tail feeding systems should be installed on these machines.
- Access to all in-running nips should be prevented by guarding designed in accordance with the standards set out in the general section of this booklet. Nip bars, where fitted, should be regularly checked to avoid excessive deflection across the width of the machine and to ensure vibration has not loosened the securing bolts.
- Where rolls are lifted during breaks, beware of additional nips that may be created. The gaps between all rolls should be at least 120 mm or additional guarding should be provided.

Replacing doctor blades

- Use proprietary devices when removing or replacing doctor blades. Suitable gauntlets should be provided to prevent cuts and the edge covered as soon as the blade has been taken out of the machine and the whole blade placed in a storage box. Do not leave them on walkways!

.....

Removing broke

- Under-floor openings for broke feeding should be kept as small as possible and should not exceed 300 mm.

Cleaning

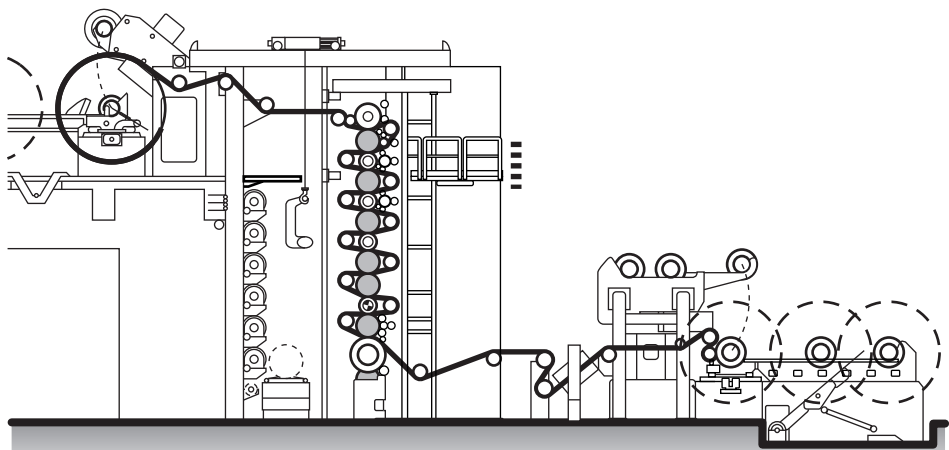
- Cleaning should always be carried out according to a safe system of work - preferably with the machine stationary using an appropriate remote cleaning device or tool. Flammable liquids should not be used.

Static electricity

- Suitable earthing and discharge systems should be provided and maintained.

Independent calenders

Figure 26 An independent calender



Hazards The following are in addition to those identified for machine calenders:

- Entanglement in in-running nips between unreeling and reeling reels.
- Falls from travelling working platforms.
- Trapping underneath the descending travelling working platform.
- Working beneath suspended loads.

Action The following are in addition to those identified for machine calenders.

- On machines wider than 3 m, nip bars may become impractical due to excessive deflection. In these cases enclosing guards should be provided to prevent access to dangerous parts.

-
- Travelling work platforms should be properly installed, maintained and examined in accordance with the requirements of the Lifting Operations and Lifting Equipment Regulations 1998. All travelling work platforms should also be fitted with:
 - interlocked gates - so that they cannot be moved unless the gates are shut;
 - a trip device on the underside that, if activated, brings the platform to a halt;
 - overrun protection at both ends of travel;
 - controls on the platform.
 - Mills should also refer to the section on 'Safe access to plant' from the 'General guidance' section of this booklet for further information.

YANKEE CYLINDERS

Figure 27 Yankees can fail catastrophically



Hazards

- Failure of the cylinder. This can be caused in several ways:
 - 'crevice corrosion cracking' which opens joint between the head and shell;
 - cracking of the shell due to differential temperature or pressure, eg during heating up and cooling down;
 - continual distortion of the shell due to over-pressure by the press rolls;
 - over-pressurisation by steam;
 - thinning of the shell, due mainly to frequent regrinding of surface, so that the cylinder no longer meets the design parameters for temperature and/or pressure.
- In-running nips between the press rolls and the cylinder and between doctor blade assemblies and cylinder.
- Burns and scalds from high pressure steam leaks.
- Entry into confined space.
- Contact with doctor blades.

.....

Action **Inspection and testing**

- Make sure that a 'head-tilt test' to detect crevice corrosion cracking is carried out at appropriate intervals as specified by a competent person.
- Check the integrity of the head bolts on older yankees using non-destructive testing (NDT).

Steam and condensate removal system

- Check routinely for steam leaks - a mirror on an extended handle can be used - and fix leaks as soon as possible to prevent steam cutting into the head/shell joint and setting up localised stresses.
- The pressure-relief valves on the steam system should be set with an appropriate safety margin and should be overhauled and recalibrated at least annually.

Hood

- The heating system for the hoods needs to be interlocked with the movement of the dryer. As the consequences of failure can be catastrophic, the control system should be to at least Category 3 of BS EN 954-1: 1997. (See 'Safety-related control systems' in the 'General guidance' section.)

Pressure rolls

- You need to monitor the loading on the Yankee applied by the pressure rolls - load cells which give an ongoing measure are recommended. You should be aware that the likely introduction of shoe presses may increase pressures on the Yankee cylinder.

Heating up and cooling down

- Make sure that the systems of work for starting up from cold and for cooling down a Yankee cylinder are written down and operators are trained in them. Check that even the experienced personnel continue to follow the correct system of work.
- Make sure that all operators are aware that cold water sprayed on to a hot cylinder can lead to catastrophic failure due to thermal shock.

