Annex A

ARAMIS Audit Manual

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The ARAMIS Audit Manual

1. Introduction

Purpose

The purpose of the ARAMIS audit is to assess the quality of the risk management system of a major hazard plant responsible for preparing major hazard scenarios, devising barriers and keeping the barriers, which prevent major hazard scenarios from materializing, effective. The ARAMIS audit only considers the control of scenarios and their related barrier combinations *in the primary business process* of the major hazard plant. The audit does not may much attention to the policy and strategic levels of safety management

Scope

This focus on scenarios and barriers also implies that the audit does not cover the full safety or risk management system, but only the relevant parts thereof, i.e. those parts that have a direct influence on the life cycle of barriers. Also, the actual definition of scenarios and their barriers do not form part of the audit. However, the *process* of scenario development and barrier formulation is covered in the assessment.

2. Underlying concepts

Introduction

To be able to understand the structure of the ARAMIS audit as well as to conduct it as intended, several underlying concepts are important. Some of these will be briefly discussed below. The audit is part of an extensive risk evaluation method that starts with the building of 'bow-ties' and the identification of scenarios herein. Some knowledge of these parts is necessary to understand the position of the audit within the method. However, neither the full methodology nor the models used therein will be discussed in this manual. They are covered in supporting Aramis documentation

Barrier typology

The notion of a barrier comes from the well-known Hazard-Barrier-Target model that was introduced by Haddon in the 1970s. Optimally, the Barrier prevents the energy represented by the Hazard from reaching the Target. However, the Barrier can have either a preventive function, or a control, mitigation or repression function. This HBT-model will not be elaborated further here. A basic understanding of the HBT-model however, will be assumed in what follows. (See WP1 documents, especially 'What is a barrier?')

In general, three types of barriers are distinguished:

1. Passive hardware barriers
2. Active hardware barriers
3. Behaviour, as an essential element of the barrier

Ad 1. Passive hardware barriers are those barriers that perform their function without any intervention, whether they control expected flows of energy or protect against unexpected ones. Examples are dykes and crash barriers.

Ad 2. Active hardware barriers do need some activation to become functional. However, within this classification scheme the intervention is not human, but may be hardware or software driven. Examples are relief valves, interlocks and automatic shutdown systems

Ad 3. Behaviour pertains to active barriers that involve some kind of human intervention. This is either to detect or diagnose a threat, e.g. from observation, instrument readings or warnings, or to respond to it, e.g. by closing down equipment, putting on protective equipment or fighting a fire.

Phases of barrier

In addition to the typology above, it is often convenient to distinguish between 3 separate phases with regard to the functionality of barriers.

1. Detection: the hardware or person identifies that safety is threatened, e.g. detection of toxic or flammable material, set point is exceeded
2. Diagnosis: the correct response is chosen, depending on pre-programming or procedure, or on analysis and choice
3. Action: the barrier is operated to prevent or mitigate the threat.

Any of these three phases can be accomplished through human intervention or by hardware. The table on p 6 of this manual develops this classification further.

Schematic overview of barrier types

In the figure below, all three types of barrier (hardware and behavioural) are shown.

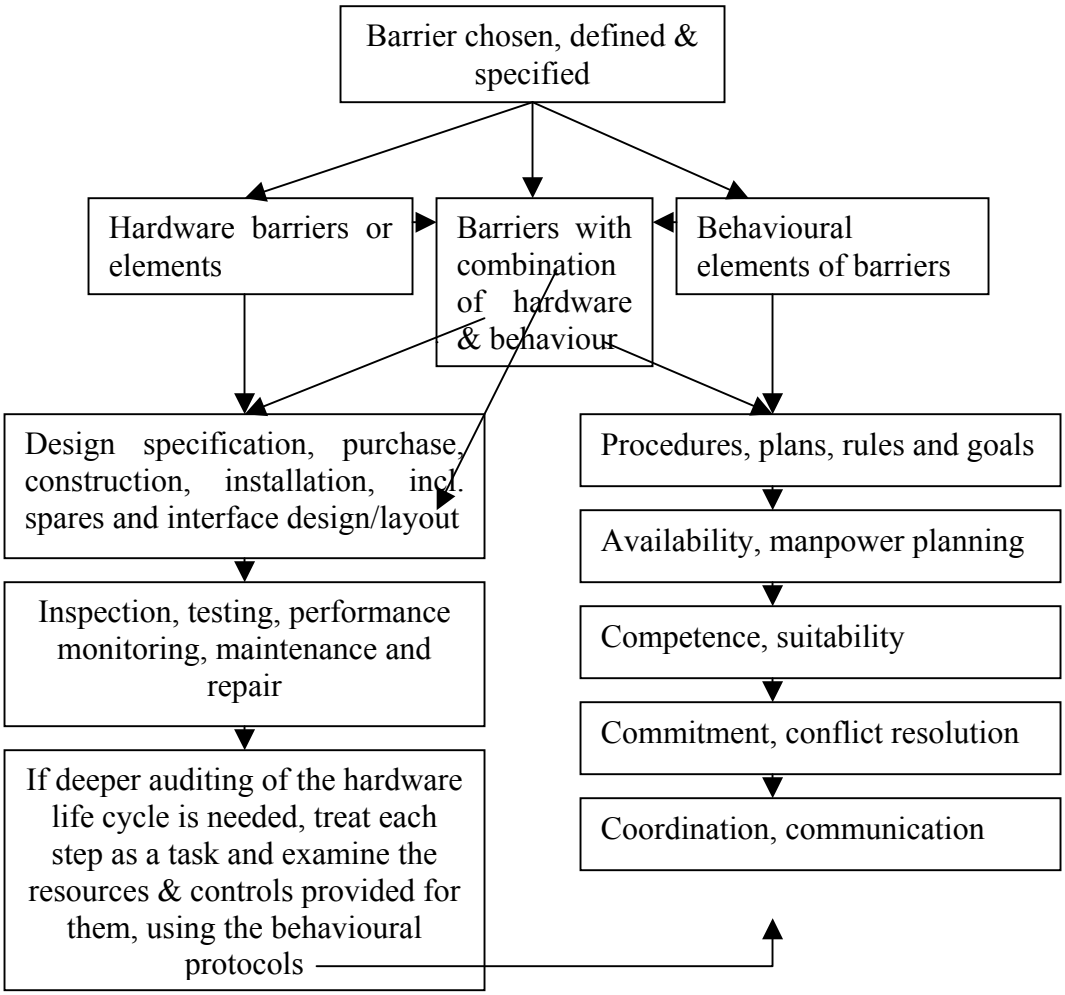


Figure 1 – The relationship of barrier types and management influences

On the left hand side of the figure the generic life cycle of a hardware barrier is shown, up to point of its use and maintenance. Good management of these steps ensures the continuing effectiveness of the hardware barriers. On the right hand side of the figure those generic management influences are specified that have a direct bearing on the quality of behaviour in relation to the functioning of barriers. Good management of these aspects ensures the continuing effectiveness of the behavioural elements of the barriers. In the ARAMIS audit the focus is primarily on the direct functioning of the hardware barriers and therefore the starting point for their assessment is the barrier life cycle and the operating and maintenance steps in particular. However, if required, any step within the life cycle of barriers can be assessed separately and more thoroughly by examining the quality of the behavioural controls and resources (the right hand side of the figure) that management has assigned to it (lowest box on the left hand side).

In relation to the ARAMIS audit, the figure depicts the assessment strategy with regard to the quality of management of individual barriers. This will explained further below.

Schematic overview of barrier life cycle

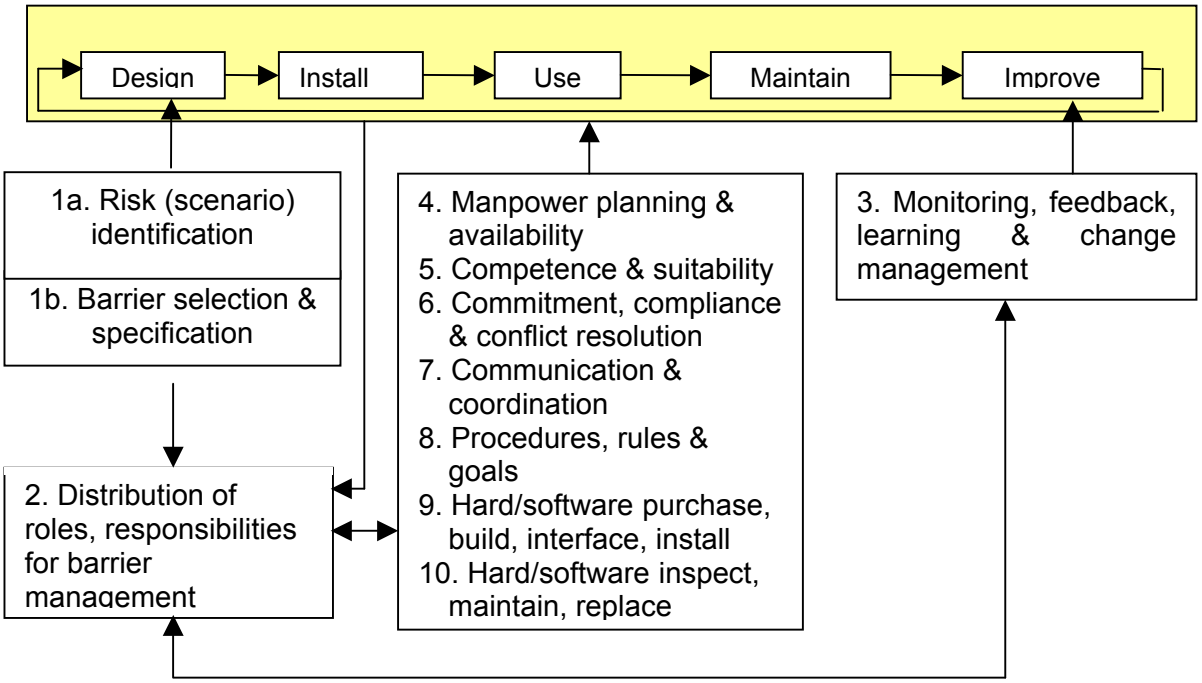


Figure 2 – The barrier life cycle

In figure 2 above the full life cycle of barriers is depicted. It is also an overview of the different parts of the ARAMIS audit which will be set out as separate protocols below. The figure illustrates which parts of the safety management system have a substantial bearing on which parts of the barrier life cycle.

Delivery systems

Management's primary influence on safety is provided through, what will be called in the ARAMIS audit, delivery systems. These delivery systems provide the required behaviour that is needed for optimal performance of a barrier. The delivery systems are generic management influences and as a whole define the full impact of management on barrier functioning.

The ARAMIS audit distinguishes 2 hardware delivery systems and 5 behavioural delivery systems.
The 2 hardware delivery systems are those which manage the following steps of the hardware barrier life cycle:

1. Purchasing, building and installing the barriers and their interface with human operators.
2. Inspecting, monitoring and maintaining the barriers and their interfaces.

The 5 behavioural delivery systems are:

1. Manpower planning & availability
2. Competence & suitability
3. Commitment, compliance & conflict resolution
4. Communication & coordination
5. Procedures, rules & goals

These delivery systems are interdependent in that the behaviour required for each barrier to function properly is a matter of barrier choice and consideration. Importantly, not all delivery systems have a similar bearing on each barrier. For instance, communication is important only when several people are working together or in succession with or on the same barrier. Competence is more important when the skills required to work with or on a barrier cannot be covered through procedures alone. And so on.

Different barrier types rely on different delivery systems. In the ARAMIS audit eleven types of barriers are distinguished (table 1.) They differ in whether hardware, software or people perform the detection, diagnosis and action phases of the functioning of the barrier. Where hardware or software performs these, the hardware delivery systems are paramount. Where people perform them, the behavioural delivery systems are paramount.

Apart from these delivery systems the management system also has to manage the processes of risk analysis and barrier selection and design, and the process of learning from experiences gained in all steps of the life cycle and of managing change. These functions of management are shown in figure 2 as well and will be assessed in the ARAMIS audit.

	Barrier	Examples	Detect	Diagnose/ Activate	Act
1	*Permanent – passive – MORT control*	Pipe/hose wall, anti-corrosion paint, tank support, floating tank lid, viewing port in vessel	none	none	Hardware
2	*Permanent – passive – MORT barrier*	Bund, dyke, drainage sump, railing, fence, blast wall, lightning conductor, bursting disc	none	none	hardware
3	*Temporary – passive* Put in place (and removed) by person	Barriers round repair work, blind flange over open pipe, helmet/gloves/safety shoes/goggles, inhibitor in mixture	none	none (human must put them in place)	Hardware
4	*Permanent – active*	Active corrosion protection, heating/cooling system, ventilation, explosion venting, inerting system	none	None (may need activation by operator for certain process phases)	hardware
5	*Activated – hardware on demand – MORT barrier or control*	Pressure relief valve, interlock with "hard" logic, sprinkler installation, p/t/level control	hardware	hardware	hardware
6	*Activated – automated*	Programmable automated device, control system or shutdown system	hardware	software	hardware
7	*Activated – manual* Human action triggered by active hardware detection(s)	Manual shutdown or adjustment in response to instrument reading or alarm, evacuation donning breathing apparatus or calling fire brigade on alarm, action triggered by remote camera, drain valve, close/open (correct) valve	hardware	Human (S/R/K)	human/ remote control

8	*Activated – warned* Human action based on passive warning	Donning ppe in danger area, refraining from smoking, keeping within white lines, opening labelled pipe, keeping out of prohibited areas	hardware	Human (R)	human
9	*Activated – assisted* Software presents diagnosis to the operator	Using an expert system	hardware	software – human (R/K)	human/ remote control
10	*Activated – procedural* Observation of local conditions not using instruments	(Correctly) follow start up/shutdown/batch process procedure, adjust setting of hardware, warn others to act or evacuate, (un)couple tanker from storage, empty & purge line before opening, drive tanker, lay down water curtain	human	Human (S/R)	human/ remote control
11	*activated – emergency* Ad-hoc observation of deviation + improvisation of response	Response to unexpected emergency, improvised jury-rig during maintenance, fight fire	human	Human (K)	human/ remote control

Table 1 – Classification of barriers in the ARAMIS audit

3 Audit strategy

Introduction

This manual only discusses the efforts of the audit team, i.e. the team that assesses the quality of barrier management of the company under scrutiny. The ARAMIS audit process consists of seven major steps.

1. Choice of scenarios / choice of related barriers
2. Mapping of company's SMS on ARAMIS audit structure and preparation of audit questionnaire
   a. Decide on depth of audit
   b. Initial review of documents
3. Conduct audit and make assessments
   a. Process of scenario formulation
   b. Life cycles of selected barriers
   c. Behavioural delivery systems
   d. Monitoring, feedback, change and learning capabilities
4. Feedback of primary results to company
5. Quantification of audit results
6. Draft report
7. Final report

It is stressed here that the preparation phase of the audit involves a significant body of work (step 2 in the list above.) All steps will be outlined further below.

Audit team

The audit team consists of at least *two* people, preferably one member with a technical background and one with a social scientific background. Previous audit experience of one or more members is mandatory. Obviously, the number of members on the audit team both determines the thoroughness of the assessment process and the speed with which the audit can be conducted.
The audit team members should distribute roles and functions before the audit.

(For the development phase of the ARAMIS audit another audit team member is recommended. This member plays the role of observer during the audit and is charged with watching and monitoring the audit process and providing feedback to the project and the auditors.)

Time schedule

Usually, the full audit consists of three episodes: a period that precedes the actual audit, during which the audit team familiarises itself with the plant and prepares and assembles the audit documents, the on-site audit and a period during which the assessments made are quantified as well as the writing of the audit report takes place.

Roughly, the following schedule can be indicated:

1. Pre-audit – basis information of the company should be available for review at least *two weeks before* the start of the audit.
2. Audit – scheduled for one week from Monday till Friday.
3. Post-audit – the draft report should be made available to the company within *one month* after the audit.

Importantly, the pre-audit should involve at least one visit to the plant by the audit team to make final arrangements for the audit and to gather enough information to make a mapping of the safety management system possible (discussed below.)

List of documents

The following documents should be made available for review before and/or during the audit:

- Safety policy
- Loss control manual / safety manual
- Organograms/organisational charts
- Responsibilities of key managers/personnel for delivery systems
- Job descriptions of key personnel
- List of safety related procedures
- Goals/targets for safety (present year)
- Safety report of previous year
- Risk analyses of the section to be audited.
- List of the most dangerous processes, activities, installations, …
- ISO 9000 certificate or implementation status
- ISO 14000 certificate or implementation status
- Safety meeting schedules
- Information about major works, large maintenance projects, change projects
- …

Below, all steps within the audit process will be discussed in more detail

4 Step 1 – Choice of scenarios / related barriers

Description

The management of each scenario and every barrier cannot be assessed. A responsible choice should be made, based on severity and impact.

Primarily, this step is not an audit team activity. However, the choice of scenarios and their associated barriers determines the focus of the audit and therefore it should be taken in close connection with the audit team.

The result of this step is a set of scenarios and barriers that serves as a point of reference for the audit. The quality of management of these barriers will be assessed during the audit and will be generalised to the whole barrier management system and will be quantified subsequently.