Entry into cylinder

- Yankee cylinders are confined spaces as defined in the Confined Spaces Regulations 1997. Follow the guidance in 'Access to pulpers' in the 'Stock preparation' section, and 'Safe work in confined spaces' in the 'General guidance' section.

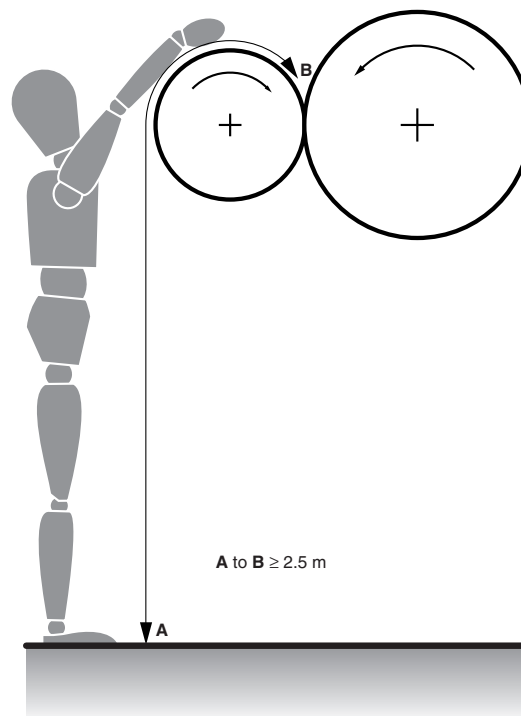
-
- Note that in some situations, steam and condensate can be back-fed into the cylinder from condensate 'flash vessels'; if this is possible, the steam/condensate return line will also need to be isolated.
 - Use purpose-designed scotching devices to prevent movement of the cylinder under its own inertia while a person is inside. Do not rely on doctor blades to prevent movement.

SECTION 5: REEL-UPS

Figure 28 Drum (Pope) reel with guard at under-machine pulper



Figure 29 Measuring the height of a nip at a reel-up



Hazards

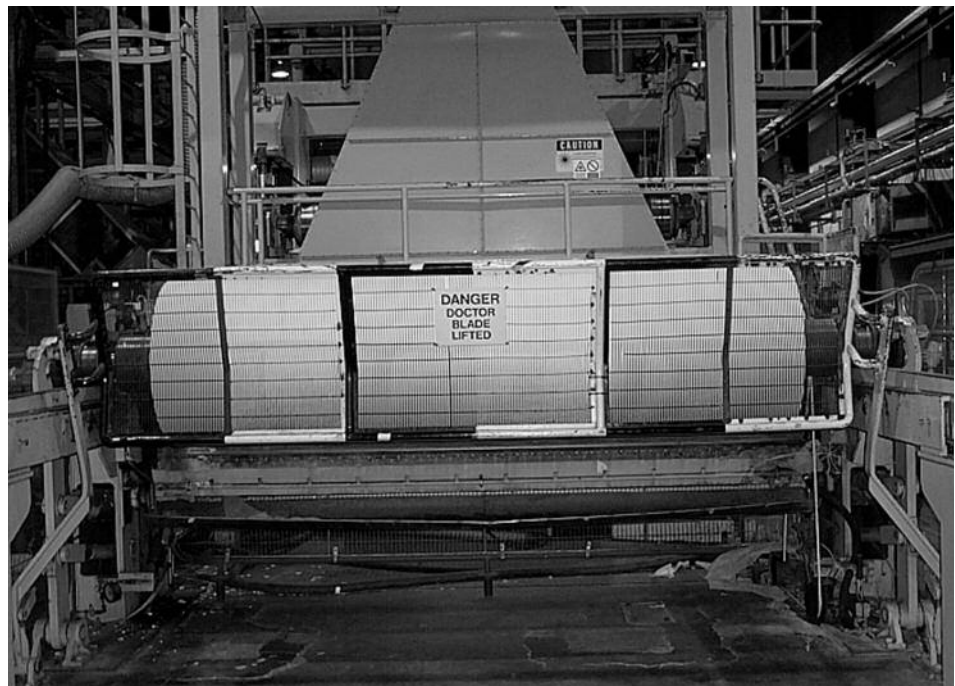
- In-running nip between shell/reel and drum.
- On reel-ups with storage for full reels, crushing between ejected reel and a full reel.

- In-running nip between web and reel (on higher grammage papers).
- Feeding web into the nip.
- Entanglement with primary/secondary arms.
- Falling into under-machine pulper.
- Working beneath the suspended load.

Action Guarding

- The in-running nip between the drum and the reel shell, throughout the range of movement of the shell, should be out of the operator's reach. This requirement is met if the distance measured from the nip over the newly transferred shell (ie in its lowest position), and vertically down to the floor or standing level is at least 2.5 m (see Figure 29).
- If this distance cannot be met, an automatic front face guard is required to prevent anyone reaching the nip (see Figure 30). The gap between the guard and reel should be at least 120 mm but not large enough to allow a person to stand between the guard and the reel.

Figure 30 Automatic front face guard which travels with the growing reel



- If the nip can be reached from raised platforms at the side of the machine, provide fixed fencing at the sides of the reeler. The height of the guard, its distance away from the nip and how far it must extend either side of the nip can be worked out from the relevant tables in BS EN 294: 1992.
- If the drive gears to the primary arms are accessible, they should be enclosed by fixed guards. The atmosphere inside the guard may be slightly pressurised to prevent the ingress of dust.

-
- Fit steel braking systems into the rails to halt the rotation of ejected reels. (If a rotating reel is lifted by a crane, it subjects the crane to dynamic loading for which it is not designed and can cause the crane to fail.)
 - On reel-ups with storage facilities for full reels there is a risk of trapping between two reels, and particularly between a stationary reel and a moving reel which has been ejected from the reel-up. To avoid this hazard, a minimum gap of 500 mm should be maintained between two full reels on the rail. This can be achieved by holding the reels at individual brake stations, with the gap between stations designed to accommodate two maximum diameter reels, plus 500 mm. If the storage rail is 2 m or more above the floor, the gap can be reduced to 300 m.
 - Where the ends of shells are shaped to fit into the re-reeler brake couplings, the rotating shaft ends should be guarded.
 - If there is a broke pit or conveyor under the reeler, fit guarding to stop anyone falling in. The gap in the barrier at floor level for feeding broke should be as narrow as possible but should not exceed 300 mm. (You should be aware that the gaps under guards for feeding broke on new machines may be up to 400 mm.) The guard should be designed to prevent someone standing on it, for example to reach broke.
 - When reeling up heavier grades of paper there have been incidents of people being drawn into the nip between the paper and the winding reel and being carried around the reel. Automatic cross-cutting devices may reduce the risk. If your risk assessment identifies this as a hazard, prevent access to the wrapping point from the sides of the reeler.
 - Equipment for handling full reels should be suitably designed and properly maintained. When full reels are lifted off the machine, they should be raised high enough only for clear transfer. Reliance should not be placed on the overtravel cutout switch on the crane crab to stop the lift. Failure of the overtravel output switch can result in the hoist rope breaking and the load and lifting gear failing. Where practical it is advisable to fit two overwind limit switches. The first limit switch may be self-resetting, but the ultimate switch must not be.
 - The risks of an accident or dangerous occurrence can be reduced by:
 - redesign of the actuating arm of the limit switch to ensure that it cannot be bypassed - a hoop or forks may be more suitable than a straight arm;
 - robust construction of the mechanical parts;
 - modification of the limit switch so that it requires manual resetting to discourage the practice of crane drivers relying on the limit switch; or
-

-
- routine testing of the limit switch at low speeds by the oncoming driver on each shift, together with planned and regular examination of the limit switch mechanism.
 - Mills should be able to show that shells have been examined regularly using, for example non-destructive testing techniques, to minimise the likelihood of failure in service.

.....

APPENDIX 1: UPDATED INFORMATION ON DESIGN AND IMPLEMENTATION OF SAFETY-RELATED ELECTRICAL CONTROL SYSTEMS

IMPORTANT NOTE

The information in this Appendix supersedes and updates the guidance on safety-related control systems for papermaking machines published in paragraphs 31-47 of the first edition (2001) of *Part 6: Making paper safely. Managing safety in the papermaking process.*

This Appendix provides a technical framework that can be used by mill engineers for the design and implementation of safety-related electrical control systems that are used to carry out safety functions at papermaking machines. This is drawn from published standards and other sources that take a systematic approach towards the specification, design, installation and operation of safety-related electrical control systems so as to achieve safety performance requirements derived from a risk assessment.

What is a control system?

1 A control system responds to input signals from the machine, or from the operator, and generates output signals, which make the machine operate in a desired manner. So if, for example, an operator presses a start button, the control system may respond by closing a contactor and energising a motor.

2 Control systems can be implemented in a range of technologies, but this guidance is mostly concerned with electrotechnical systems employing electrical, electronic and programmable electronic technologies.

What is a safety-related control system?

3 A control system in a papermaking machine should be regarded as being safety-related if it contributes to reducing any risk to an acceptable level 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'. Safety-related control systems should be designed and configured to:

- be reliable enough (bearing in mind the consequences of any failure); and
- perform the necessary functions to achieve or maintain a safe state or mitigate the consequences of a hazard.

4 For the purposes of this guidance, a distinction can be drawn between those safety-related systems that use programmable technologies (such as a programmable logic controller (PLC) or microcontroller) and those that do not use programmable electronic devices (such as systems that use

.....

electromechanical components). The main purpose of this subdivision is to help the designer decide which of the two main standards that address the design of safety-related control systems to use - BS EN 61508: 2002 *Functional safety of electrical/electronic/programmable electronic safety-related systems*³¹ or BS EN 954-1: 1997 *Safety of machinery. Safety-related parts of control systems. General principles for design*.

5 Regardless of which standard is used, the design must take full account of the level of risk reduction that the system is required to achieve. This is because, in principle, the required level of risk reduction will have a significant influence on the design techniques needed for reliability and tolerance to faults.

General principles of safety-related control system design

6 The design characteristics for reliability and fault tolerance of a safety-related control system must stem from the basic risk assessment carried out on the machine. This assessment will identify aspects of the machine’s operation that create risks that may need to be reduced to an acceptable level.

7 Designers may employ a range of techniques to reduce the level of risk, many of which will not involve the use of safety-related control systems. For example, the use of fixed guards will prevent access to dangerous parts, and the provision of platforms and walkways will reduce the risk of falls from height. However, in many cases risks cannot be reduced to acceptable levels without incorporating safety-related control systems. In this case, the designer needs to understand and assess the contribution that these systems make to the reduction of risk, and the consequences for system reliability and fault tolerance. The more critical the role played by the safety-related control system, the more reliable and resistant to faults it must be. This property is known as the safety integrity of the system, which is a measure of how well the safety-related control system will perform the required safety function(s) under all stated conditions within a stated period of time. An adequate level of safety integrity may be achieved by a combination of:

- the reliability of the hardware and software; and
- the way the parts are combined in the design of the control system; and
- the use of diagnostic and testing techniques.