Scenarios

For each site a choice needs to be made of the scenarios which will be chosen for the assessment study. The choice needs to take account of the need to look at a representative sample of the risk control problems of the company related to loss of containment. It will obviously need to focus on the most serious risks, but other teams need to define what those are and how to choose them.

Scenarios will be required both from the operating phase of the plant (including start-up, shutdown, and non-nominal operations) and from maintenance activities during which loss of containment can occur. Questions which need to be decided here are:

- How many scenarios?
- From what area(s) of the plant?
- Taken from what steps in the life cycle?

Barriers

The company will then need to provide to the research team the information about how it believes it controls the chosen scenarios. The generic scenario and barrier diagrams (the bow ties) will guide the dialogue in this step. The company will inform the team what form of barrier is chosen to fulfil each safety function defined in the generic diagram. (It may be that the site has to organise an internal activity to collect and present this information.) The result of this dialogue will be a mapping of the company's choice of barriers onto the generic bow ties.

As indicated in table 1 on barriers, it is likely that many safety functions will be carried out by barriers consisting of several elements, chosen from passive or active hardware and active behavioural elements, which must be matched together. These elements have been identified as the steps to 'detect', 'diagnose' and 'activate' the barrier function. The specification from the company should be phrased in terms of the barriers which fulfil the *complete safety functions* in the bow tie, with all three elements covered[1], giving a complete description of all the barrier elements necessary to fulfil that complete function. Appendix 1 gives a table for recording the barriers to be used

It is important that the generic bow ties contain all relevant barriers. This will guarantee that the behavioural/procedural elements in barriers are suitably represented. (For example, by all bow ties that there should be a generic barrier fulfilling the function of keeping the process within the boundaries of the design envelope in relation to a range of parameters. This function will often be fulfilled by the skill of process operators.

[1] Except for passive barriers, which do not need the 'detect' and 'diagnose' elements.

Moreover, in the scenarios dealing with the maintenance phase of the plant the majority of the barriers will consist largely of behavioural or procedural elements.)

The following table gives an indication of how the list of barriers may look:

	Barrier	Detect	Diagnose/ Activate	Act
1	Safety relief valve. X1110	Pressure reading instrument A1046	Set point modified by control room operator based on procedure	Motorised with feedback of actual position
2	Fitter breaks opens correct line for maintenance	Marked on piping diagram. Pipes colour coded for contents. Tag with number	Fitter compares permit to work to piping diagram and labels	Unbolts flange and breaks seal
3	Use of chlorine suit and respirator	Signs indicate zones for use	Obey signs and put on & adjust suit & respirator	Conduct task with suit on, respirator working & suit intact
4	Bund around storage tank	Not applicable	Not applicable	Collect & retain spill from tank
5	etc			
6				
7				
8				
9				
10				
11				

Choice of barriers

The first step in tailoring the audit to the specific site is to make a choice of which types of barrier from the chosen scenarios are going to be used as the focus of the audit. If the choice of scenarios is relatively limited, it may be possible to consider all the barriers which the company has defined. Otherwise a choice will have to be made. The criterion for this choice is that it should enable the audit team to evaluate all of the relevant aspects of the safety management system of the company. To ensure this, it is important to classify the barriers into a typology which links to the way in which the barrier and its effectiveness must be managed.

The classification in table 1 should be used as basis for this choice of barriers and at least one example from each category should be used as example by the different protocols for which it is significant. Some guidance on this is as follows (numbers are those indicating type of barrier in table 1 – where numbers are separated with a slash (/), an example can be chosen out of either of the two [or one of the several] types):

- For the **hardware** life cycle protocols at least the following types: 1, 2, 3, 4, 5, 6/9, 7, 8
- For **procedures** and **commitment**: 3/8, 7/10, 9, 11
- For **competence**: at least one at each level of Skill/Rule/Knowledge
- For **communication**: 3/7/9/10/11 requiring coordinated action of more than one person
- For **availability**: 3, 7/10, 11

If the barrier is made up of active hardware the emphasis must be on inspection, monitoring and adjustment.
If the barrier consists of passive hardware elements the audit should almost exclusively concentrate on construction and installation, with some concern for maintenance, to ensure the passive barrier is not compromised by modifications and is kept functioning to specifications.
If the barrier has behavioural elements these can be audited using the behavioural delivery systems:

- The procedures, which describe the required behavioural in relation to the barrier
- The availability of individuals whose required behaviour forms (an element of) the barrier function
- The competence of individuals to carry out the required behaviour
- The commitment of individuals to carry out the required behaviour at the right moment, with the right care and alertness in order to control the risk
- The necessary communication and coordination in cases where more than one individual's behaviour is responsible for the effectiveness of the barrier.

Again, see figure 1 for a summary of these links

Output of step 1

1. A set of relevant scenarios
2. A set of related barriers implemented by the company to prevent the occurrence or development of these scenarios
3. A categorisation of the elements of the barrier for detection, diagnosis and action
4. Proposed links from these elements to the delivery systems which must be audited to assess the management of the effectiveness of the barriers

5 Step 2 – Mapping of SMS on ARAMIS Audit structure

Description

This is a most important and rather time-consuming step of the audit. Mapping is the projection of the company's specific SMS onto the ARAMIS audit structure and it involves the linking of the different components of the ARAMIS audit depicted in figure 2 to the relevant parts of the SMS of the company under investigation. This should be done at least 2 weeks in advance of the on-site audit.
The mapping should be based on documentation of the company, as well as interviews conducted during the pre-audit visit. The interviews are needed either to verify the audit team's initial impressions or to add to the information from the available documentation if this does not provide enough information to conduct the mapping exercise. The mapping should make clear *who* will be asked *what* during the audit.
Documentation that should be consulted during the pre-audit visit is listed below.

Documentation for mapping

- Safety management system / Loss control manual / Safety book
- Organograms
- Key managers/personnel for delivery systems
- Job descriptions of key personnel
- Safety meeting schedules
- …

Mapping

Based on information taken from the documentation specified above as well as interview(s) conducted during the pre-audit visit, the audit team should have a clear picture of the organisation of responsibilities for management of the chosen barriers and should therefore be able to assign persons to the structure of the ARAMIS barrier management system (again, see figure 2). This system consists of ten structural elements, nine of which are used during the mapping exercise (i.e. 1b, 3 - 10).
As will be outlined further below, all of these nine elements have been divided into several steps, comprising the particular 'life cycle' for that structural element.
Based on the assignment it should also be possible for the audit team to allocate questions to each person that has been identified. Audit protocols have been formulated (see appendices 2-10) to assist the audit team in formulating questions for this purpose. Also, a mapping sheet is provided (appendix 11) which can support the audit team in mapping persons onto the ARAMIS structure. Care should be taken that each structural element is addressed at least twice during the audit, to enable some verification.
The mapping should also provide an audit scheme, listing the persons that will be interviewed during the audit week as well as the questions or topics that should be posed to each person, the documents that have to be reviewed or consulted in between the interviews and the observations or checks in the plant which are considered essential or desirable. The interview scheme should be prepared as soon as possible and should be communicated to the plant without delay, so preparations can be made and appropriate actions can be taken on the plant's part.

Output of step 2

Step 2 should have the following output:

- A complete overview of how the company's SMS maps onto the structure of the ARAMIS barrier management system
- A detailed interview schedule specifying who will be interviewed when, what documents have to be reviewed in between and what checks and observations are required
- An audit protocol, listing the issues and questions that will be posed to each interviewee
- A distribution of roles and tasks within the audit team

The following short-list might be helpful in preparing the interview schedules:

Day 1: Interviews with responsible managers
Days 2 – 4: Interviews with barrier users, i.e. operators, supervisors / review of documentation
Day 5: Wrap up findings and prepare presentation, final checks, last minute interviews

6 *Step 3 - Conduct audit and make assessments*

Description

The ARAMIS audit covers four areas that are separated in the ARAMIS barrier management system structure (figures 1 and 2). It depends on the particular company that is assessed to what extent these areas are also managed by different local safety systems. The mapping performed in the previous step should have provided a clear picture of the distribution of these areas of safety management at the plant.

The four areas of assessment are:

1. Audit of the process by which the decisions were arrived at for choosing the barriers
2. Audit of the hardware (aspects of the) barriers using the life cycle steps, and going, where necessary, into the relevant delivery systems associated with them
3. Audit of the behavioural/procedural barriers using the relevant delivery systems
4. Audit of the learning and change management system

These areas of assessment will be discussed separately below. However, the auditor may decide not to separate topics 2 and 3 when actually conducting the audit, especially when dealing with the operation of barriers with both hardware and behavioural elements.

Audit of management process of choosing barriers

A protocol of checkpoints is included in appendix 2 in order to assess the process by which the company arrives at the choice of barriers. This protocol looks at how explicit and systematic the process of risk assessment and decision-making is, the quality of the information which is generated and used in that process and the quality of the staff used to carry out the process.

Audit of hardware/software (parts of the) barriers

The audit of the hardware/software elements, whether whole barriers or parts of them, is organised as a critical review of the life cycle steps of the barrier. This review starts from the instant that the type of barrier has been specified. The remaining steps in the life cycle are:

1. Purchase or construction according to that specification, which must reflect also the environment in which the barrier is installed (temperature, air pollution, humidity, etc.)
2. Installation correctly at the correct point
3. Adjustment/calibration to the required functioning parameters
4. Operation according to the specification within the defined envelope
5. Inspection and monitoring of performance to check it is still in good order and to decide when to undertake maintenance/replacement/ recalibration
6. Maintenance or repair when it falls outside a defined condition or functionality

The step of improvement, which is shown in figure 2, has been left out in this protocol since this is dealt with in of the part of the audit dealing with the learning system.

The six steps above are grouped into two separate protocols:

1. Dealing with the steps from the point at which the choice of barrier form has been made and the design specification has been written (end of audit protocol appendix 2) up to the point at which the barrier has been installed and adjusted for use. This protocol also deals with the purchase, storage and issue of spares and parts for hardware barrier elements. It also considers the design of the interface between hardware/software and the user (operator, tester, inspector, maintenance fitter) in mixed barriers. (Protocol hardware and software, appendix 9)
2. The processes of keeping the hardware/software barrier element functioning according to its specification. This includes inspection and testing or other forms of condition monitoring, maintenance and repair and periodic adjustment. (Protocol inspection and maintenance, appendix 10)

The attention in the protocols largely goes out to the operational level of each step, since this will determine to a significant extent the continuing effectiveness of the barrier. However the audit team also has to consider, per protocol, whether there is a policy, at the strategic level in the organisation, which specifies how that step will be dealt with, and whether that policy is turned at the tactical level into a plan and set of procedures and responsibilities for carrying out that policy. This consideration of strategic and tactical levels is particularly important for the steps of inspection, monitoring and maintenance, being reflected in an explicit maintenance concept and plans for the resourcing and scheduling of the necessary activities.

(Each of the barrier life cycle steps is considered as a 'safety-critical' task, which need to be carried out competently, following the appropriate procedures, at the right time and with suitable commitment to quality. A number of the tasks also involve communication, e.g. handover from operations to maintenance of parts of the plant for maintenance or repair activities. This means that the audit team has to take account of all of the issues represented in the five safety management delivery systems related to behaviour. If the team wants to audit more exhaustively, these five delivery systems for each of the six life cycle steps could be explicitly assessed. Most probably, this would lead to a too extensive and heavy commitment of time and resources. It is therefore proposed that the audit team limits itself to the questions contained in the 2 protocols on hardware barriers.)

Audit of procedural/ behavioural (elements of the) barriers

This part of the audit is also based upon following the life cycle of the barriers concerned. (For behavioural barriers the names given to the steps are slightly different:)

1. Specification of the behaviour to be demonstrated for a given safety function, including at what level in the Skill/Rule/Knowledge hierarchy that is and when that behaviour has to be carried out. This will usually involve some sort of task analysis
2. Selection or designation of the person or persons who will and can carry out the behaviour, including whether that is own staff or contractors
3. Instruction or training in the correct behaviour and development of the necessary level of competence and commitment
4. Carrying out of the behaviour at the right place and time, with suitable skill, commitment and expedience and where necessary in coordination with other persons
5. Detection and correction of deviations from the desired behaviour
6. Practice, refresher training and reinforcement of the desired behaviour to maintain it in a suitable state of readiness and level of competence and commitment

The issue of improvement and learning has been left to the learning system part of the audit, described further below.

As explained above, the behavioural elements of barriers have been grouped into five delivery systems. Depending on the type of barrier (element) being considered, the emphasis on each delivery system may differ. For example diagnosis and action at a rule- or knowledge-based level will require more competence than following routine procedures at a skill-based level. Commitment will be more important in detecting and responding to deviations and following routine procedures or using equipment which is difficult, time consuming or uncomfortable to use. Communication will only apply to barriers which have elements operated by different people. The relative importance of a delivery system per (type of) barrier has been discussed and explored in step 2 of the audit process above.

In the appendices these delivery systems are worked out in the form of sets of issues for questioning.

As indicated already, the level of cognitive effort implicated by the required behaviour significantly determines the way in which each step should be filled in.

- If skill-based behaviour is appropriate as element of a barrier or for a safety-critical task, the emphasis will be on developing a high level of competence in the staff who are given the task and on ensuring that those specialised staff are always available at the critical times to perform the task. Procedures will only be important in the training phase and there will need to be attention given to preventing skills becoming so routinised that they erode, or drift towards unsafe 'shop practices', or result in complacency and lack of alertness.
- If it is rule-based behaviour which is wanted, the role of written procedures may become considerably more important as support for the execution step. Training will need to concentrate on diagnosis skills and care will need to be taken to prevent expectations taking over behaviour. Back-up competence may become more important and introduce extra communication requirements.
- If the behaviour required is at knowledge-based level, in order to cope with unexpected and unplanned situations, the demands on general competence will be greatly increased; skills in problem solving will need to be trained, and communication with other employees and experts will be far more important.

Audit of learning and change management system

The learning and change management parts of the safety management system are considered in one consolidated part of the audit, even though the learning is appropriate for all types of barrier and for all delivery systems. One main reason for this is that this area of the audit has a rather different function to the other areas. In the previous steps we are concerned with an assessment of the current effectiveness of the barriers being used by the company for the scenarios we have identified and chosen. In step 8 we are trying to look into the future, by assessing how well the company is able to adapt itself and its risk control measures:

- To changes in its own technology, design and layout or reorganisations of the company or part of the company, which change the way in which responsibilities for barrier management are allocated.
- To lessons which it learns about its own performance in the form of incidents

and accidents which occur despite the barriers in place, or because the scenarios were not anticipated and included in the risk control measures
- To lessons which it learns from failures in its management system for its own scenarios and barriers
- To lessons which other similar organisations in comparable technologies learn about good practice and about failures in their systems
- To changes in the demands made by society, regulators or top management of the company in relation to safety performance

The focus of this part of the audit is therefore on the following parts of the safety management system:
- Incident and accident reporting and analysis
- Inspection and performance monitoring
- Audit and management review
- System for learning from external developments in science, technology and good practice
- System to detect and influence developments in markets, regulations and other external pressures on, and requirements for safety performance
- Technical change management procedures
- Organisational change management system

In appendix 3 there is a protocol dealing with the auditing of these aspects.

Audit schedule

The following schedule for the audit week is proposed.

Day 1	▪ Start with introduction of audit ▪ Interviews with responsible managers ▪ Review of documentation ▪ Closing: Wrap up findings of the day, impressions of the audit team
Day 2	▪ Evaluation of 2 (or more) barrier types (interviews, review of documentation, local verification) ▪ Closing: Wrap up findings of the day, impressions of the audit team
Day 3	▪ Evaluation of 2 (or more) different barrier types (interviews, review of documentation, local verification) ▪ Closing: Wrap up findings of the day, impressions of the audit team
Day 4	▪ Evaluation of 2 (or more) different barrier types (interviews, review of documentation, local verification) ▪ Closing: Wrap up findings of the day, impressions of the audit team
Day 5	▪ Make initial assessments through filling in the diagrams, prepare presentation ▪ Feedback session to management

7 Feedback of primary results to company

On the last day of the on-site audit the audit team prepares a presentation to the company of their initial findings. This feedback session is a valuable part of the audit in that the combined observations of the audit team are checked against the expectations and beliefs of the company. The feedback given at this session by the company should be incorporated in the final audit results.

The estimated time for the feedback session is about 2 hours, with 1,5 hours of presentations by the audit team and about half an hour of discussion.

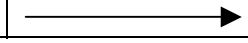
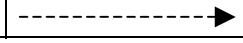
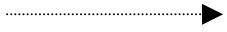
The following program for the feedback session is suggested:

1. Welcome to participants by the audit team
2. Overview of the ARAMIS audit structure and the areas that have been assessed
3. List of scenarios/barriers that have been the focus of the audit
4. Clarification of how feedback will be given
5. Overview of assessments of barrier management systems
6. Discussion
7. Arrangements for concept report
8. Audit team leader thanks the company for its hospitality and sharing of information

For all protocols diagrams have been provided, which describe the developmental steps of that particular part of the barrier management system. (These diagrams are also provided within a separate PowerPoint presentation.) It is suggested to use these diagrams during the feedback session in the following way.

The audit team assesses all steps within all diagrams based on their first impressions. This is, of course, an ongoing activity during the whole audit week. The flow of information between all steps within all diagrams is also judged.

The following coding scheme is proposed:

	Present, documented and working	Present, but with significant shortcomings in documentation or working	Absent in significant parts or aspects
Steps			
Flow			

Coding the boxes and lines between the boxes in each of the diagrams gives a quick overview or impression of the particular barrier management system by the audit team.

Assessment The effectiveness of barriers and their elements as indicated by their SIL ratings, or equivalent, is dependent upon a number of assumptions about the way in which the barriers are managed. These assumptions form the focus of the audit of the management system. Does the management system live up to those assumptions, or are there indications that the effectiveness of the barriers can be, or is compromised by less than adequate management? We propose that the auditors operate with an ideal picture of a management system, as indicated in the protocols and deduct points for gaps in it. This implies an anchoring at the top end of the performance scale. Any deficiency in the management of the barrier will therefore reduce the performance level below the SIL (or equivalent) level awarded.

8 Quantification of audit results

Description After the on-site audit, the assessments of the audit team have to be quantified. It is suggested to use the coloured diagrams for this purpose and to give final ratings to the *whole* diagrams, not the steps therein, meaning that ratings will be given to the nine diagrams that will be assessed by the team during the audit. This will result in at least nine separate ratings. Auditors may wish to make differences in the ratings when a given diagram is assessed for a particular type of barrier, e.g. maintenance may be judged good for active barriers, but poor for passive ones; competence may be judged poor for dealing with barriers requiring knowledge-based action in emergencies, but good for routine operation of barriers such as protective equipment.

Ideally, several members of the audit team do the quantification independently so that mutual agreement can be calculated. This means that each member of the audit team rates the barrier management systems independently. Afterwards, a coefficient of agreement between those ratings can be calculated by using the Cohen's KAPPA statistic or a rank order correlation coefficient. When this coefficient is low (say, below .75), the audit team should investigate the cause for such disagreement.

It is suggested to give ratings on a four point ordinal scale with the following ranks:

1 – System is in place and supported by continuous improvement
2 – System is largely in place and improvement plans have been developed and are (in the process of being) implemented
3 – System / improvement is in the process of being developed
4 – System is rudimentary, no improvement plans yet

9 Concept report, final report

After finishing the quantification and resolving any conflicts between auditors, if any, the concept report should be written. This report should be presented to the company within four weeks after the on-site audit, to make realistic suggestions for changes possible.

This report should include the following information:

1. General overview of the ARAMIS audit structure
2. Choice of scenarios/barriers
3. Audit planning, preparation
4. List of interviewees, mapping
5. Course of the audit
6. Overview of judgements/ratings per barrier management system
7. Conclusion
8. Points for improvement

Appendices

Appendix 1 Proposed table for recording information on the barriers to be used as focus for the audit.

	Barrier	Detect	Diagnose/	Act
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Risk analysis & barrier selection

1. Introduction

This protocol covers the process of risk assessment and selection of the barriers. In the audit it is intended as a check of the process by which the company has arrived at its barrier choice, which can be compared to the assessment of the quality of the barriers choice itself. This process forms the necessary basis for all the rest of the audit.

1.1 Definitions and coverage

Barrier functions and elements

The process emphasises that barrier functions should first be defined (prevent, protect, mitigate), followed by a choice between all possible principles and forms of barrier which could fulfil that function. Most barrier forms chosen will be combinations of hardware and software elements with behavioural elements. Some barriers may be pure hardware, either passive, in which case it requires no activation after its installation (temporarily or permanently), or with active elements, which require adjustment and activation. A number of barriers may be purely dependent on behaviour, such as evacuation, or skilled dismantling of equipment. The elements out of which the complete barriers are constructed must consist (except in the case of passive barriers) of elements which perform the functions of detection or diagnosis of the need to respond, activation of the barrier and its response. Either hardware or behaviour elements can fulfil each of the functions and these can be combined in many different ways. The company must make its choices out of these combinations.

Coverage

The process should cover all accident scenarios which the company wishes to control, or wishes to demonstrate to regulators and auditors that it has controlled. The steps follow the normal processes of risk assessment, but emphasise more clearly the selection and specification of barriers to control the hazards. They also emphasise that barrier selection should take account of the whole life cycle of the barrier and its elements in deciding what is likely to be the most effective choice to make.

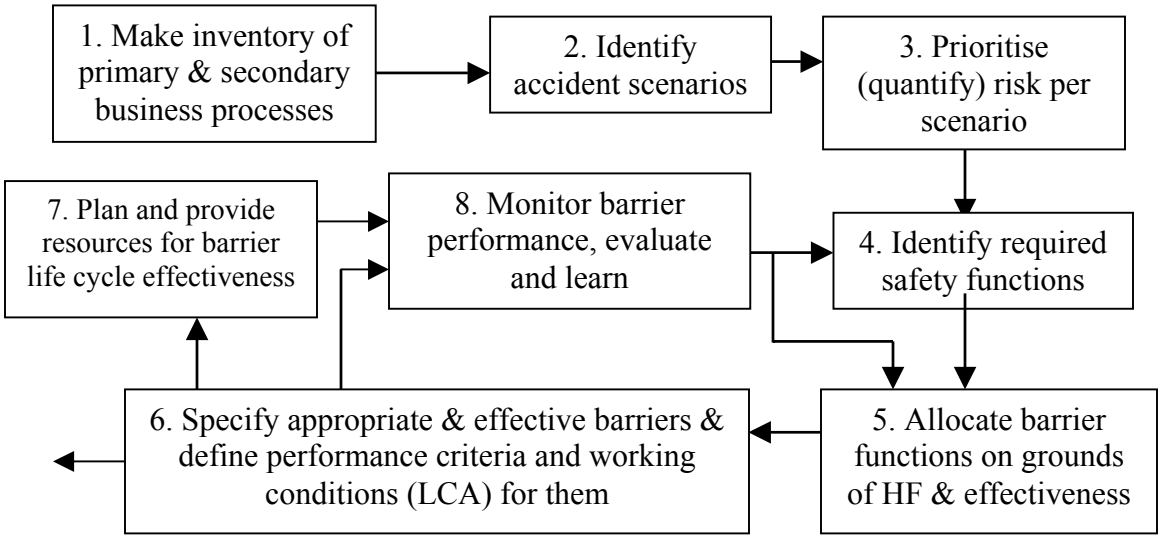
1.2 General requirements

I. Overall policy goals for risk control and barrier selection
II. Articulate senior management commitment and knowledge
III. Coherent structure for managing all aspects of the company providing controls and resources to manage barriers
IV. Monitoring, feedback and learning system in place for improving the Risk Analysis and Barrier Selection system (including system for keeping management practice up to best practice)

2. Evaluation of risk identification system

2.1 Introduction

Schematic overview



2.2 Assessment of risk identification system

Step 1 Inventory of business processes with hazards to be controlled

Critical issues

- Records of all processes operating on the plant/site that have an accident potential and which must be considered under this management system
- Up-to-date documentation of plant layout, equipment, current barriers
- Plans for new or modified plant formulated at a level of detail necessary for analysis of the accident scenarios

Sample questions

- Does the organisation have up-to-date documentation of all the processes, plant layouts, description of equipment, etc?
- Does the organisation have an inventory of barriers?
  - Is this information sufficient for risk analysis?

Step 2 Identify hazard scenarios

Critical issues

- Appropriate risk analysis methods used to make qualitative scenarios of all accident processes which need to be controlled
- Competent persons to develop scenarios and carry out risk assessments, including those with expertise from outside the unit/company, as appropriate
- Use of incident and accident experience and industry good practice to arrive at scenarios
- Documentation of scenarios
- Independent checks of the quality of risk assessments
- Specify the interval before, or the circumstances under which, a reanalysis of scenarios or a reassessment of priorities should take place – link to change management

Assessment

- An overall risk analysis plan is updated annually
- Documentation includes the reason for the RA-methods used and the assumptions made
- Results of RA's and assessments are accessible to employees

Sample questions

- What is the competence level of people involved in risk analysis?
- How many percent of potential accident scenarios is analysed and documented?
- Are the triggers for re-analysis of accident scenarios clearly defined?
- How many information sources are used to identify accident scenarios?

Step 3 *Prioritise scenarios*

Critical issues

- Company risk control and safety targets and data on past experience, incidents and accidents as basis for assessing priorities
- Suitable methods for (semi-) quantitative assessment of the consequences of risk scenarios
- Competent persons to carry out the prioritisation
- Involvement of senior managers and staff (representatives) in the prioritisation process
- Input from the regulator, past experience and industry benchmarking/good practice
- Documentation of the prioritisation process

Sample questions

- What is the competence level of people involved in prioritisation of accident scenarios?
- Are senior managers involved in the process of accident prioritisation?
- Does the organisation have a list of critical accident scenarios?

Step 4 *Specify barrier functions*

Critical issues

- Identification of steps in the scenarios where barrier functions can prevent development or escalation of the scenario

Step 5 *Allocate barrier functions on appropriate grounds*

Critical issues

- Identification from industry practice, suppliers, designers, literature and other sources of good practice which barrier (element) forms and types are available to fulfil all the functions necessary for an effective barrier.
- Assess the likely maximum performance of different combinations of barrier elements for fulfilling the barrier function. Consider the human factors aspects of the possible combinations
- Assess the necessary life cycle management effort to keep the candidate barriers functioning at or close to their maximum effectiveness
- Take account of the design philosophies incorporated in legislation or design practice guidelines for selection of barriers (e.g. hierarchy of measures: elimination/reduction, collective barriers, individual barriers; CCPS guidelines, etc.)
- Involvement of competent persons for this assessment, drawn from designers, managers, operators and maintenance experts.

Sample questions

- What is the competence level of people involved in definition of barriers?
- Does the organisation have the list of all the barriers, well documented and classified?
- Who (what kind of kind of competent personnel) are involved in barrier analysis?

Step 6 *Specify barrier form and performance criteria for all necessary barrier elements*

Critical issues

- Choose the optimum barrier type and form based on clear criteria.
- Document barrier choice and the reasons for it
- Specify the conditions (physical, process, environmental, organisational) under which the barrier will be required to work
- Specify the performance criteria for the barrier as a basis for performance monitoring

Assessment

- Are there safeguards against any tendency to choose low capital cost barriers (which may only be effective in the long run if high running costs are paid to keep them working)

Sample questions

- Is the selection of barriers properly documented?
- For how many percent of barriers is the performance specified?

Step 7 *Plan resources for barrier life cycle management*

Critical issues

- Assess and document the necessary resources required to keep the barrier (elements) functioning through its life cycle – links to other audit protocols

Sample questions

- For how many percent of the barriers the organisation has a plan of resources for the whole life cycle of barriers?

Step 8 *Monitor barrier (element) performance for learning*

Critical issues

- Monitor barrier (element) performance against the performance criteria specified
- Record data on barrier (element) performance
- Record incidents of (incipient) failure of the barrier for analysis and learning.

Sample questions

- How often are barriers monitored and evaluated against performance criteria?
- Are the barrier failure data used for analysis and learning? In what way? Give examples.

Management of learning and change

1. Introduction

This factor deals with the management processes designed to achieve continuous improvement and adaptation of barrier performance to the current best practice and to the current state of the risks in the organisation.

The processes interact with all other protocols. It takes information from them about the performance of each part of the management system relating to barriers and their performance, evaluates it and identifies the need, and opportunities for improvement. It also collects information about proposed changes both to the technical plant and the organisational structure of the company and assesses these for their impact on the hazard scenarios and need for barriers, and for their effect on the allocation of tasks relevant to barrier performance and to the management of barriers. Finally it organises the external awareness of the company, to allow it to learn from the experience of other relevant organisations in all of these areas of barrier performance and management.

1.1 Definitions and coverage

Learning

Learning is defined as the collection of information about the performance of a barrier (element) or management process relating to barrier performance, the analysis of the performance data, its comparison with desired performance and/or good practice, the drawing of conclusions about improvements and changes which are required to bring about better performance, and the implementation throughout the organisation of the changes. Learning should be triggered by both deviations from expected or desired performance within the organisation, as by comparisons with good practice outside it.

Change management

Change management is designed to ensure that any changes to the technical, human or organisational aspects of the design, layout, functioning, control or management of the organisation are reflected in changes to the barriers provided to control risk and/or changes to the appropriate part of the life cycle or management processes which ensure the functioning of the barriers. This requires that the organisation specify and identify what will be considered to be 'significant changes' requiring assessment.

Incident, accident and failure

Incident: any deviation from expected or desired operation or performance, which, if uncorrected, would lead to damage, injury or other undesired outcome, and which is defined as relevant to be recorded for the purposes of learning.

Accident: any deviation from expected or desired operation or performance, which leads to actual damage, injury or other undesired outcome.

Failure: any deviation of a barrier (element) or management process relevant to barrier performance which results in a partial or complete loss of function of that barrier (element) or management process.

Coverage

The learning and change control system covers the performance of all barriers and their elements, whether they are achieved by hardware, software or behaviour.

1.2 Overall Policy

An explicit policy for this aspect of barrier management, covering:

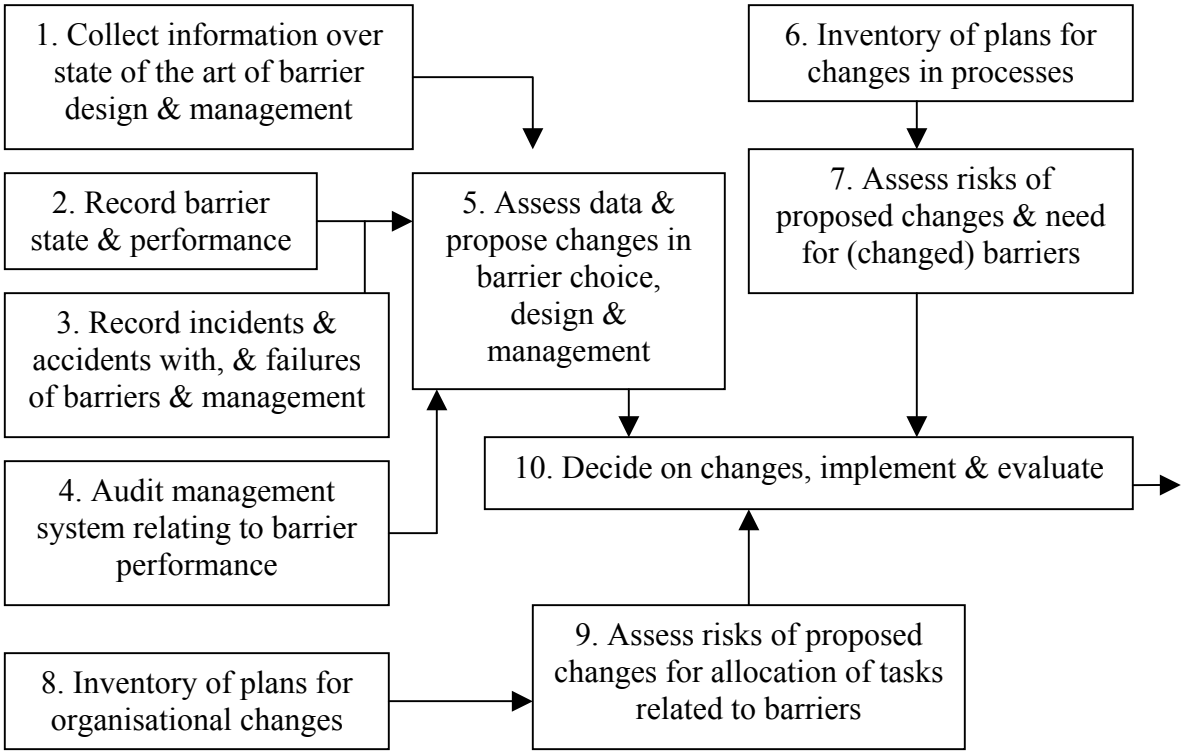
- Objectives for barrier performance, learning and improvement
- Objectives for, and commitment to the importance of learning
- Objectives for the change management system, recognising the importance of both technical and organisational change
- Resources allocated for monitoring, inspection, auditing, review and organisational learning and for change management
- Designation of persons responsible as 'learning agents' for the success of organisational learning
- Definition of events and information which will form the basis for learning
- Definition of the changes which will trigger different levels of assessment and review in the change management system
- Review and improvement of the learning and change management processes

2. *Evaluation of management of learning and change*

2.1 Introduction

The auditing of the learning system should be linked to specific examples of barrier (elements) and of the management processes related to them. Auditing of the recording of the performance of the barrier (elements) and of the other relevant processes may be best done when these protocols are assessed. The core of the learning and change management process itself is the definition of the triggers for initiating learning or change management, the way in which responsibilities are allocated for the process, the way in which information is analysed and used for identifying possible and necessary improvement and the way in which the improvements or changes are implemented.