8 The designer should identify all the safety functions to be performed by the safety-related control systems and then specify their required safety integrity. This is known as the safety requirements specification and is of fundamental importance for achieving safety by design. The overall process is illustrated in Figure 31.

9 In designing a safety-related control system to achieve an appropriate level of safety integrity that is commensurate with its contribution to risk

reduction at the machine, consider the following:

- the reliability of the equipment that comprises the safety-related control system;
- the use of techniques such as redundancy and/or automatic diagnostics;
- how to prevent, as far as possible, faults in design and manufacture of hardware and software (eg software 'bugs' or faulty wiring);
- how to incorporate design features which may help the control system to recover from faults during operation (eg programme sequence monitoring);
- the behaviour of the safety-related control system under fault conditions (failure modes) and the desired reaction to these fault conditions;
- how to test the safety-related system(s) initially to show, as far as possible, that there are no design, or manufacturing or installation faults before the machine is put into operation;
- how to design periodic test and inspection procedures for the safety-related system(s) that can be applied periodically throughout the lifetime of the machine to show that no part (including both hardware and software) has changed or deteriorated beyond reasonable limits.

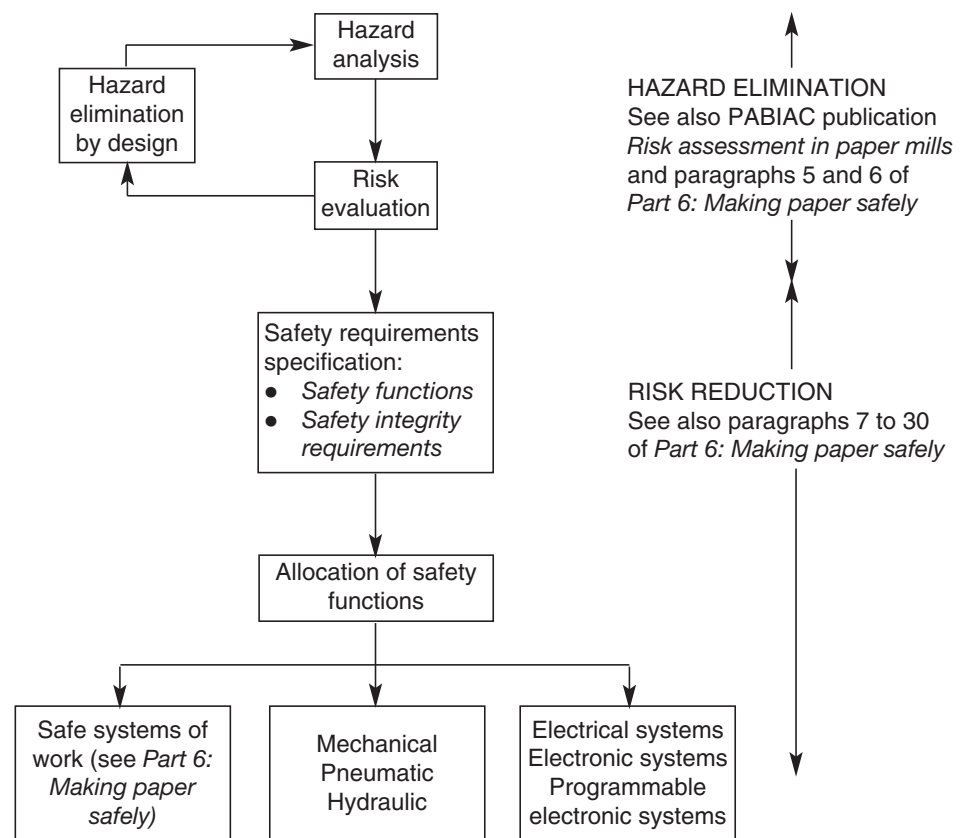


Figure 31 The risk control process

.....

10 These issues must be taken into account for all parts of the safety-related control system including hardware, software and the way that parts are combined during integration. Remember that the safety-related control system comprises everything necessary to carry out the required safety function (eg sensors, control logic and brakes).

Designing safety-related control systems

11 The following points aim to help the process of designing safety-related control systems:

- As part of the risk assessment exercise, determine which of the measures relies on a safety-related control system.
- For each safety function, determine the contribution required from the safety-related control system to achieve the necessary level of risk reduction.
- Draw up the safety requirements specification that relates the required safety integrity to each of the safety functions.
- Design the system, including the safety-related system.
- Validate the design to ensure that it meets the safety requirements specification. This should include consideration of the consequences of failures and may require the application of failure mode and effects analysis (FMEA) to the control circuits to determine the behaviour under fault conditions. (In the simplest form of FMEA the question 'What happens if a particular part fails to function as intended?' is asked.) The design should consider failures within purpose-built control units, such as electronic motor drives and any external to the drives. There are a number of standards on safety-related systems available that provide relevant guidance, the main two being BS EN 954-1 and BS EN 61508. It is essential that designers are familiar with these standards and are competent to apply their principles in practice.
- Document the process so that anyone who needs to can understand how and why the system meets the safety requirements.

12 These points are applicable to new machines, machines being refurbished to present-day standards and to older machines being reassessed for the purpose of improving safety.

Use of standards for safety-related control systems

13 The transposed harmonised standard BS EN 954-1: 1997 *Safety of machinery. Safety-related parts of control systems. General principles for design* provides requirements by which the safety-related parts of control

.....

systems of all operating media can be categorised in a qualitative manner according to their reliability and performance under fault conditions.