Schematic overview



2.2 Assessment of management of learning and change

Step 1 External information on state of the art

Critical issues

- Identification of relevant peer groups and organisations with whose performance the organisation can compare itself
- Identification of relevant sources of information (standards, guidance notes, publications, workshops, conferences & other presentations, etc.) which contain relevant information for the company about the state of the art of barrier design, performance and management
- Establishment of channels of communication with (representatives of) peer groups and other experts for the exchange of information on good practice (both business-sensitive and open communications)
- Allocation of responsibility within the organisation for persons to use the communication channels, collect and process the information and feed it to the relevant points in the organisation where it can be used.

Assessment

- Systems are in place that provide information timely to sites and functions on regulatory revisions
- Compliance plans are developed and implemented that satisfy applicable laws and regulations

Sample questions

- What kind of external information sources are available and also used in learning?
- Who is responsible for collecting relevant external information and distributing this to the appropriate people within the organisation?

Step 2 Recording of barrier state and performance

Critical issues

- Policy, derived from the analysis of risks and barrier specification and selection, specifying what information on barrier performance should be collected, by whom and how
- Specification of methods and programme for condition monitoring, inspection and testing of hardware barriers
- Specification of methods and programme for monitoring of behaviour and competence directly related to barrier performance (e.g. behavioural auditing of use of protective equipment and other barriers, compliance with rules and procedures, respect of the design and operating envelope, effective diagnosis of risk situations, appropriate extemporisation or innovation of control in unplanned situations)
- Allocation of resources for the inspection, testing and monitoring of all barriers/ elements (responsible persons, available and trained, equipped with necessary methods and equipment)
- Effective and efficient (user-friendly) systems for recording the performance data

Sample questions

- How is the barrier monitoring system outlined (responsible people, methods for monitoring, inspection, testing, records)?
- Are necessary resources allocated to inspections, testing, monitoring, performance evaluation, etc. of barriers or barriers elements?

Step 3 — Recording of incidents, accidents & failures

Critical issues

- Policy for recording, analysing and using data from incidents, accidents and failures, specifying what information should be collected, by whom and how and how it will be used for improvement of safety performance.
- Training of staff about what should be reported, how and why: what deviations from normal performance/situation are of concern.
- Measures to encourage reporting of incidents, accidents and failures: positive feedback about use and usefulness, praise or reward for useful reporting, demonstrated interest in all levels of management for positive value of reporting.
- Measures to deal with questions of confidentiality of recording and of blame, so that people are not afraid to report: explicit policy on responsibility and blame, prevalence of learning over disciplinary action, policy on dealing with negligence.
- Simple procedures for reporting and recording incidents, accidents and failures
- Procedure for filtering reports, if there are large numbers, so that useful information is extracted and reporting is not discouraged.
- Procedure for analysis of data to derive possible lessons

Assessment

- Timely feedback of incident/accident information to all potentially affected plant employees.

Examples

Incident and accident analysis methods used

- Root cause analysis
- Change analysis
- MORT

Sample questions

- Does the organisation have procedures for the registration and investigation of incidents, accidents and failures related to barriers?
- What is the system used for causal analysis?
- What is the system used for corrective actions?
- How is registration of incidents, accidents and failures related to barriers promoted?
- Is the confidentiality of the barrier investigation process ensured?
- Who receives the information on the most important findings of the investigation about incidents, accidents and failures?

Step 4 — Auditing and review of management processes for barrier management

Critical issues

- Programme of internal audit of management processes relevant to barrier performance
- Audit method appropriate for assessing the performance of the management processes relevant to barrier performance, which assesses both the formal, written systems as the application of them in practice
- Designated and trained internal auditors, knowledgeable in both the process being audited as well as the skills of auditing
- Measures to ensure sufficient independence of the audit (e.g. auditor from other department or site, use of external audit organisation)
- Clear system of rating the processes being audited and their performance
- Effectiveness of assessment process is reviewed periodically

Examples

- A system is in place that allows employees to participate in the assessment process and demonstrate their involvement in the continuous improvement of barriers

Sample questions

- Who is in charge of the review of barrier management?
- What are the competencies of internal auditors?
- Are the auditors independent to the audited units?
- How often is the effectiveness of the assessment process reviewed?

Step 5 — Assessment of information & proposed improvements

Critical issues

- Organise local response to inspection, monitoring and incident analysis: supervisor and local operators
- Designation of suitable learning agents with time and resources to support the various learning processes: e.g. designated responsible persons for different barrier (elements) or parts of the safety system and its management, involvement of the safety service/department.
- Procedures for analysing and combining information from the different sources (performance monitoring, incidents, audits) to draw conclusions about lessons to be learned
- Procedures for reviewing and approving proposed changes based on the learning system: involvement of responsible managers, supervisors and workforce
- Procedure for prioritising actions and for follow-up

Sample questions

- What is the role of supervisors and operators in post-audit activities?
- Is there a follow-up system in place?
- Are corrective actions prioritised? On what base?

Step 6 — Inventory of plans for technical change

Critical issues

- Definition of which technical changes will be subject to which assessment and approval procedure
- Method of dealing with series of small changes (below the assessment threshold) which may add up over time to a significant change
- Procedure for identifying and reporting proposed changes with safety implications

Examples

- Does the organisation have a procedure for change management?
- Does this procedure recognise/distinguish major and minor change?
- How are safety related changes documented and their impact on aspects of safety?

Step 7 — Assessment of need for new barriers or changes in existing barriers

Critical issues

- Appropriate methods for analysing proposed changes for their effect on barrier need or performance and modifying them where necessary: process review, HAZOP, etc.
- Designated and trained personnel to carry out assessment and review
- Procedure for final approval of the technical changes based on the assessment process, including any necessary modifications.
- All changes falling under the scope of the assessment procedure are in practice assessed

Sample questions

- Who is responsible for barrier assessment?
    - What are the competencies of these people?
- What kind of risk analysis methods is used?
- Is risk analysis used as part of the change management process?

Step 8 — Inventory of plans for organisational changes

Critical issues

- Definition of which organisational changes will be subject to which assessment and approval procedure
- Method of dealing with series of small changes (below the assessment threshold) which may add up over time to a significant change
- Procedure for identifying and reporting proposed changes with safety implications for barrier (element) performance

Sample questions

- Does the change management procedure also cover organisational changes?
- Does this procedure recognise/distinguish minor and major organisational changes?
- How are the safety related organisational changes documented and their impact on aspects of safety?

Step 9 — Assessment of implication for tasks related to barriers and barrier management

Critical issues

- Method for assessing the effect of (proposed) organisational changes on barrier (element) performance.
- Assessment of, and decisions about the need to reallocate responsibility for critical aspects of barrier (element) performance or management (all relevant aspects covered by this audit, including both behaviour directly relevant to the barrier performance, as well as tasks relating to the life cycle of hardware barriers, the provision of procedures, competence, manpower, commitment and communication, and the operation of the learning and change management systems)
- Assessment of, and decisions about the need for (re-)training of workforce or management in critical aspects of barrier (element) performance or management
- Assessment of, and decisions about the need to modify communication, reporting or decision making channels

Sample questions

- What are the formal methods to assess barrier performance after organisational change?
- Does the organisation have a procedure describing in detail all safety related aspects of organisational change?
- Does the organisation have a checklist that deals with activities required after changes have been effected? (i.e. re-training, verification of work instructions, emergency instructions, revision of work permit system, etc.)

Step 10 — Decision on and implementation of changes/improvements and their evaluation

Critical issues

- Timely feedback of the approved changes and lessons to be learned to the appropriate parts of the organization. Feedback includes incident/accident/change description, lessons learned and actions taken
- Procedures to ensure that those who have to carry out the changes recognise ownership of the changes and are committed to implementing them: involvement in the learning and change processes, feedback and explanation.
- Procedures for follow-up of actions agreed to ensure their implementation
- Procedures for assessing the effect of the changes implemented

Sample questions

- How is the need for improvement of change management detected (e.g. incidents/accidents related to poor change management)?
- How are the change management procedures evaluated and improved?

Manpower planning

1. Introduction

Overview

The delivery system for manpower planning for availability of personnel concerns itself with the timely planning of requisite operational tasks and maintenance projects throughout the life cycles of all installations. It also considers the availability of critical personnel at all times for emergency situations, coverage for peak loads, holidays, etc.

The output of this delivery system is the presence of the right people at the right place and time to operate the barriers defined by the company. When used to audit the life cycle of the hardware barriers, its output is the necessary people to select, design, purchase, install, adjust and maintain those barriers.

1.1 Definitions and coverage

Manpower planning

Manpower planning covers:
Allocating the necessary time (or numbers) of competent people to the tasks that have to be carried out, at the moment (or within the time frame) when they should be carried out. It also covers the process of planning and allocation of tasks over time, including coverage for:

- Holidays
- Sick leave
- Peak loads
- Ensuring breaks and rest pauses
- Limiting overtime and fatigue

Personnel availability

Personnel available to all relevant tasks in relation to the functioning and management of barriers (operations, maintenance, emergency):

- Operating personnel
- Maintenance personnel
- Inspection & testing incl. general plant walk-rounds
- Supervision
- Back-up & emergency crews

1.2 General requirements

I. Planning system for personnel availability in place
II. Incorporation of explicit safety criteria and considerations into personnel planning system
III. Explicit evaluation system for monitoring personnel availability in place, with performance indicators

1.3 Links to other delivery systems

Because this delivery system is concerned with planning the right people, there is a strong relationship with the competence delivery system that provides these people with their skills and knowledge to carry out the allocated tasks.
Importantly, manpower planning should cover both normal and abnormal – i.e. back-up and emergency - operations.
While presence of sufficient people is - obviously - essential for all life cycle steps, for hardware barriers manpower planning is especially important during the inspection and maintenance life cycle steps.

2. Evaluation of manpower planning

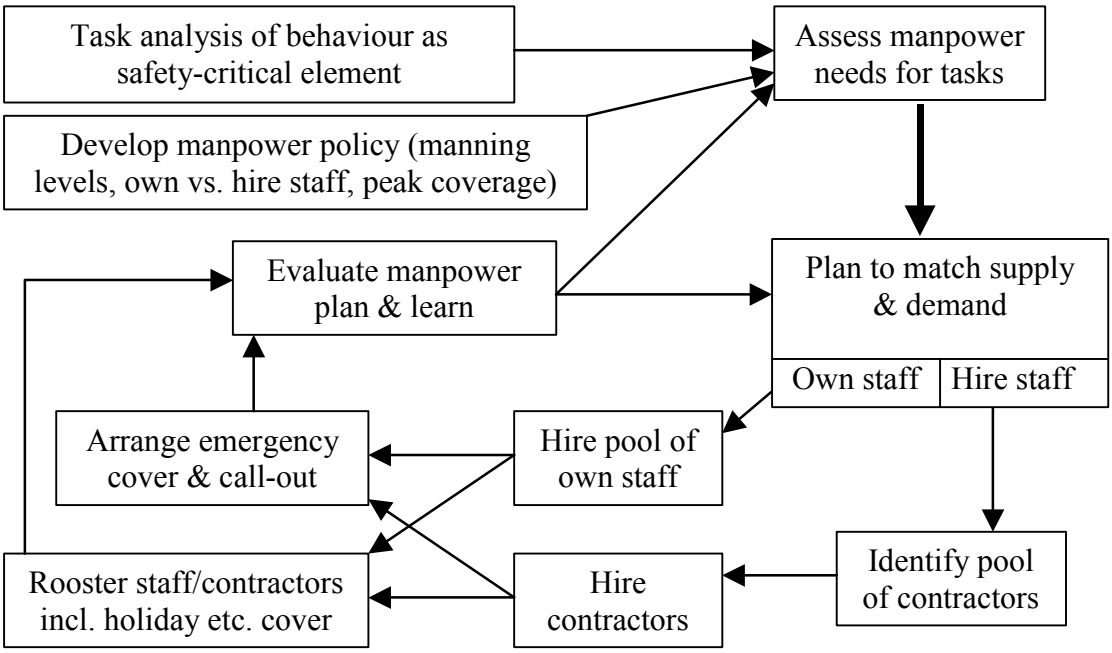
2.1 Introduction

Manpower planning should deliver the necessary numbers and type of people to ensure that the safety barriers fulfil their functions. Two different situations can be distinguished:

I. Delivery of the right people at the right place and time to perform tasks which themselves constitute safety barriers or which involve correctly using hardware barriers, e.g. skilful dismantling for maintenance of a piece of plant which contains toxic chemicals; responding to alarms by closing down a piece of plant. This use of the delivery system should always be audited for appropriately chosen behavioural or mixed barriers in the plant. Situations in which such manpower planning issues are likely to be crucial include:
   a. Manning levels to respond to emergency situations at all times of day, week or year.
   b. Coverage of unexpected absence of operators with crucial safety tasks
   c. Planning of sufficient staff (time) for handovers of functions, including briefing on safety critical aspects.

II. Delivery of the right people at the right place and time to perform tasks necessary to ensure that the life cycle of hardware barriers is well managed, e.g. installing, adjusting, inspecting or maintaining hardware barriers. This use of the delivery system may be audited in cases where the analysts or the audit team decides that particular steps in the life cycle of particular hardware barriers are particularly crucial to their overall performance and manpower planning appears crucial to carrying out such tasks. Situations in which such issues are likely to be crucial include:
   a. Planning of sufficient labour (own or contractors) for maintenance work on barriers during plant shutdowns
   b. Manning levels permitting regular plant walk-rounds to detect incipient failures of barriers or unusual signs indicating deviations from the safe operating envelope
   c. Availability of staff to carry out necessary adjustments of hardware barriers at sufficiently frequent intervals
   d. Sufficient staff to ensure that handovers from operations to maintenance are conducted properly and without unacceptable delay.

Schematic overview



2.2 Assessment of manpower planning

Input → *Policy on manpower (manning levels, own vs. hire staff, peak coverage)*

Check
- Manning philosophy for safety critical tasks & emergencies.
- Manning costs do not limit safety needs

Task analysis of behaviour as safety-critical element

Critical issues
- Task analysis and job safety analysis used as a basis for manpower planning
- Tas analysis methods used allow analysis of time critical and overlapping tasks to underpin decisions on manpower planning

Step 1 Assess manpower needs for tasks

Critical issues

Analyse tasks
- Performance criteria for assessing (the need for revisions to) manning levels
- Manning levels cover procedural requirements and special needs regarding task(s), including peak loads, reserve for covering sickness, holidays, etc.
- Responsibilities for (revisions to) manning policies/job specifications
- Input from past experience and incident analysis to ensure manning levels are adapted to safe standards
- Critical methods to assess plans for manpower reductions on safety criteria

Sample questions
- Who is responsible for the manning policy?
- How is incident/accident analysis used to improve manning system?
- Does the organisation have criteria for assessing a minimal manning level based on safety requirements?

Step 2 *Plan to match supply & demand*

Critical issues

Allocate tasks to types of people

- Manpower planning of own staff and out-sourced staff takes account of safety criteria (see also competence protocol)
- Time critical need for safety critical outside knowledge/skills/ services identified

- Check manning levels cover plans & procedural requirements
- Use of feedback from previous experience in success of allocating and planning tasks
- Methods available for assessing plans for (further) outsourcing on safety criteria

Sample questions

- How is manpower guaranteed for safety critical tasks?

Step 3 *Identify pool of contractors*

Critical issues

- Pool of suitable contractors identified
- System for calling in outside knowledge/skills/services for back-up for critical jobs
- Formal responsibilities/criteria for planning and scheduling contractor work, esp. for shutdowns, using competent persons
- Suitable methods used in due time to make contracting plan & schedule, using lessons from the past

Sample questions

- Has the organisation defined the possible contractors using safety related criteria: knowledge, skills, experience, equipment, etc.

Step 4 *Hire pool of own staff*

Critical issues

- Match hiring to requirements of manpower planning, allowing sufficient time for additional training

(See also competence protocol)

Sample questions

- Does the organisation have a clear policy in preparing own staff and giving them necessary training?

Step 5 *Hire contractors*

Critical issues

- Match hiring to requirements of manpower planning, allowing sufficient time for additional training

(See also competence protocol)

Sample questions

- Does the organisation have a clear policy in giving necessary training to staff of contractors?

Step 6 *Rooster staff/contractors including holiday etc. coverage*

Critical issues

Plan tasks, allocate people

- Effective communication of needs to allow planning
- Overview of special needs/requirements for safety-critical tasks
- Coverage for peaks, holidays, sickness, etc. (back-up)

Sample questions

- Does the organisation have a procedure to ensure manning for safety-critical tasks?
  - Does that procedure cover peaks, holidays, sickness, etc?

Step 7 *Arrange emergency cover & call-out*

Critical issues

Identify & correct unavailability

- Effective communication of (unexpected) shortages of personnel
- Responsibility for activating back-up

Planning for emergencies

- Definition of staff and specialists/services required for emergency situations and roster of call-out
- Protocol for contacting staff in emergencies set up and tested

Sample questions

- Does the organisation have a clear policy in preparing emergency teams?

Output	***→ Evaluate manpower plan & learn***
Critical issues	**Record & analyse performance of manpower planning** ▪ Registration and analysis of shortages of personnel ▪ Available back-up personnel ▪ Analysis of incidents for evidence of shortage of personnel ▪ Feedback of learning to other steps in the protocol and evidence of action taken
Sample questions	▪ Does the organisation registers shortages of personnel? ▪ Does the organisation treat manpower shortage as a possible basic cause of incidents and accidents?