14 Guidance on the processes and procedures appropriate to the design and development of electrical, electronic and programmable electronic technology based safety-related control systems is set out in the basic safety publication BS EN 61508: *Functional safety of electrical/electronic/programmable electronic safety-related systems*. It provides guidance on all aspects of the design, development and use of safety-related control systems using the Safety Lifecycle Model (explained in BS EN 61508-1) to indicate the measures that should be applied from the conceptual design phase through to decommissioning. It describes quantitative and qualitative methods of control system analysis.

15 Machinery designers and/or control systems integrators should decide on the appropriate standard that can be applied to the safety-related control circuits (see Figure 32).

BS EN 954: 1997 Safety of machinery. Safety-related parts of control systems. General principles for design

16 This harmonised standard includes requirements by which the safety-related parts of control systems can be categorised in a qualitative manner according to their performance under fault conditions and where the behaviour of the system under fault conditions can be completely determined by analytical and/or test methods.

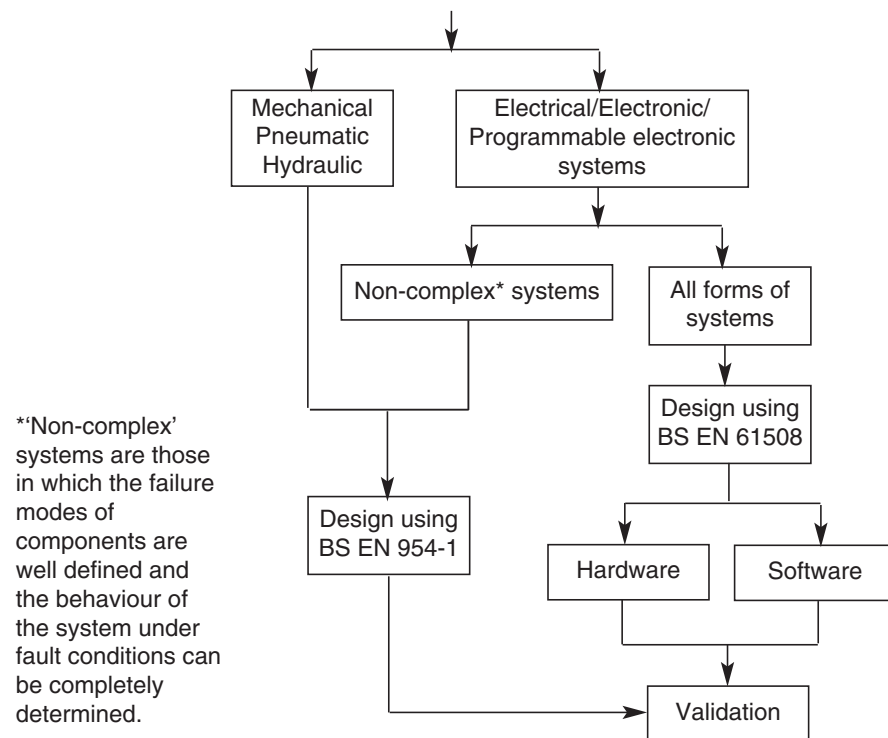


Figure 32 Use of standards

.....

17 The categories provide a basis for system design (in total or in part) according to the system's ability to resist the occurrence of faults and whether it will continue to perform its safety function after a fault has occurred. Fault resistance may be achieved by the reliability of the hardware and the way the component parts are combined in the design of the control system.

Categories of control systems used in BS EN 954-1: 1997

18 There are five main categories of performance of control systems in accordance with the standard, which are broadly:

Category	Basic requirements
B	Use of good engineering principles
1	Use of well-tried components and principles (reducing the probability of failure)
2	Incorporates a safety function check at machine start-up and may also be checked periodically (safety monitoring). A single fault may lead to the loss of the safety function
3	A single fault will not cause the safety function to fail (redundancy of hardware)
4	Two or more faults will not cause the safety function to fail (redundancy and monitoring)

Application of BS EN 954-1: 1997

19 It is important to bear in mind that safety-related parts of control systems may not neatly fit into a single category, particularly if they use different energy sources - a control system can incorporate electrical, electronic, programmable electronic, pneumatic or hydraulic devices.

20 The categories should not be regarded as hierarchical with regard to safety. For example, a single positively operated safety switch element, manufactured to a published safety standard will, itself, meet the requirements of Category 1 but not the criteria for higher categories. However, its level of safety performance may be considered at least as reliable as technologies that meet Categories 2 and 3. Therefore, the selection of categories for the safety functions on papermaking machines is a matter of judgement that should be based on the risk assessment and failure analysis.

21 Additional information can be found in BS EN ISO 13849-2: 2003 *Safety of machinery. Safety-related parts of control systems. Validation*³² on the validation of safety-related parts of machinery control systems that have been designed in accordance with BS EN 954-1: 1997 and published document PD CR 954-100: 1999 *Guide on the use and application of EN 954-1: 1996*.

.....

BS EN 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems

22 This standard is a basic safety publication in the IEC and has been formally adopted within Europe but not harmonised to a specific Directive. It is regarded as the authoritative good practice in this field.

23 BS EN 61508 contains advice on the system hardware and software architectures aimed at achieving an adequate level of safety integrity. A quantitative analysis concept in BS EN 61508 is that of safety integrity levels (SILs), which specify the failure rate (for high demand and continuous mode safety functions) and probability of failure on demand (for 'on demand' safety functions) for each safety function. SILs range from SIL1 to SIL4, with the latter having the highest level of safety integrity. The failure rates allocated to SIL values are shown in the following table; this definition of SILs is most appropriate in machinery safety applications. The initial risk assessment process determines the SIL of a safety function, the analysis of the machine's safety requirements and the level of risk considered acceptable in the specific application. It is essential that a competent person carries out this analysis.