Competence and suitability delivery

1. Introduction

Overview

The delivery system for competence is concerned with providing competence to personnel working directly with or on barriers. It delivers the necessary ability to show the required behaviour to work with other barrier elements to achieve the barrier function (e.g. responding to instrument readings and shutting down the plant, adjusting emergency breathing apparatus, evacuating a danger area, etc.) This competence pertains to both physical and cognitive qualities of workers. With regard to cognition, three basic levels of functioning are differentiated – skill, rule and knowledge based – each requiring different cognitive strategies and capabilities. Competence in skill-based tasks is dependent on sufficient practice, in rule-based tasks on good diagnosis, and in knowledge-based tasks, where procedures do not or cannot sufficiently cater for task requirements, on deeper technical and procedural understanding of what can be occurring in the plant. For barriers made up of a combination of hardware and behavioural elements, the behavioural element and hence the competence to show this behaviour plays an important part during the detection and diagnosis and activation steps.
Competence is also necessary to carry out the steps in the hardware life cycle covered by the two hardware protocols. For hardware barriers competence is important during the adjustment, inspection, testing and maintenance life cycle steps of the barriers.

The output of this delivery system is competent workers with adequate situational awareness who can handle the safety-critical tasks they are assigned in routine/proceduralised situations or during unplanned or unexpected situations. When used to audit the life cycle of the hardware barriers, its output is the necessary competence to select, design, purchase, install, adjust, operate and maintain those barriers.

1.1 Definitions and coverage

Competence

The knowledge, skills, and abilities of first-line and/or back-up personnel for the safe execution of safety-critical tasks related to barrier functioning or management. Competence covers the cognitive aspects of behaviour, which can be learned through training, experience and practice. They include:

Job content/safety, e.g.:

- *Plant & process knowledge*:
  - Operating procedures, critical tasks, action alternatives, skills
  - Boundary of safety operations
  - Hazards, safety consequences of actions, safety priorities
  - Safety responsibility/task boundaries

- *Inspection & testing procedures*:
  - Fault diagnosis & response
  - Emergency procedures
  - Maintenance diagnosis
  - Safe isolation and recommissioning
  - Equipment dismantling, repair, testing & reassembly

Other skills:
- Communications
- Team work
- Supervision/management
- Issuing instructions

The competences of those carrying out the tasks in the other delivery systems of the risk management system are covered in those systems.

Suitability

Suitability covers physical attributes that are usually more permanent characteristics of an individual, though some can be modified or compensated for over the longer term. They include:

- Size, strength, dexterity
- Physical condition, health
- Visual acuity, colour blindness, hearing

1.2 General requirements: policy

I. Management system for competence of personnel in place
II. Policy of task and job safety analysis with explicit concern for safety competence for safety critical tasks
III. Manning philosophy for allocating safety critical tasks in normal operations and emergencies
IV. Selection and training policy for own staff and contractors or other temporary labour
V. Explicit evaluation system for monitoring competence in place, with performance indicators, as basis for learning and improvement

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1.3 Links to other delivery systems

This delivery system provides competent people to any job they are assigned to through the manpower planning delivery system. Therefore, there is a strong link with that protocl that should ensure that the demand for the 'right' people is sufficiently covered. There is also an important link with the delivery system concerned with rules and procedures, to consider and decide upon the optimal balance between these two for any job – i.e. specifically the trade off between the on-line use of written procedures and reliance on learned competence at skill-, rule- or knowledge-based level. There are also links with the

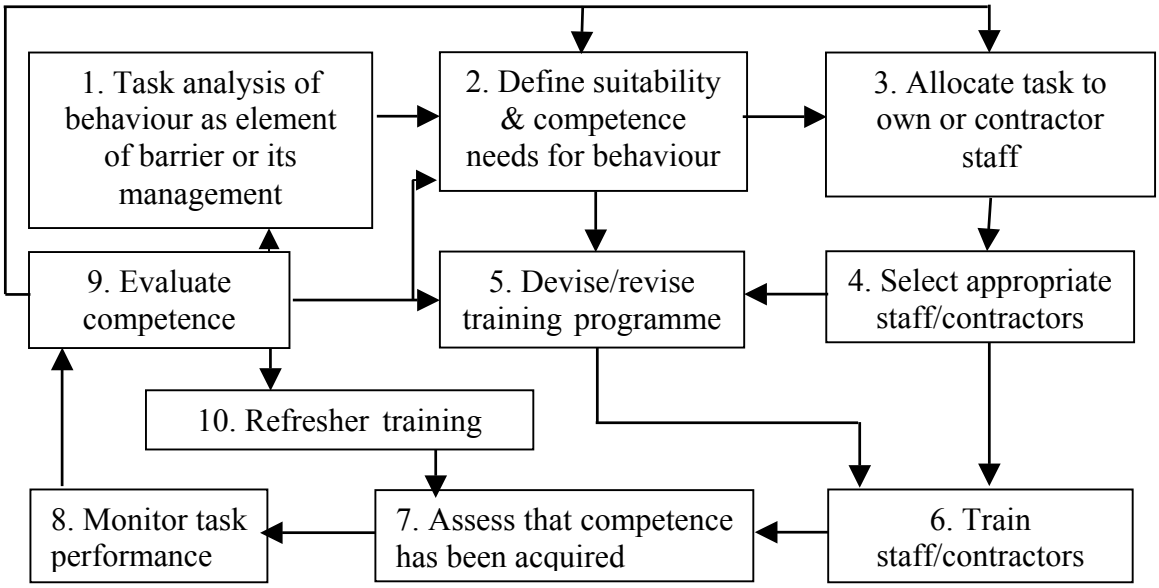
commitment protocol, since training courses are also an opportunity to influence also the attitudes and beliefs which underlie commitment to safety. There is some overlap with the communications protocol, since communication is also a skill which needs to be learned. Finally the links to the protocols concerning the hardware life cycle have already been mentioned. Competence is required to carry out the steps in that life cycle and is indicated in the two protocols dealing with those barriers.

2. Evaluation of competence and suitability delivery

2.1 Introduction

The evaluation section is composed as follows. First a schematic overview of the delivery system is given (2.1). This overview is followed by a methodical questioning of the consecutive steps in the overview (2.2). The steps follow a systematic order for development and delivery of the required behaviour. These steps are worked out in detail and critical issues for each step are given. This outline is considered to be a blueprint for setting up and running any delivery system, and providing the desired and optimal behaviour. Assessment occurs by comparing the actual local practice with the anchoring points given for each step. The quality of delivery for the management system under examination is established by judging the full system, i.e. the sum of its parts.

Schematic overview



2.2 Assessment of competence and suitability

Step 1 Task analysis of behaviour as element of barrier or its management

Critical issues

Critical barrier functions and tasks analysed for competence requirements

- Formal task analysis/job safety analysis (JSA)
- Involvement of experts + operators in analysis
- Coverage of tasks relevant to all barriers in all plant states and phases of life cycle: normal operations, start-up, shutdown, non-nominal operations, emergency, maintenance & repair (and, if appropriate construction, installation and modification)

Sample questions

- Who is responsible for JSA?
- Who is performing JSA (individual persons or teams)?
- For how many percent of a task JSA is done?
- Is JSA related to barriers in all life cycle steps?

Step 2 Define suitability & competence needs for behaviour

Critical issues

Competence requirements explicitly identified & recorded

- Task specifications/job descriptions refer to competence for safety, critical tasks, diagnosis skills, emergencies/unusual events and deep knowledge requirements
- Specifications used as a basis for selection and training
- Specifications up-to-date and showing evidence of learning from past experience

Assessment

- Appropriate core knowledge and skills training programs, as well as position training programs, are in place

Sample questions

- Does JSA results refer to job description, needed competence, skills, etc?
- To what extent do existing training and skills reflect needs defined in JSA?
  - How are they documented?

Step 3 *Allocate task to own or contractor*

Critical issues

Decisions made to allocate tasks to own or contractors staff based on considerations of competence

- Formal system and records, incl. safety-based criteria for allocation: special knowledge, availability, commitment to safety, proven safety performance
- Safety considerations not compromised by considerations of cost

Sample questions

- Is JSA used to decide between using own personnel or contractors?
  - Is this decision based on predefined competencies and skills?

Step 4 *Select appropriate staff/contractors*

Critical issues

Selection system for selecting own staff for specified competence

- Pool of labour identified and "cared for"
- Safety requirements explicit in selection profiles
- Competence testing, formal matching
- Records kept

System for identifying, assessing, selecting & supervising contractors with the relevant competence

- Explicit system for contractor selection, attention to sufficient pool of contractors
- Testing of safety competence and commitment of personnel and competence at and commitment to safety management (SMS)
- Criteria for full/probationary contractors linked to regime of supervision
- Regime for supervision & improvement of contractor competence and SMS

Assessment

- Criteria are in place to ensure that necessary levels of individual and collective experience and knowledge are maintained and are carefully considered when personnel changes are made

Sample questions

- Does the company have a formal system to evaluate and select contractors?
- Which safety criteria are used to select and approve contractors?

Step 5 *Devise/revise training programme*

Critical issues

System for preparing training & testing competence of own staff

- Defining training needs, explicit training criteria including safety considerations

Liaison between trainers and trainees, supervisors and management before and after training to ensure relevance, acceptance and success of training

System for preparing and informing the contractors of work to be done and competence required

- Regime for communication, coordination, briefing

System for keeping training programme up to date

- Training reviewed on basis of feedback from trainees, management, incident analysis and kept up-to-date with latest state of the art on safety-related behaviour

Sample questions

- How are the training needs defined?
- How are the training programs / materials developed and maintained?

❖ Evaluate the competence and skills of safety trainers / instructors.

❖ Evaluate the programs of safety training - up-to-date approach? (safety culture, safety performance, modern risk analysis, internal safety policy and rules, registration and investigation of near-misses etc.).

Step 6 *Train staff/contractors*

Critical issues

System for training & testing competence of own staff

- Requesting & providing training
- Emergency training/simulation
- Competent trainers
- Involvement of boss/field

System for testing, eventually training and supervising competence of contractor staff

- Induction training
- Safety passport

Sample questions

- How far given training fulfil company needs?
- What kind of training is available to employees?
- How are trainers evaluated?
- What kind of training is available for employees of contractors?
- Do contractors' employees must have safety passports?

Step 7 *Assess that competence has been acquired*

Critical issues

- Periodic explicit testing/evaluation of acquisition/retention of the skills/knowledge, with explicit concern for safety
- Records of training and of the means used to verify that the employee understood the training

Sample questions

- How often are competencies and skills of own staff evaluated?
- How often are competencies and skills staff of contractors evaluated?
  - Describe corrective actions in both situations

Step 8 *Monitor task performance*

Critical issues

Identify & correct unplanned gaps in competence during specific tasks

- Back-up system for drop-out

Record & analyse performance

- Registration & analysis of poor competence in tasks, incl. distinguish poor training from poor selection
- Evaluation of personnel knowledge of operations & hazards against criteria/standards
- Analysis of incidents for evidence of poor competence

Sample questions

- What kind of safety performance indicator is used to evaluate the training system?
- Is the training system evaluated against personnel's knowledge of operations and hazards involved?
- In what way are incident / accident data used to evaluate / maintain the training system?

Step 9 *Evaluate competence*

Critical issues

Evaluate and modify use of competence delivery system

- System for checking & modifying requirements and provision of competence for specific tasks (incl. use of contractors)
- Evidence of action on signals of insufficient competence leading back to changes in task analysis, competence specification, training programmes and refresher training

Sample questions

- Evaluation of competence delivery system?
- In what way and how successfully is the competence delivery system assessed and improved?

Step 10 *Refresher training*

Critical issues

Programme of refresher training

- Identification of the need for regular or specific retraining to keep competence up-to-date covering:
  - Deterioration of routine skills
  - Emergency skills (use of practices, drills, simulators)
- Provision and recording of refresher training and its success

Sample questions

- Are the requirements for refresher training defined?
- How many percent refresher training is performed according to the specified requirements?

Commitment delivery and conflict resolution

1. *Introduction*

Overview

This delivery system covers both the execution of and management decisions about giving appropriate priority to safe behaviour in relation to barriers and their management.
In the primary business process commitment is concerned with behaviour which is a direct part of the barrier function, e.g. detection or diagnosis of deviations, skills of emergency response, etc. It is concerned with being attentive when actions are needed, to carry these out in the correct way, and to resolve any conflicting pressures, which might make incorrect behaviour attractive or even necessary. It therefore deals with incentives of individuals carrying out the primary business activities not to choose other criteria above safety (such as ease of working, time saving, social approval etc.) as well as the resolution of conflicts between safety and other criteria.
Such conflict resolution takes place not only at the level of execution of the behaviour, but also in the management hierarchy, which creates many of the conflicting pressures.

When this protocol is used for deeper auditing of the hardware life cycle it has particular relevance to the steps of inspection, testing and maintenance, since these are the most likely to be reduced or delayed under production pressures

When the commitment and conflict resolution delivery system is properly managed, it has the following observable qualities:

- Explicit demonstration of concern by higher echelons for safety (company statements, involvement of top management in safety activities and committees, explicit reporting)
- Alertness at workfloor level to hazards and (incipient) failure states
- Alertness to taking of action, esp. in the case of (threatened) failure and/or emergency
- Use at the correct times of temporary barriers such as protective equipment or protective barriers around worksites
- Refraining from unauthorised removal, adjustment or modification of barriers
- Care and attention to safety-critical tasks
- Pride in work quality
- Self-critical and self-checking approach to carrying out tasks
- Concern for own and others' safety
- Risk avoidance

- Compliance to safety rules unless there are weighty reasons for deviations and improvisations
- Responsible initiative in unplanned situations

1.1 Definitions and coverage

Commitment delivery

This protocol covers the systems for provision of the incentives and motivation that personnel have and/or need to carry out their tasks and activities according to the appropriate safety criteria and procedures. These criteria may be specified by the organisation, derived from external sources (legal, societal criteria) or generated by individuals and/or groups within the discretion allowed to them in the system.

Conflict resolution

The mechanisms (such as supervision, monitoring, decision-making procedures,) by which potential and actual conflicts between safety and other criteria in the allocation and use of personnel, hardware and other resources are recognised, avoided or resolved if they occur.

Coverage

Commitment and conflict resolution are concerned with:

- Information, training and discussion on what is important and has priority
- Rapid confrontation and correction of deviations from the desired working method, state or condition
- High (publicity) profile and reward for achievements on safety
- Appraisal schemes with explicit attention to safety performance
- Recurrent active attention to safety in meetings, discussions and actions
- Procedure violations
- Keeping to the prescribed operating envelope
- Safety and production/time pressures e.g. production pressures reducing scheduled maintenance/inspection, operations which come under time pressure for implementation, reluctance to declare emergencies or shutdown plant because of loss of production
- Safety critical maintenance priority over production
- Balancing production targets, resource availability/costs and inspection and maintenance requirements via e.g. time schedules and budget setting
- Safety budget (increased/decreased)

1.2 General requirements: policy

I. Management system in place for encouraging commitment and alertness and for conflict resolution between safety and other criteria/pressures
II. Task analysis system pays attention to motivation and incentives needed
III. (Safety) policies on cost-safety trade-off, safety critical maintenance, balancing production/inspection/testing and maintenance
IV. Staff appraisal system from top to bottom of organization in place
V. Explicit evaluation system for monitoring safety culture, commitment and alertness in place, with performance indicators
VI. System for adapting management of commitment to best practice outside company
VII. Methods to safeguard commitment to safety against adverse external market conditions, competition, etc.
VIII. Explicit evaluation system for monitoring success of conflict resolution in place, with performance indicators

1.3 Links to other delivery systems

This delivery system is closely linked to the communication and coordination delivery system in that …….???? It has links to the other (personnel) delivery systems, procedures, competence and manpower planning, which also depend on a good task analysis,. It also links to the protocol on procedures and rules, since these provide the criteria against which compliance and rule violations can be judged. Finally commitment is also closely related to the learning and change management systems, particularly to the step of reporting incidents and deviations from safe behaviour and working conditions, which form the basis of learning.