SIL	Dangerous failure rate of the safety function (per hour)
4	$\geq 10^{-9}$ to $< 10^{-8}$
3	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-6}$ to $< 10^{-5}$

24 A SIL is assigned to each safety function in a safety-related control system and has a strong influence on the requirements that have to be taken into account during its design and integration. These measures, together with the calculation of failure rates for the safety-related control systems, are an integral part of the process of achieving a safe design.

25 Part 5 of BS EN 61508 gives examples of methods for the determination of SILs for allocation to safety functions. Note that the examples given in BS EN 61508-5 only illustrate general principles and should not be used directly without development to take into account the risk factors (especially tolerable risk) associated with specific applications.

26 A machinery sector implementation of BS EN 61508, IEC 62061, has been approved for publication as both an international standard and European Standard. IEC 62061/EN 62061 will provide machine designers with guidance on how to develop and validate safety-related electrical, electronic and programmable electronic control systems. It is likely that EN 62061 will have the status of a transposed harmonised standard under the Machinery Directive (98/37/EC). It is anticipated that it will be available as BS EN 62061 by mid-2005.

.....

Comparing SILs and categories

27 The fact that categories in EN 954-1 and SILs in BS EN 61508 both have allocated numbers 1 to 4 does not mean that there is a direct relationship between them. Both standards are written from different perspectives so SILs and categories are not comparable measures. Categories are not to be assumed as hierarchical measures for all applications but SILs are hierarchical because they relate to probabilities of failure.

28 As an approximation, the relationship between the required categories and SILs assigned to safety-related control functions to be implemented by electrical, electronic or programmable electronic safety-related control systems at a typical machine may be considered to be:

Category of safety-related control function in accordance with BS EN 954-1	Target failure measure for safety-related control function in accordance with BS EN 61508
1 or 2	SIL 1
3	SIL 2
4	SIL 3

29 It is very important to note that this approximation can only be used when considering the entire safety function that will be implemented by a safety-related control system at a papermaking machine. It does not apply to only a part of a safety-related control system.

Testing and preventative maintenance

30 To maintain safety integrity, all safety-related control systems should be tested regularly as part of a preventative maintenance strategy. For any particular safety-related control system, the frequency of testing should be determined taking into account the required safety integrity, the demand rate on the system, the degree of fault tolerance, and the diagnostic capabilities of the safety-related control systems. For example, consider a machine with an overspeed detection and protection system in which failure of the system could lead to injury in the event of the machine exceeding its maximum speed. It is likely that the demand rate on the safety function (ie prevention of speed above a set value) will be very low in normal operation and its design may be such that a potentially dangerous fault could remain undetected until a demand is placed on the system. In this type of safety-related control system, the overall safety integrity could be improved by arranging for the safety function to be tested as part of a routine maintenance programme at a frequency recommended by the designer, with instructions on the maintenance regime being included in the machine's documentation.

.....

Modifications to safety-related control systems

31 Typical reasons for modification of a safety-related control system include changes to the conditions of use, incident/accident experience, and modification of the machine or its operating modes. The following points are applicable when modifications are being made:

- The proposed modification should be assessed to determine the contribution that the modified safety-related control system will make towards risk reduction. The proposed modification should then be analysed to establish the impact on the hardware and software elements of the safety-related control system. This should include an appropriate review of the failure modes, particularly new failure modes that may be introduced by the modification, and their consequences for safety at the papermaking machine.
- Where it is agreed that a modification can be made without an adverse impact on safety, hardware and software changes to the safety-related control system should be processed within a structured work programme incorporating, as appropriate, specification, design, integration, installation, commissioning, and validation.
- The changes made to the safety-related control system should be documented and marked with appropriate version numbers and dates.
- Before re-instating the papermaking machine into normal operation, it is recommended that the modification work be reviewed by a competent person to ensure that the work has been properly implemented.

Programmable electronic safety-related control systems

32 In general, programmable electronic safety-related control systems on papermaking machines should make use of devices that have been specifically designed and assessed for use in safety-related applications. General industrial programmable logic controllers (PLC), or general-purpose computers and similar devices will usually not have enough safety integrity for safety-related applications unless additional measures are employed to protect against failure and the overall arrangements are assessed against relevant standards.

33 The safety integrity level (SIL) claimed for any PLC or similar device that has been supplied for use in safety-related applications should be equal to that of the most critical safety function that it performs. For papermaking machines, it is recommended that single PLCs and similar programmable devices used in safety-related applications should, in themselves, be capable of satisfying the requirements of SIL3 in accordance with BS EN 61508. This also applies to the application software (eg ladder logic, function blocks).

34 Programmable safety-related control systems contain software components so, as well as considering the design features needed to control

.....

the effects of random hardware failures, the designer must take steps to ensure that the software does not contain faults, known as systematic faults, that can lead to danger. Since it is generally recognised that software cannot be tested with enough confidence to detect all such faults, the preferred approach to minimising the likelihood of errors being introduced during the specification and development of the safety-related software is to ensure that the project is well managed within a structured framework, with progressive verification and validation of the software components throughout the development cycle including final development work during commissioning activities. It is strongly recommended that such work be carried out within a formal quality control system.

35 Within this structured framework, the accuracy and completeness of the initial specification for the requirements for safety performance in the control system is of fundamental importance. If the initial specification is at all deficient, the follow-on stages in the development cycle will not prevent systematic faults from being inadvertently introduced, regardless of how rigorously they are implemented.

36 A programmable safety-related control system at a papermaking machine may also include non-programmable technologies, such as electrical and electronic parts (eg gate switches, transposing relays etc). These parts normally have assigned safety performance categories to BS EN 954-1: 1997. Before they are integrated into a programmable safety-related control system it is important that the designer/integrator is able fully to determine whether their application will allow the safety function to achieve the appropriate SIL in accordance with BS EN 61508.

37 It is essential that work on the specification, design and development of programmable safety-related control systems is carried out by people who are competent in this particular field and who, in particular, are skilled in the concepts of capturing safety requirements, safety validation, safety-related system architecture design, hardware and software realisation, and project safety assurance. The Institution of Electrical Engineers, in conjunction with the British Computer Society, has published guidance on the competence requirements for people working in this field.³³

Non-programmable safety-related control systems

38 This type of safety-related control system does not contain programmable electronic parts, although it is recognised that systems implemented in non-programmable technologies may in themselves be quite complex in nature. They can include electromechanical relay-based systems, hydraulic and pneumatic systems, and mechanical systems that can be assessed using deterministic principles.

39 The general principles for the design of these systems are similar to those used for programmable electronic systems. This is because the requirements

.....

should be based on a fundamental assessment of the risks created by the machine and the extent to which the safety-related control system is needed to reduce those risks to an acceptable level, taking into account all other measures taken to control the level of risk.

Particular safety functions on papermaking machines

40 There are three particular safety functions on papermaking machinery that need to be given careful consideration - emergency stop, the speed-control system and pre-start warning device. There can be many other safety functions that will also need to be considered, including guard interlocking and hold-to-run control.

Emergency stop

41 The emergency stop function should be designed in accordance with BS EN 60204-1: 1998 *Safety of machinery. Electrical equipment of machines Part 1: General requirements* and BS EN 418: 1992 *Safety of machinery. Emergency stop equipment, functional aspects. Principles for design*. Stopping categories 0 or 1 may be used. Adequate environmental protection of the system hardware should be provided to reduce the probability of dangerous failures.

42 Since an emergency stop circuit can remain inactive for long periods of time it is important that the reliability and architecture of the design solution, and the maintenance and testing requirements, are such that there is a high confidence that it will function effectively on demand.

43 The emergency stop function should not be reliant on the correct operation of a machine control system that deals with other safety functions and where unrevealed failures in the control system would negate the operation of the emergency stop functions. In such cases, an independent emergency stop control system should be provided.

Speed-control system

44 The risks that occur in the event of overspeed at a machine arising from control system failure can be significant, particularly when the operator is working inside the hazardous area, for example to remove broke. The use of a hold-to-run or enabling device by the operator or an accompanying person will not eliminate the risks completely, so the control system should be designed, or modified, to minimise the risk of injury from:

- unexpected increase in crawl speed, hold-to-run speed or other pre-set low speed;
- unexpected start-up while machines are held at stop condition by the control system only, ie a Category 2 stop as described in EN 60204-1.

.....

45 Where reasonably practicable, to recognise a deviation from a set speed condition where danger could arise (including zero speed) design options should include one or more of the following:

- Monitoring techniques to enhance the safety features of the speed set point control circuitry and the reliability of the speed detection devices. Dangerous deviations detected by monitoring should initiate a safe stop.
- A speed reference tachometer/encoder/motion transducer or overspeed trip/detection device automatically set for use during slow speed or stop conditions. Activation should initiate a safe stop.
- Allow more time for machine operators to react by, for example:
 - modifying the acceleration or current limit control signals;
 - modifying inertia compensation control signals.

Pre-start warning device

46 Failure of a pre-start warning device could result in the machine being started before the waiting time has elapsed (ie people would not have enough time to leave a hazardous area on hearing the alarm) or the machine could be started up without a warning being sounded.

47 The aim should be to ensure that the pre-start warning system would have very high reliability and availability and be effective so that the warning signals can be recognised by all personnel who would be exposed to danger when machines are started.

48 The control system safety reliability considerations should include:

- monitoring of components so that recognised failures will prevent start-up;
- applying redundancy techniques to the safety critical parts of the warning system.

49 The effectiveness considerations should include:

- selecting the audible warning, or other warning indication device (including voice messages), so that it is easily understood by the workforce at risk, taking account of hearing impairment from medical conditions or use of hearing protection (PPE);
- where there are a number of separate machines, ensuring that each device dedicated to a particular machine is recognised by those at risk from the particular machine.

REFERENCES

- 1 *Working with ionising radiation. Ionising Radiations Regulations 1999. Approved Code of Practice and guidance L121* HSE Books 2000 ISBN 0 7176 1746 7
- 2 *Buying new machinery* INDG271 HSE Books 1998 (Available free for single copies or in priced packs on ISBN 0 7176 1559 6)
- 3 BS EN 1034-1: 2000 *Safety of machinery. Safety requirements for the design and construction of paper making and finishing machines. Common requirements*
- 4 BS EN 1034-3: 2000 *Safety of machinery. Safety requirements for the design and construction of paper making and finishing machines. Winders and slitters, plying machines*
- 5 *Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice (Revised) L22* HSE Books 1998 ISBN 0 7176 1626 6
- 6 *5 steps to risk assessment* INDG163 (rev1) HSE Books 1998 (Available free for single copies or in priced packs on ISBN 0 7176 1565 0)
- 7 *Guide to managing health and safety in paper mills. Part 2: Risk assessment in paper mills* Part of PABIAC binder ISBN 0 7176 2942 2
- 8 BS EN 294: 1992 *Safety of machinery. Safety distances to prevent danger zones being reached by the upper limbs*
- 9 *Guide to managing health and safety in paper mills. Part 1: Application of the Provision and Use of Work Equipment Regulations to the paper and board industry* HSE Books 1996 ISBN 0 7176 1287 2
- 10 BS EN 954-1: 1997 *Safety of machinery. Safety-related parts of control systems. Part 1: General principles for design*
- 11 BS EN 60204-1: 1998 *Safety of machinery. Electrical equipment of machines. General requirements*
- 12 BS EN 418: 1992 *Safety of machinery. Emergency stop equipment, functional aspects. Principles for design*
- 13 *Guide to managing health and safety in paper mills. Part 5: Control of contractors in paper mills* HSE Books 2000 Part of PABIAC binder ISBN 0 7176 2942 2