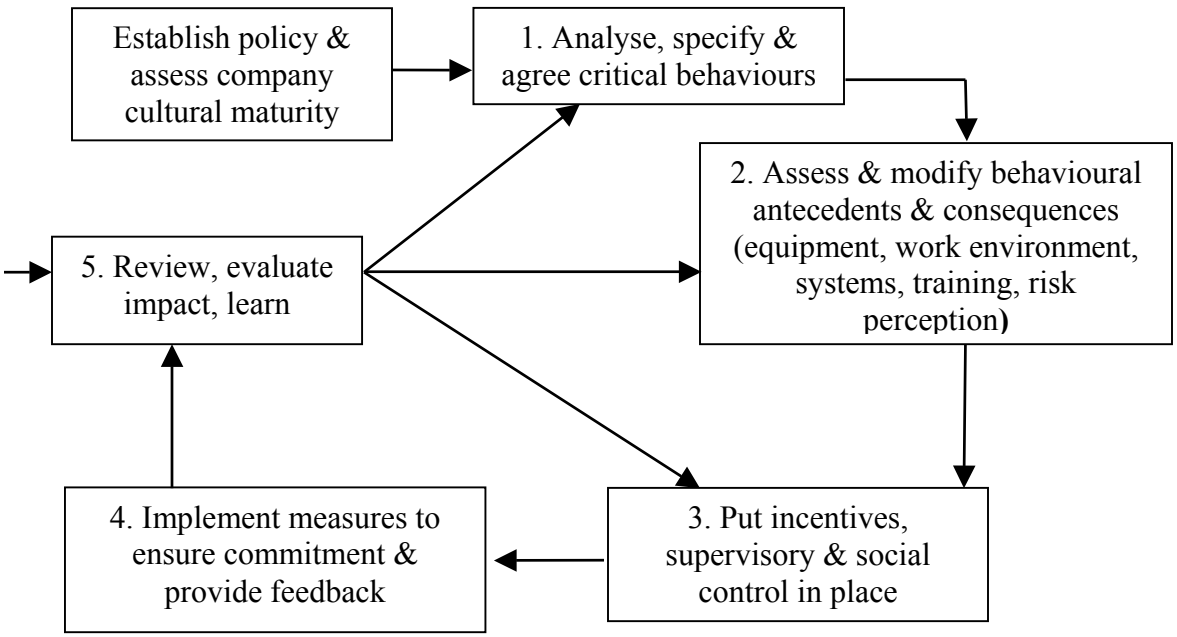
2. Evaluation of management of commitment and conflict resolution

2.1 Introduction

The evaluation section is composed as follows. First a schematic overview of the delivery system is given (2.1). This overview is followed by a methodical questioning of the consecutive steps in the overview (2.2). The steps follow a systematic order for development and delivery of the required behaviour. These steps are worked out in detail and critical issues for each step are given. This outline is considered to be a blueprint for setting up and running any delivery system, and providing the desired and optimal behaviour. Assessment occurs by comparing the actual local practice with the anchoring points given for each step. The quality of delivery for the management system under examination is established by judging the full system, i.e. the sum of its parts.

Schematic overview

The steps in this overview are aimed in the first instance at behaviour which forms a direct part of the barrier functioning. They are also applicable to the behaviour of managers in avoiding and resolving conflicts between safety and other objectives in their decisions over priorities, planning (e.g. of production stoppages for repair or maintenance) or working methods.



2.2 Assessment of commitment and conflict resolution delivery

Input → *Policy on commitment and cultural maturity assessment of company*

Critical issues

Means to resolve conflicts planned in advance

- Formal policy/procedure to manage conflicts between production and safety
- Training of managers & supervisors to recognise and resolve conflicts
- Money available for safety:
  - Estimates and budget for planned safety expenditure
  - Method for approving additional, exceptional expenditure for urgent or emergency needs
- Disciplinary policy for disregard of practices and procedures is communicated

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Step 1 *Specify & agree critical behaviours*

Critical issues

Analyse tasks for need for commitment/alertness for safety

- Identify tasks most susceptible to any conflicting pressures, based on analysis methods and past experience/incidents
- Identify during task analysis critical task elements in barrier functioning and management which are sensitive to lack of commitment, sloppiness or risk taking
- (Formal) system for predicting potential conflicts in activities
- Formal systems for identifying conflicts in the delivery of controls and/or resources

Specify task requirements for commitment

- Identify personal characteristics/motivation relevant to safety critical tasks

Identification and notification of potential conflicts & pressures

- Specify targets for barrier performance and safety results
- Specify and agree critical behaviours important to barrier performance in each part of the process or site

Assessment

- Involvement of employees in this process?

Sample questions

- How is safety critical behaviour identified?
- What is the company policy / system to resolve potential conflicts related to safety?
  - How is the performance of this system evaluated?

Step 2 ***Assess & modify behavioural antecedents and consequences (equipment, work environment, systems, training, risk perception***

Critical issues

Review design and layout of equipment, instrumentation, protective equipment, etc. to resolve conflicts between safe use and other incentives (comfort, ease of operation, openness to short cuts

- Link to protocol on hardware purchase and spares

Review training and job familiarisation programmes to ensure that risk perception and reasons for safe behaviour are covered and stressed

- Link to protocol on competence

Review supervision to identify behaviour and (informal) rewards and punishments which encourage unsafe behaviour, turn a blind eye to it, or reward risk taking

- Based on monitoring and incident analysis

Review work group behaviour to identify beliefs, attitudes and behaviour and (informal) rewards and punishments which encourage unsafe behaviour, turn a blind eye to it, or reward risk taking

- Based on monitoring and incident analysis

Select people with appropriate basic attitude

- Explicit evaluation of safety motivation in selection & training

Sample questions

- Are potential safety conflicts part of the training programs?
- What is the supervisor's attitude to safety conflicts?
- What is the employee's attitude to safety conflicts?
- Is the safety attitude used to select people for safety critical tasks?

Step 3 *Put incentive schemes, supervisory & social control in place*

Critical issues

Specify motivators available

- Explicit motivation programme addressed at safety and pride in work
- Supervision, incentive schemes, motivation schemes assessed, based on state of the art and experience

Select and apply motivation package (managers & staff)

- Functioning recognition/appraisal system on safety for operators: behaviour monitoring or auditing, toolbox meetings etc.
- Functioning recognition/appraisal system on safety for managers/supervisors
- Explicit and repeated training/information on safety priority at all levels
- Explicit demonstration of top management concern through active behaviour (visits, inspections)
- Safety achievement recognition
- Active attention in meetings, reports, etc.

Train supervisors and managers to apply motivation system

- Supervisors and managers trained in safety supervision, incl. confrontation of unsafe acts and reward of safe acts
- Supervisors and managers trained in staff appraisal with explicit attention to safety-related behaviour and safety performance

Sample questions

- How often are safety campaigns organised?
- How often are safety attitudes subject of a safety campaign?
- In what way are personnel motivated to behave safety (give examples)?
- Is the motivation system evaluated and improved if necessary?
- Is safety attitude part of the employee's evaluation system?

Step 4	***Implement measures to ensure commitment and provide feedback***
Critical issues	**Identify & correct poor commitment or alertness and conflicts in the short term** ▪ Active supervision, incl. confrontation of unsafe acts and reward of safe acts (behavioural monitoring/auditing) ▪ Means of/procedure for reporting immediate conflicts/safety concerns ▪ Formal policy on, and method for identifying/signalling and handling production pressures ▪ Procedure revision methods to authorise deviation from rules ▪ System for preparation of *ad-hoc* instructions/plans for coping with unexpected or unplanned safety-critical situations ▪ Procedure/authority to stop an unsafe practice ▪ Authority to refuse to carry out an unsafe procedure
Assessment	▪ Current rules, procedures and standards are accessible and used
Sample questions	▪ What triggers are used to start identifying problems related to a poor safety attitude? ▪ Describe and evaluate the corrective system related to a lack of commitment and poor safety attitudes

Step 5 *Review, evaluate impact, learn*

Critical issues

Record & analyse commitment and conflict resolution performance

- Registration and analysis of cases of poor alertness/attention/commitment
- Analysis of incidents for evidence of problems of commitment/alertness
- Log of conflicts & resolution kept
- Information
- Analysis of incidents for conflicts

Evaluate and modify use of appraisal/commitment delivery system

- Evidence of action on signals of insufficient commitment or alertness

Evaluate and modify commitment & alertness and conflict resolution delivery system

- Audit system for reviewing appraisal and motivation system for safety critical jobs
- Evidence of response to signals for general improvements in delivery system
- Evidence of formal redesign of delivery system to resolve conflicts
- Audit system for reviewing conflict resolution

Make structural resolution of conflicts

- Method of revising standards, practices and procedures to prevent future safety-production conflicts
- Evidence of formal adaptation of rules, schedules, resourcing, budgets

Sample questions

- Does the organisation have formal procedures to resolve conflicts related to safety?

❖ Evaluate the effectiveness of the conflict resolving system
❖ Evaluate the effectiveness of the appraisal / punishment system

Communication and coordination delivery

1. Introduction

Overview

The communication and coordination delivery system is engaged in setting up and activating communication channels and platforms for informing and coordinating worker and staff actions, where the operation or functioning of barriers depends on the behaviour of more than one individual. This is the case when the barrier function involves detection, activation and/or response at separate locations or times. This is common by plant start-up and shutdown, by emergencies and shift changeovers and where hardware cannot be remotely controlled from control rooms.

With regard to behaviour in relation to the management of barriers, communication is especially central in the operations and maintenance phases of complex activities and, in particular in the handover between operations and the inspection and maintenance life cycle step of barriers.

1.1 Definitions and coverage

Communication

Internal communications are those communications, which occur between people within any primary business activity. They are only relevant to this protocol if the activity related to a barrier and its functioning is carried out by more than one person (or group), who has to coordinate or plan joint activities. Communications between tasks that are represented in the other parts of the management system are not included here, since they are represented by the continuity of activity within those delivery systems and protocols. Communication occurs either face-to-face, or through communication channels such as (mobile) telephone, data link, radio, e-mail, memo. It can be spoken or written.

Coordination

By **coordination** is meant those mechanisms designed to ensure the smooth interaction of actions between individuals and groups working on a joint task or responsible for the correct functioning of a given barrier. These include plans, meetings, authorisation and communication procedures and supervision.

Coverage

The communication and coordination delivery system concerns itself with:

- Communication channels (phone, radio, minutes, reports, etc.)
- Coordination methods (e.g. meetings, supervision)

- Communication between:
  - Different persons engaged on one task as team or working in sequence
  - Shifts at changeover
- Communication about:
  - Work content
  - Barrier/plant status
  - Job instructions
  - Priorities
  - Who does what, where and when
  - Need for action or (back-up) personnel and equipment
- Communication systems for sharing operation/maintenance hazard concerns and experience

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1.2 General requirements: policy

- Management system for communications and coordination in place for all safety-critical activities and handovers of responsibility related to barrier functioning and management in all states of the plant from normal operations, through start-up and shutdown, maintenance and emergency conditions
- Identification of requirements for communication in safety-critical tasks related to barrier functioning and management:
- Explicit evaluation system for monitoring success of communications and coordination in place, with performance indicators
- System for adapting communications system to regulatory requirements and best practice
- Harmonisation of communication & permit-to-work systems with local industry using the same contractors
- Agreement over communication and coordination during emergency conditions both within the plant and with external services

1.3 Links to other delivery systems

This protocol links to the protocol on competence, since communication is also a procedure and skill which has to be learned. It also links to the protocol on procedures and rules, since many communication processes are, or should be, formalised and subject to procedures. Communication is a critical part of the processes by which hardware barriers and elements are tested, inspected and maintained. Hence this protocol relates to the protocol on that aspect of hardware management. The hardware and software of the communication channels can also be seen as subject to both hardware management protocols. In this sense it can be regarded as

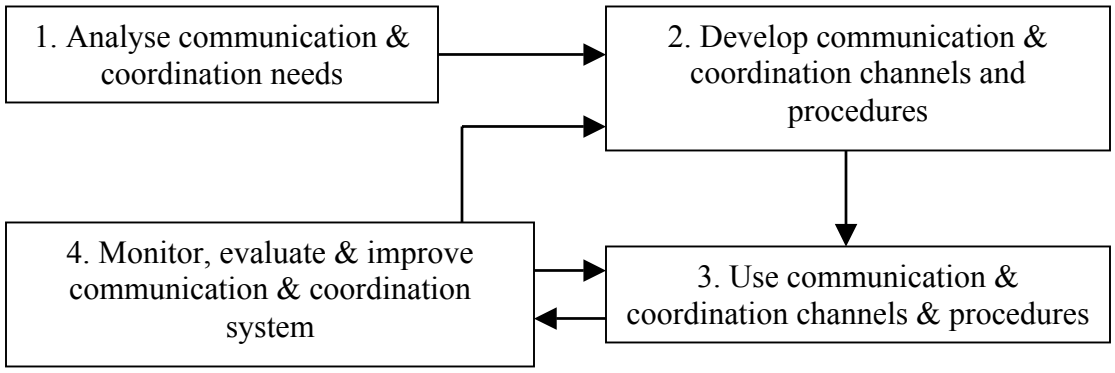
part of a safety barrier, especially in emergency situations when it forms the link between detection of an incipient emergency and activation of the response to that situation (e.g. calling out the fire service, initiating emergency shutdown, etc.).

2. Assessment of communication and coordination delivery at operational level

2.1 Introduction

The evaluation section is composed as follows. First a schematic overview of the delivery system is given (2.1). This overview is followed by a methodical questioning of the consecutive steps in the overview (2.2). The steps follow a systematic order for development and delivery of the required behaviour. These steps are worked out in detail and critical issues for each step are given. This outline is considered to be a blueprint for setting up and running any delivery system, and providing the desired and optimal behaviour. Assessment occurs by comparing the actual local practice with the anchoring points given for each step. The quality of delivery for the management system under examination is established by judging the full system, i.e. the sum of its parts.

Schematic overview



2.2 Assessment of delivery of communication and coordination

Step 1 Analyse communication & coordination needs: task analysis, function allocation

Critical issues

Identification of communication & coordination needs

- Attention in task analysis for requirements for communication & coordination in successful functioning of barriers and barrier management:
- Consideration of full range of situations requiring communication: normal operations, start-up, shutdown, control-room field, operations-maintenance, emergency call-out and coordination
- Explicit attention to communication in procedures, manuals, etc.
- Explicit incorporation of safety into planning of shift/team handovers
- Explicit attention to communication during emergency situations, both within the plant and to outside organisations (e.g. emergency services, media, etc.)
- Identification of coordination requirements relating to barrier functioning and management: plans, meetings, supervision

Sample questions

- Are communication needs identified and defined (process, procedure)?
- How are the safety critical communication aspects identified and included in the description of communication processes?

Step 2 ***Develop communication & coordination channels, procedures and protocols***

Critical issues

Definition and furnishing of information/communication channels

- Planning/allocation of communication channels: consideration for availability, reliability, sensitivity to failure under normal and extreme conditions, learning from past experience
- Availability of communication hardware: sufficient quantity and quality, tested and kept in good condition
- Presence of procedures and protocols for communication under all situations, based on good practice and past experience
  - Responsibilities for initiating communication
  - Under what circumstances,
  - Protocols for the form, language and style of communications (verbal, written)
- Situations include:
  - Control-room field communication for normal operations, start-up and shutdown
  - Shift changeover and shift logs
  - Operations – maintenance handovers and permit-to-work systems
  - Emergency call out procedures
  - Emergency management communications

Definition and supply of coordination mechanisms

- Presence of planning and coordination meetings where safety aspects are discussed
- Presence of informal meetings for solving daily safety issues between relevant parties

Sample questions

- How many communication channels are used?
  - Are they suitable and sufficient for safety critical communication?

❖ Evaluate inter-personal and group communication

Step 3	***Use communication channels, coordinate/conduct handovers***
Critical issues	**Use communication channels and protocols and coordination mechanisms correctly** ▪ Check **Identify & correct poor coordination or communications** ▪ Active supervision anticipating communications problems ▪ Use of ad hoc meetings, etc. to correct coordination & communications problems
Sample questions	▪ To what extent (percentage) are communication channels used correctly? ▪ In what way are errors and shortcomings in communication processes identified and corrected?

Step 4 *Monitor communication/coordination activities, evaluate and learn/improve*

Critical issues

Record & analyse performance (communication/ coordination)

- Registration and analysis of cases of poor communications & coordination: incident reports, complaints, checks of paperwork & communication practice
- Conduct practices and drills for communications under emergency conditions

Evaluate and modify use of communications/coordination delivery system

- Analysis of incidents for evidence of problems of communication & coordination
- System for modifying specific forms of communication & coordination
- Evidence of action on signals of insufficient communication or coordination

Evaluate and modify communications & coordination delivery system

- Audit system for reviewing coordination & communications system for safety critical jobs
- Evidence of response for general improvements in delivery system

Sample questions

- What system is used to evaluate the performance of the communication and co-ordination system?
- What kind of information is used to evaluate the communication and co-ordination system, and how is this done?
- Is special attention paid to safety critical communication processes?

Management of procedures, rules and goals

1. Introduction

Overview

The procedures, rules and goals delivery system is occupied with identifying tasks that need (detailed) written rules and procedures, and subsequently providing and promulgating these. This system also delivers output goals for tasks that do not need a detailed procedure.

Importantly, procedures are not developed on their own, but with detailed knowledge of the hardware that is involved and the people who are going to use or operate on it. This implies that the trade-off between design, competence and rules should always be considered and made explicit. When procedures are also (very) demanding, commitment to their correct execution should receive proper attention.

With regard to procedures the distinction between functioning at skill or rule level becomes pertinent. Tasks requiring a high level of skill are ideally not carried out using detailed written procedures; the emphasis should be more on competence and commitment, to carry out what is required.

Tasks requiring a rule level of functioning do involve significant use of procedures, especially in a diagnostic phase or as checklist reminder for complex sets of steps. Moreover, here also is an additional requirement for competence.

Functioning at knowledge level is, by definition, not procedure based for it deals with novel and unplanned situations. However, procedures or meta-rules should be available describing how to proceed in such situations, e.g. who should be involved in deciding what to do, what sources of information should be checked, etc.

1.1 Definitions and coverage

Procedures and rules

Procedures and rules: procedures and rules are specific performance criteria, which specify in detail, usually in written form[2], a formalised 'normative' behaviour or method for carrying out an activity (checklist, task list, action steps, plan, instruction manual, fault-finding heuristic, form to be completed, etc.).

[2] In work groups which work intensively together rules and procedures may be unwritten, but known and used by all concerned in every other way as though they were written.

Output goals

Output goals: output goals are performance measures for an activity, which specify what the result of the activity should be, but not how the results should be achieved. They are objectives, goals or outputs (e.g. accident/incident targets or trends, exposure or risk levels, ALARA, 'safe', numbers of activities carried out, etc.). It is also convenient to regard definitions and criteria for choosing one course of action over another as output criteria.

Coverage

The **procedures, rules and goals delivery system** concerns itself with:

- Coverage (i.e. all safety situations)
- Accuracy
- Readability/usability
- Size/complexity/overload or rule sets
- Clarity/ambiguity
- Up-to-date
- Indicating priorities

Procedures, rules and goals management covers the functioning of barriers in all life cycle phases:

- Plant operations: start up/shut down, loading/unloading, etc.
- When PPE is required
- Good housekeeping and clean-up
- Halting unsafe operations and reporting safety concerns
- Communications protocols
- Emergency shutdown procedures
- Emergency response plan
- Criteria for emergency shutdown and implications for production

When applied to the hardware life cycle it is particularly important in maintenance & inspection:

- Specific procedures on plant maintenance like testing, hand-over, PTW, sampling/draining, diagnosis, (dis)assembly, repair, replacement (like with like), return to service.
- Specification of inspection and test intervals, and requirements, and inspection and test methods

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1.2 General requirements

I. Management system for procedures and goals in place for all activities

II. Clear criteria for deciding what means will be used to achieve desired behaviour and when this will be rules and procedures

III. Incorporation of explicit safety considerations into procedures/goals system
IV. Explicit evaluation system for monitoring success of procedures & goals in place, with performance indicators

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1.3 Links to other delivery systems

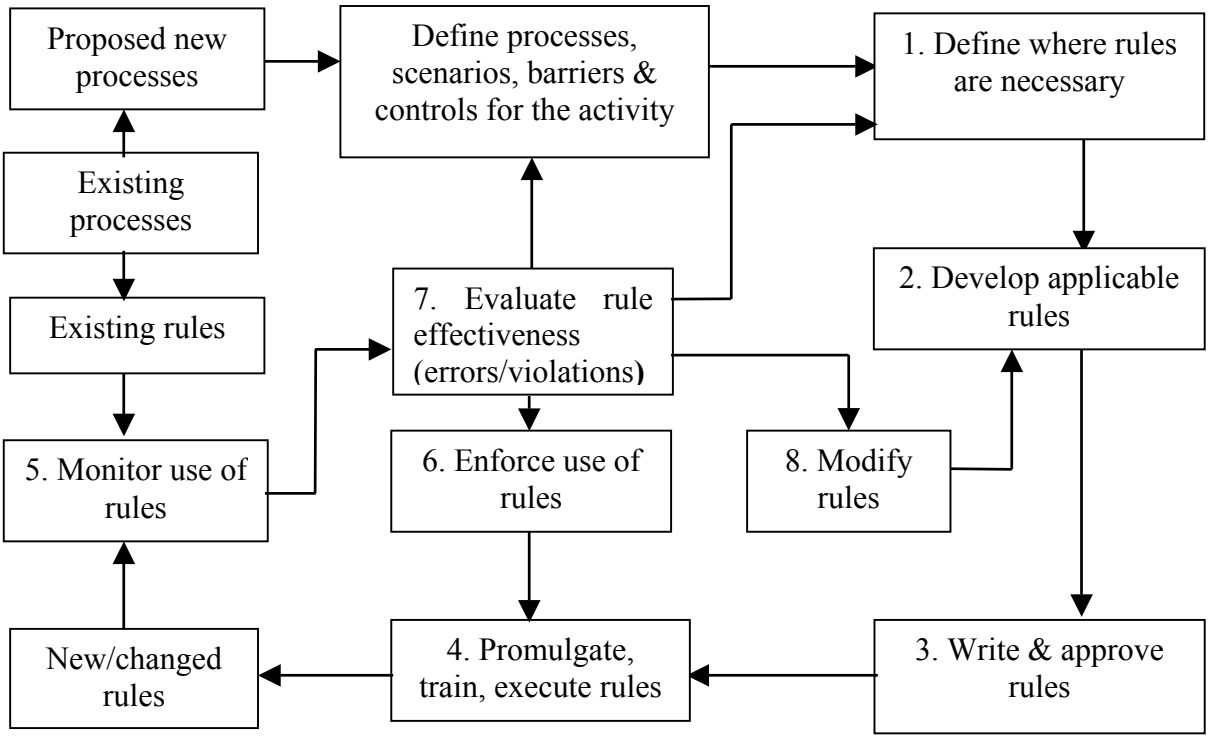
The procedures delivery system has a direct link with the competence delivery system in that competences and procedures should be well balanced in the execution of tasks. Additionally, performing any task in the prescribed way also requires full commitment to do so. Procedures therefore, should be developed in close connection with those delivery systems responsible for providing the conditions that ensure that people understand and carry out procedures as intended. There is also a link to the communications protocol, since many communication processes are proceduralised.

2. Evaluation of delivery of procedures, rules and goals

2.1 Introduction

The evaluation section is composed as follows. First a schematic overview of the delivery system is given (2.1). This overview is followed by a methodical questioning of the consecutive steps in the overview (2.2). The steps follow a systematic order for development and delivery of the required behaviour. These steps are worked out in detail and critical issues for each step are given. This outline is considered to be a blueprint for setting up and running any delivery system, and providing the desired and optimal behaviour. Assessment occurs by comparing the actual local practice with the anchoring points given for each step. The quality of delivery for the management system under examination is established by judging the full system, i.e. the sum of its parts.

Schematic overview



2.2 Assessment of rules and procedure delivery

Input → *Defined processes, scenarios, barriers & controls for the activity*

Step 1 Define where rules and procedures are necessary

Critical issues

Analyse tasks and objectives & need for procedures

- Explicit policy on safe procedures/goals; choice between using design/automation, written rules, competence or group decisions as a way to achieve the desired behaviour
- Access to:
  - Design specifications
  - Process descriptions
  - Human factors reviews
  - Operational hazard reviews
  - Task analyses
  - Experiences/incident records
  - External requirements/demands
- Explicit attention to choice of general safety goals vs. detailed procedures
- Explicit attention to tasks involving (potentially) high(er) risks

Analysis of process

- Responsibility allocated & methods available for ensuring processes are analysed and safe operating procedures are developed/usable/ available
- Involvement of operators & learning from past experience

Sample questions

- Which method is used for task analysis?
- Does the organisation have formally defined criteria to select tasks that require procedures?
- Are the responsibilities for task analysis and development of procedures clearly defined and kept to?

Step 2	***Develop applicable rules and procedures***
Critical issues	**Definition and composition of team for the production of procedures, rules & methods and goals** ▪ Formal competence criteria of team members (background, department, experience) ▪ Involvement of operating personnel
Sample questions	▪ What people are responsible for the development of procedures? ▪ Are they selected based on their experience and knowledge?

Step 3	***Write and approve rules and procedures***
Critical issues	**The writing of draft procedures/goals** ▪ Formal procedure for writing draft procedures/goals ▪ Sources of information on operational/maintenance safety performance criteria ▪ Level of information in procedures dependent on type of task ▪ Involvement of technical writers ▪ Criteria for clarity, depth, extent of procedures ▪ Explicit identification of safety measures, incl. PPE **Evaluation & approval of draft procedures/goals** ▪ Formal procedure for evaluation of draft procedures/goals ▪ Criteria on involvement of personnel ▪ Means of ensuring that procedures cover all key aspects of operational safety policy ▪ Procedure for approval and allocation of responsibilities ▪ Specification of expected performance/output
Sample questions	▪ Does the organisation have specified formal requirements for work procedures? ▪ How are the procedures approved? Who is responsible?

Step 4 *Promulgate, train, execute rules and procedures*

Critical issues

Introduction of new and/or renewed approved procedures/goals

- Specification of safety criteria in formal documentation (safe operation limits)
- Key safety procedures are together in one safety manual
- Revision dates on procedures and manuals
- Distribution of operational/maintenance standards/-rules/criteria
- Responsibility allocated for ensuring safe operating procedures are implemented
- Specification/adaptation of training needs/requirements
- Availability of handbooks/checklists
- Non-confusable criteria for when to use different procedures

Sample questions

- How are the procedures updated?
- Are the criteria describing the need for updating procedures clearly defined?

Step 5 *Monitor use of rules*

Critical issues

Recording/analysis of problems from implemented procedures/goals

- Formal logging of experience
- Complaints procedure
- Assessment methods for reviewing procedures/criteria and whether these are complied with; e.g. inspections, observations/spot checks, audits
- Analysis of incidents to detect poor goals and procedures

Sample questions

- What kind of registers related to procedure implementation is available?

Step 6 *Enforce use of rules*

Critical issues

Correct deviations from implemented procedures/goals

- Agreed approach towards detected deviations
- Policy/criteria for what tasks are supervised or checked
- Supervision to detect and immediately correct deviations
- Attention to group and social pressures to follow or violate rules
- System for explicit approval of required deviations

Sample questions

- In what way is implementation of procedures assessed?
- Are the corrective actions effective?

Step 7	***Evaluate rule effectiveness (errors/violations)***
Critical issues	**Evaluate & modify procedures/goals for specific tasks** ▪ System for procedure review & updating with criteria for frequency & responsibility allocated, incl. involvement of users ▪ Identification of tasks with missing procedures ▪ Evidence of changes to procedures (dates/logs) and/or decisions to achieve desired behaviour in other ways than rules **Evaluate & modify procedure/goals delivery system** ▪ Procedure/goal system reviewed in audit ▪ Evidence of response to signals for general improvements in delivery system
Sample questions	▪ In what way is the use of procedures assessed? ▪ Are the corrective actions effective?

Step 8	***Modify rules***
Assessment	▪ Evidence of changes to rules based on monitoring and evaluation or changes in technology, regulations ***➔ output to learning system***

Management of barrier (and spares) purchase, construction, installation and adjustment

1. Introduction

Overview

This factor deals with the management process for ensuring that the hardware/ software barriers and barrier elements which have been specified by the 'Risk Analysis and Barrier Choice' process are acquired, either by purchase from outside, or by construction on site, are put in place and adjusted and that the spare parts or replacements purchased and stored for the maintenance phase of their life cycle are the correct ones and are in good condition when used. The process should pay explicit attention to the human factors aspects of the interface between barrier elements and their users in the case of mixed barriers.

1.1 Definitions and coverage

Hardware and software

This protocol covers all hardware and software which has a function within any barrier designed to fulfil a safety function in the plant. It forms the part of the life cycle after the specification of the barriers, up to the point where the barrier or element has been installed and adjusted and is ready for use or functioning. It also covers the purchase, storage and issue of spare parts and replacements, which will be used in the maintenance and modification phase of the barriers and elements. It also covers the step of recording the performance of all of the hardware and software covered, so that its functioning can be assessed and evaluated for the learning process. The human factors (HF) aspects of the design, layout and interfaces must be explicitly considered under this heading.

Coverage

Coverage includes:

- Passive barriers such as vessels and pipes, bunds round storage tanks
- Passive elements of barriers such as warning signs, labels
- Temporary passive barriers like blind flanges, tape for marking off areas
- Active barriers such as relief valves, automatic shutdown systems, sprinkler systems
- Active elements in combined barriers, such as instrumentation, control panels, test equipment
- Spares and replacement parts for any of these barriers or elements

1.2 General requirements

An explicit policy for this aspect of barrier management, covering:

- Overall responsibilities and task allocation for the tasks set out here
- Choice criteria for purchase and contracting or in-house construction and installation
- Consideration for human factors aspects of layout and interface design, both user- and maintenance-friendly
- System for evaluating policy and improving it to increase barrier effectiveness
- System for keeping up to date with best practice in barrier performance and of regulatory and other requirements

1.3 Links to other delivery systems

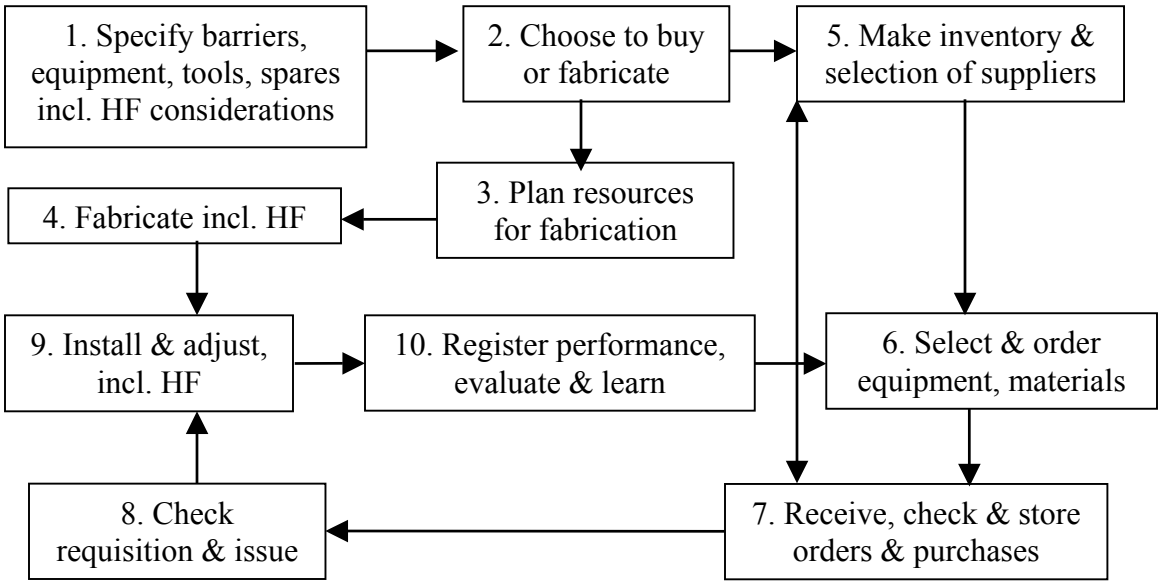
The links to the other parts of the hardware/software life cycle have been indicated above. This process comes between the specification of the hardware/software (elements of the) barriers and their inspection and maintenance. There is also an output to the learning system of the company (step 10). At a number of points specific mention is made of the qualities of the persons who carry out different steps in the life cycle. These qualities are their competence, the procedures and methods they use, their availability at critical times and their supervision (or other ways of ensuring that they are committed to high quality work). This means that it is possible, if desired, to take the 'behavioural' delivery systems relating to each of these aspects and apply them in detail to those steps. This can give a deeper check of the way in which these qualities are delivered to the different steps. It is suggested that this only be done if one of these steps is particularly critical for a particular barrier type or element, or if the initial audit gives no clear indication of how well that aspect is managed.

2.2 Evaluation of management of purchases

2.1 Introduction

The assessment of hardware and software delivery follows the steps of the generic barrier life cycle. For each step critical issues specific are defined. Assessment occurs by comparing the actual local practice with the anchoring points given for each step.

Schematic overview



2.2 Assessment of management of purchases

Step 1 Specify barriers, equipment, tools, spares including human factor considerations

Critical issues

This step links to the protocol on risk analysis and barrier selection. Under that heading the barrier specification should have been made, down to the point of the form of the barrier – either a pure hardware/software barrier or a hardware/software element of a combined barrier, which has to be interpreted or used by a person. Either in that protocol or here must be covered:

- Detailed specification of the form of the barrier (element) including consideration of the interface for the user and maintainer: minimum and desirable requirements, concern for possible defeating of barriers
- Performance criteria for use in specifying, purchasing and evaluating the barrier (element)
- Conformity to relevant standards (knowledge about and presence of standards documentation)

Sample questions

- Describe the system to select and approve barriers
- Does this system cover human factor considerations?
- In what way?
- Are performance criteria specified for every barrier?

Step 2 Choice to fabricate in house or purchase

Critical issues

- Criteria for deciding what should be made or modified in house and what should be contracted out to (specialist) suppliers, e.g.
  - Specialist knowledge and skill
  - Availability of suppliers
  - Past experience
  - Other
- Review of criteria based on experience

Sample questions

- In what way is the choice to fabricate or to purchase being made?

❖ Evaluate the criteria for these decisions

Step 3 *Plan resources for in-house fabrication and/or installation*

Critical issues

(To be used only if some in-house fabrication or installation is undertaken. This step links to the topics of the 'behavioural' delivery systems.)

- Staff possess the required competencies for the tasks carried out
- Sufficient staff available at the times needed
- Procedures present for controlling the quality of the work done and the products produced
- Incentive systems and supervision adapted to produce commitment to high quality

Sample questions

- How is the installation plan made?
- What are the obligatory points in such a plan?