-
- 14 *Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance* L101 HSE Books 1997 ISBN 0 7176 1405 0
 - 15 *Safe work in confined spaces* INDG258 HSE Books 1997 (Available free for single copies and in priced packs on ISBN 0 7176 1442 5)
 - 16 *Guide to managing health and safety in paper mills. Part 4: Prevention of heat stress in paper and board mills* HSE Books 2000 Part of PABIAC binder ISBN 0 7176 2942 2
 - 17 *Safe use of lifting equipment. Lifting Operations and Lifting Equipment Regulations 1998. Approved Code of Practice and guidance* L113 HSE Books 1998 ISBN 0 7176 1628 2
 - 18 *Manual handling. Manual Handling Operations Regulations 1992 (as amended) Guidance on Regulations* L23 (Third edition) HSE Books 2004 ISBN 0 7176 2823 X
 - 19 *Guide to managing health and safety in paper mills. Part 3: Manual handling in paper mills* Part of PABIAC binder ISBN 0 7176 2942 2
 - 20 *Slips and trips: Guidance for employers on identifying hazards and controlling risks* HSE Books 1996 HSG155 ISBN 0 7176 1145 0
 - 21 *Workplace health, safety and welfare. Workplace (Health, Safety and Welfare) Regulations 1992. Approved Code of Practice and guidance* L24 HSE Books 1992 ISBN 0 7176 0413 6
 - 22 *Compressed air safety* HSG39 HSE Books 1998 ISBN 0 7176 1531 6
 - 23 *Lighting at work* HSG38 HSE Books 1997 ISBN 0 7176 1232 5
 - 24 *Personal protective equipment at work. Personal Protective Equipment at Work Regulations 1992. Approved Code of Practice and guidance* L25 HSE Books 1992 ISBN 0 7176 0415 2
 - 25 *Managing vehicle safety at the workplace* INDG199 HSE Books 1995 (Available free for single copies or in priced packs on ISBN 0 7176 0982 0)
 - 26 *Workplace transport safety: Guidance for employers* HSG136 HSE Books 1995 ISBN 0 7176 0935 9
 - 27 *Reducing noise at work. Guidance on the Noise at Work Regulations 1989* L108 HSE Books 1998 ISBN 0 7176 1511 1
 - 28 *Sound solutions: Techniques to reduce noise at work* HSG138 HSE Books 1995 ISBN 0 7176 0791 7

.....
29 *Noise assessments in paper mills* PBIS1 HSE Books 2000 (web only version available at: www.hse.gov.uk/pubns/papindx.htm)

30 *Noise mapping in paper mills* PBIS2 (web only version available at: www.hse.gov.uk/pubns/papindx.htm)

31 BS EN 61508: 2002 (Parts 1-7) *Functional safety of electrical/electronic/programmable electronic safety-related systems*

32 BS EN ISO 13849-2: 2003 *Safety of machinery. Safety-related parts of control systems. Validation*

33 *Safety, competency and commitment: Competency guidelines for safety-related system practitioners* Institution of Electrical Engineers 1999 ISBN 085296787X

FURTHER READING

Management of health and safety at work. Management of Health and Safety at Work Regulations 1999. Approved Code of Practice L21 HSE Books 2000 ISBN 0 7176 2488 9

Successful health and safety management (2nd edition) HSG65 HSE Books 1997 ISBN 0 7176 1276 7

Other British/European Standards

BS EN ISO 12100-1: 2003 *Safety of machinery. Basic concepts, general principles for design. Part 1: Basic terminology, methodology*

BS EN ISO 12100-2: 2003 *Safety of machinery. Basic concepts, general principles for design. Part 2: Technical principles*

BS EN 953: 1998 *Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards*

BS EN 1050: 1997 *Safety of machinery. Principles for risk assessment*

BS EN 1088: 1996 *Safety of machinery. Interlocking devices associated with guards. Principles for design and selection*

prEN 12437: *Means of permanent access to machines and industrial plant*

Part 1 - *Choice of a fixed means of access between two levels*

Part 2 - *Working platforms and gangways*

Part 3 - *Stairways, stepladders and gangways*

Part 4 - *Fixed ladders*

BS 4211: 1994 *Specification for ladders for permanent access to chimneys, other high structures, silos and bins*

FURTHER INFORMATION

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA. Tel: 01787 881165
Fax: 01787 313995. Website: www.hsebooks.co.uk

HSE priced publications are also available from good booksellers.

British Standards are available from BSI Customer Services, 389 Chiswick High Road, London W4 4AL. Tel: 020 8996 9001 Fax: 020 8996 7001.

Confederation of Paper Industries publications are available from Confederation of Paper Industries, 1 Rivenhall Road, Swindon, Wiltshire SN5 7BD. Tel: 01793 889600.

.....

.....