Step 4 *Fabricate*

Critical issues

(To be used only if some in-house fabrication is undertaken.)

- Detailed design and fabrication takes account of criteria for effectiveness, user- and maintenance-friendliness
- Procedures for supervision and quality checking are carried out, including final independent acceptance check for quality, effectiveness and robustness against misuse
- (Deviation from approved design and/or construction practices and standards is approved and documented > link to learning and change system)

Sample questions

- Describe the course of the standard in-house fabrication process?
- What are the obligatory reviews and analyses during this phase?
- In what way are deviations from design or plan corrected?

Step 5 *Inventory & selection of suppliers*

Critical issues

This step covers suppliers of complete barriers, elements for them, spares for them, and parts for any in-house fabrication which is conducted.

- Inventory of potential suppliers to form pool, updated at intervals
- Up-to-date information about quality standards of suppliers
- Up-to-date list of approved suppliers based on clear criteria

Sample questions

- How is the usage phase of the barrier life cycle documented?
- What are the obligatory elements of this document?

Step 6 *Select and order hardware/software*

Critical issues

- Selection of materials based on criteria established above
- Testing of sample materials Assessment of quality, functioning and robustness, susceptibility for misuse, easy removal or defeating
- Explicit policy on stock level and on-demand delivery (for repair and replacement)
- Order system for materials, including built-in checks
- Inventory for purchased, stored and installed barriers and spares, including location and history and coupled to requirements for use, testing, inspection, cleaning and maintenance

Sample questions

- Who is responsible for defining purchase specifications?
- Who is responsible for testing of materials?
- Who is responsible for final orders of goods and materials?

❖ Evaluate the system

Step 7 *Receive, check and store ordered goods*

Critical issues

- Formal registration and checking of incoming goods against order and specifications
- Storage under appropriate conditions to prevent damage, accidents or deterioration: temperature, humidity, sunlight, stacking, floor loading, accessibility for lifting and handling equipment
- Labelling and recording of inventory for secure access and checking

Sample questions

- Who is responsible for acceptation (comparison against the orders) of the delivered goods and materials?
- What are the standards for storage of vulnerable goods and materials?
- What are the standards of labelling and keeping inventories of chemical and dangerous substances?
- How often are the standards mentioned above violated and what is the standard corrective procedure?

Step 8 *Check, requisition and issue equipment, tools and spares*

Critical issues

- System for issue including checks of requisitions to prevent issue of incorrect items or ones in poor condition (issuer and receiver)
- Record of issue for all barrier elements, including required recall and replacement timescales for 'perishable' items such as personal protective equipment
- Issue of materials includes, where necessary, instructions for use, adjustment and maintenance
- On-site check before use of spares
- Check of returned material and tools to test condition before re-storing

Sample questions

- ❖ Evaluate the system for checking, requisition and issuing of equipment, tools and spares
  - Is this system effective and safety oriented?

Step 9 *Installation & adjustment*

Critical issues

(This step covers only initial installation and adjustment of barriers and elements. The installation of the spares and replacements and the necessary periodic adjustment, cleaning, etc. for barrier elements is covered in the protocol dealing with 'Inspection, monitoring and maintenance'. If the same staff does the two tasks, however, they need only be assessed once.)

- Place of installation and layout planned to be safely and conveniently accessible, both for installation and for later inspection, testing, cleaning and adjustment.
- Access means provided for these activities
- Inventory of potential contractors to be hired in to do installation work.
- Criteria of competence, availability, safety management and quality control system specified for installation contractors
- Up-to-date list of approved contractors
- Supervision system specified for installation work (own staff and contractors)
- System of handover from installation to operations, including agreement over responsibility for testing, acceptance and adjustment

Assessment

- Pre-start up review is performed and documented

Sample questions

- Does the organisation have formal procedures for initial installation and testing of barriers?
- Are the criteria related to safety clearly defined for all steps within that process?

Management of inspection, testing and maintenance

1. Introduction

This factor deals with the management processes for ensuring that the hardware/software barriers and barrier elements which have been specified by the 'Risk Analysis and Barrier Choice' are kept in an effective state.

1.1 Definitions and coverage

Overview

This protocol covers all hardware and software which has a function within any barrier designed to fulfill a safety function in the plant. It forms the part of the life cycle of these barrier elements from the point where they have been installed and adjusted and are ready for use. It covers all the activities which monitor the working of the barriers, detect the (chance of) deviation from the designed working and identify the need for work to be done to restore the functioning or replace the barrier (elements) with new ones.

This process also manages small modifications which are carried out at the same time as, and under the same management as the maintenance activities. Where the modifications are of a more major type, which are (or should be) dealt with by a change management process, these are covered by the protocol on learning and change.

Coverage

Coverage of barrier (elements) includes under this protocol:

- Passive barriers such as vessels and pipes, bunds round storage tanks
- Passive elements of barriers such as warning signs, labels
- Temporary passive barriers like blind flanges.
- Active barriers such as relief valves, automatic shutdown systems, sprinkler systems
- Active elements in combined barriers, such as instrumentation, control panels, test equipment

Note that this protocol does not deal with the safety of the personnel who carry out the inspection, testing and maintenance work. It is focussed on the question whether the inspection, testing and maintenance activity ensures the continuing effectiveness of the barriers. The safety of the personnel carrying out this work is dealt with under the heading of the barriers which ensure their safety – which will often be barriers relying on their behaviour and hence on their competence and commitment, etc.

1.2 General requirements

An explicit policy for this aspect of barrier management, covering:

I. Overall responsibilities and task allocation for the tasks set out here
II. Choice criteria for carrying out corrective or breakdown maintenance and whether the work is done by contracting out or in-house labour
III. Documentation of equipment, inspection and maintenance plans
IV. Resourcing of inspection and maintenance work
V. System for maintenance scheduling and follow-up
VI. System for control of handover between production and maintenance and supervision and checking of test and maintenance work.
VII. System for evaluating this policy and improving it to increase barrier effectiveness
VIII. System for keeping up to date with best practice with inspection and maintenance policy

The policy should be informed by the general company safety policy, good practice in other comparable organisations and learning from incidents, accidents and performance assessment in past designs of plant and earlier experience with existing plant.

1.3 Links to other systems

The process is dependent on the successful completion of the protocol for 'Risk analysis and barrier selection'. This link is indicated by the arrow entering the picture at the top left of the diagram, which leads to an inventory of all of the barriers and their hardware and software elements.
The protocol also has links to the protocols which deal with the management of 'Purchase and spares', 'Competence', 'Manpower', and 'Procedures'. The arrows leading out of the box 'Plan resources and methods' to the left of the diagram show this link. The three boxes shown can be audited in summary under this protocol. If a deeper audit of these elements is required, the auditor can use the protocols with these headings, with, as focus, the delivery of the necessary resources for this maintenance activity.

This protocol also covers the recording of the performance information (from inspection and testing) of the barrier elements and of the information discovered during the maintenance process about any deviations from required status or performance. This is input for the learning system of the company, which ensures, when combined with the information from the process covered under the protocol

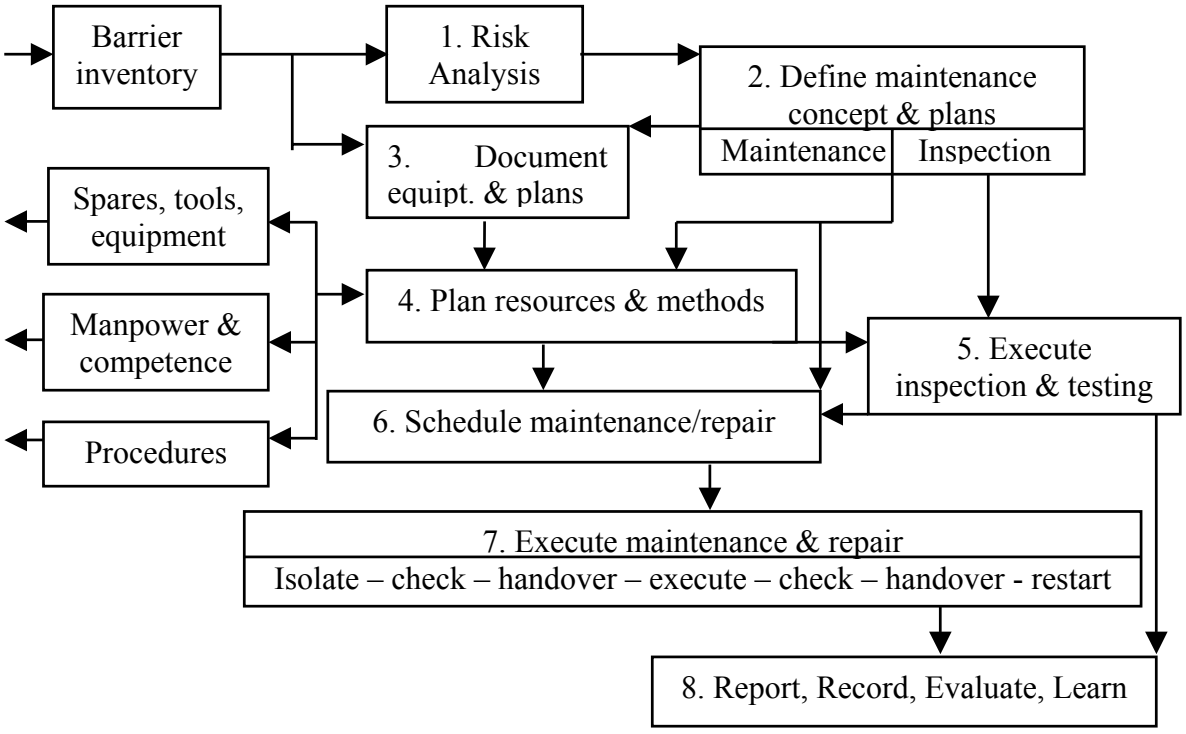
'Management of purchase and spares' that barrier (elements) are improved in design and performance.

This protocol also links to the protocol 'Management of purchase and spares' in respect of the design and layout of the plant and barriers so that they are easy to inspect and maintain. These aspects are criteria in the purchase/construction/installation phase. The human factors (HF) aspects of the inspection, testing and maintenance must be explicitly considered in this protocol. This covers the interface of the barrier (elements) with inspection, testing and maintenance (e.g. accessibility, design for user-friendly maintenance, etc.)

2. Evaluation of inspection, testing and maintenance system

2.1 Introduction

Schematic overview



2.2 Assessment of inspection, testing and maintenance system

Step 1 Risk analysis

Critical issues

This step links to the protocol on 'risk analysis and barrier selection' and that on 'management of purchase and spares'. Under those headings the barrier (elements) should have been specified and installed. As part of this, or under the heading of this protocol the organisation needs to have an inventory of these barrier (elements). In addition the following aspects need to be covered:

- Inventory of the barrier (elements) actually installed in the plant to control the specified scenarios
- Specification of the circumstances under which these are required or expected to operate
- Analysis of the threats to the effectiveness of the barrier (elements), which come from deviations in its state or functioning, how and when they can be expected to appear, given the conditions of use

Sample questions

- Does the organisation have clear methods and criteria to determine when and which barriers are necessary?
- Does the organisation have an inventory of all barriers?
- Is the analysis of barrier effectiveness part of the risk analysis?

Step 2 Define maintenance concept(s) and plans

Critical issues

- Per (type) of barrier (element), specify what the regime for maintenance will be: preventive maintenance (e.g. fixed term or based on condition monitoring) or corrective maintenance/repair.
- Decision to be based on analysis of the life cycle of the barrier (element), the expected degradation scenarios and their time dynamic and the criticality of the barrier (element). Consideration to be given not only to the functioning of the barrier, but also the safety of the staff conducting inspection, testing and maintenance.
  These and the decisions under the next headings should be informed by regulations, manufacturers guidance and standards, machinery standards and good practice guidelines.
- For preventive maintenance regimes, specify what the time periods for maintenance are, or the measurements of condition of the barrier (element) which should lead to maintenance work
- For repair regimes, specify the time interval within which the barrier (element) must be repaired and returned to functioning.
- For all appropriate barrier (elements)[3], specify the regime of inspection and/or testing which will be used to assess the barrier (element) condition and functioning and to ensure that the availability and/or performance of the barrier (element) is checked and verified at appropriate intervals
- Keep the concepts and plans up-to-date with modifications in the plant, learning from experience and from good practice elsewhere.

Sample questions

- Does the organisation have a system for preventive maintenance covering all the barriers?
- Are the dates, scope and responsibilities clearly defined?
- How many percent of planned activities are performed according to planned dates and scope?

[3] Particularly barriers which are only addressed in infrequent situations, when the process deviates, but which must work effectively when that occurs.

Step 3 *Document equipment and plans for inspection, testing and maintenance*

Critical issues

- Maintain an inventory of barrier (elements), classified according to type and inspection, testing and maintenance regime
- Develop, maintain and use a planned programme of inspection, testing and maintenance derived from the specified regime.
- Keep the documentation up-to-date with changes in plant, maintenance concept, plans and methods etc.

Sample questions

- Are barriers classified by type?
- Is the maintenance program related to barrier type?

Step 4 *Plan resources and methods*

Critical issues

- Develop and keep up-to-date an appropriate and effective set of procedures and methods for carrying out the tests, inspections and maintenance work on the different types of barrier (elements)
- Estimate the manpower requirements for the test, inspection and maintenance work (numbers and competences)
- Identify, recruit and train, or contract and inform the necessary manpower for the work to be done: ensure competent persons available for the work
- Define the spares and other equipment (e.g. measuring equipment, tools, access scaffolds, lifting equipment, etc.) required for the test, inspection and maintenance work and when it needs to be available
- Purchase and store the necessary equipment

Sample questions

- Does the organisation have a barrier-monitoring program?
- Is this program related to barrier effectiveness and the effectiveness of the preventive maintenance program?

Step 5 *Execute inspection and testing (cleaning & adjustment) programme*

Critical issues

- Schedule the inspection, testing, cleaning & adjustment work on the different types of barrier (element)
- Plan the necessary staff and equipment availability:
    - allocation of tasks between operating staff and specialists from an inspection and testing department:
    - routine pre-operation checks by local staff/supervisors
- (Where appropriate) release the barrier (elements) for inspection, testing, cleaning & adjustment, isolate it and make it safe and hand it over to the inspection/testing staff, using appropriate PTW systems
- Provide safe and convenient access to the barrier (elements)
- Carry out the inspection, testing, cleaning & adjustment in a safe manner (taking account of isolation requirements for testing)
- Check barriers for functioning, adjustment, susceptibility to, or signs of misuse or tampering, wear, defects or damage: presence of suitable checklists
- Return the barrier (element) to its correct position and functional state, verify and hand it back to the operational staff
- Record, report, analyse and act on data recorded in this phase: local action by plant supervisor and operators and central action by specialist departments
- Encourage, record and act on informally acquired information about barrier functioning, state and possible anomalous condition coming from all staff who walk round the plant and note how it is working
- Programme of unannounced checks on hardware barriers (especially ones which have to be used properly) to discover if use is correct
- Record, monitor and act on back-logs of work

Sample questions

- Evaluate the functioning of the barrier maintenance program
    - What are the information sources related to functioning of barriers?

Step 6 *Schedule maintenance/repair programme*

Critical issues

- Decide, based on the maintenance concept, programme and results of condition monitoring, testing and inspection the schedule for planned maintenance
- Receive, process and take decisions on reports of poor condition, functioning or breakdown of barrier (elements) and arrive at a schedule of repair work (routine and emergency)
- Plan and organise the necessary staff and equipment for planned maintenance and for stand-by for (urgent) repair work
- Record, monitor and act on back-logs of work

Sample questions

- Does the organisation have a schedule for maintenance activities based on priorities related to safety?
- Describe the system to set up those priorities
- Are all the maintenance activities properly recorded?

Step 7 *Execute maintenance and repair*

Critical issues

- Decommission and release the barrier (elements) for maintenance or repair, isolate it and make it safe.
- Verify the safety of the situation and hand it over to the maintenance staff using appropriate PTW systems
- Provide safe and convenient access to the barrier (elements)
- Carry out the maintenance in a safe manner: demounting, repair in situ, removal, repair or replacement, remounting, reconnection
- Verify the functioning of the barrier (element)
- Verify the safety of the site and hand it back to the operational staff
- Recommission the barrier (element)

Sample questions

- Does the organization have a formal system to repair barriers?
- In what way are repaired barriers tested and brought back into operation?

Step 8 *Recording of information for learning*

Critical issues

- Record information about barrier (element) state, maintenance and repair work, eventual degraded restoration to operational state
- Compare with predicted and planned state and draw conclusions about the design, purchase, operational conditions or inspection/test/maintenance concept/plan for the barrier (element)
- Record information about incidents and accidents (or other surprises) during the inspection, test and maintenance phases and draw conclusions for improvement in staffing, methods or planning.

Sample questions

- In what way is the preventive maintenance program evaluated and improved?
- In what way are data on failures, repairs, incidents and accidents used to improve the maintenance system?

Appendix 11 – Mapping sheets

Mapping sheet 1

Mapping sheet