

Fig.7 - Use of the Research results summarised in Fig.1 in an offshore context. The figure illustrates the additional work needed to generate a working method for offshore application.

SAFETY MANAGEMENT OFFSHORE - SYSTEM REQUIREMENTS

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SYNOPSIS

"... safety is crucially dependent on management and management systems." (1)

It has emerged that Safety Management Systems (SMS) are of paramount importance to the safety of offshore operations.

This paper details, step by step, the design and development stages of the SMS.

Then it illustrates how such a system would function and evolve.

Moreover it portrays the need for the system to be comprehensive, while discussing the appropriate mechanisms and characteristics which afford the system the ability to respond to sudden or subtle change.

Such changes can be brought about by the requirements of current safety legislation, or from the day to day changes encountered during the design, production and decommissioning life cycle stages of an offshore installation.

Keywords: safety, management, risk, offshore, auditing, control.

INTRODUCTION

Because of the hostile environment and hazardous nature of offshore operations (especially in the event of an emergency), there is pressing need for a comprehensive, dynamic, efficient and effective SMS. The focus of the system should be on prevention of unwanted events while adequate emergency response systems are still important.

Robust SMS should therefore strive to encompass the many scenarios that can be envisaged in such an environment. Such a system should (as a minimum) assess the risks, devise and implement adequate control measures, monitor the condition of the system and have appropriate feedback mechanisms.

The safety specific discussion which follows should not detract from the understanding that safety management is not some type of 'stand alone', 'isolated' or 'bolted on' aspect of management as safety is ingrained in the totality of the organisation and in every aspect of every activity that takes place. It has ramifications for all management issues such as training, communication, morale, awareness and much more.

1 A SIMPLE SYSTEM

A system may be described as a process with an input and an output. This is of course a drastic simplification of what actually happens. In any process where people and technology interact there are many areas which may impact on safety.

So, unless the technology being used is very simple, complex management systems are required.

2 COMPLEX SAFETY MANAGEMENT SYSTEM

To an extent the complexity of a SMS will reflect the complexity of the technology and the degree of human involvement. However within this it must be borne in mind that the system is to be administered by people.

If the system is to be effective and efficient then careful planning and analysis of needs is necessary.

For new installations, early consideration of safety issues during installation design, taking into account the interconnectedness and interdependency of the design, production and decommissioning stages in the life cycle of an installation will assist in the development of a robust SMS. In the case of existing installations a review of safety issues with a considered response to problems is required. This may lead, however, to greater reliance on correct human response.

A simplified overview of a Safety Management System is depicted at figure 1 showing the system, sub systems and elements which are necessary for the prevention and control of safety problems. - These are discussed below:

2.1 Resources for the Safety Management System

Designing, implementing and maintaining a SMS requires resources. Responsibility, decisions and policies for resourcing the SMS usually rests with the highest level of management within an organisation.

The basic resource is financial, ie enough money to ensure that the other resources such as people, training and equipment, can be realised and in the required amounts to ensure

a robust SMS. Indeed it could be money well spent, as the estimated cost of the following major disasters illustrates:

Exxon Valdez	-	\$2000M
Mexico City	-	\$2-100M
Seveso	-	\$50M
Flixborough	-	\$70M
Bhopal	-	\$470M

Common to them all were weaknesses in the Safety Management System.

3 RISK ASSESSMENT [1]

"Risk assessment requires identification of hazards presented by the undertaking, and an estimate of risks they present, taking account of any precautions already being taken..." (2).

Risk assessment is the logical starting point for SMS development. This is inevitably the case, as no system can successfully be formulated without initially considering the hazards that are to be controlled. However, the SMS itself also has a role to play in continually defining how hazards should be identified and their resulting risks assessed (see figure 1).

"For the generality of health and safety hazards, the SMS should describe arrangements for their identification and for the assessment and recording of related risks..." (2).

Thus a combination of the SMS and the risk assessment provides an integrated approach for an overall safety case methodology. This is acknowledged in Regulation 9 of the above reference. Entitled 'Management of health and safety and control of major accident hazards', it outlines the requirements for:

- management system adequacy and acceptability
- management system auditing
- hazard identification
- risk evaluation and measures for risk reduction.

Specifically the latter section requires the safety case to demonstrate that:

"...risks have been evaluated and measures have been, or will be, taken to reduce the risks to persons affected by those hazards to the lowest level that is reasonably practicable."

The "reasonably practicable" proviso has been carried through from the Health and Safety at Work etc. Act and is, by intention, open to interpretation (3). Designers and users of the SMS must ensure that this proviso is not abused in avoiding the implementation of

necessary measures for risk reduction. It is important to note in this context that in the event of an accident/incident the burden of proving that appropriate steps were taken to prevent such an accident may lie with the operator (4).

3.1 Identification of Hazards and Threats

Hazards can be initiated from or by:

- normal operations
- abnormal operations
- disasters and local emergencies
- geographical/environmental influences.

In addition, human factors can have a significant effect in the initiation of hazards, and may be brought about by any of the following (5):

- commercial influences
- legal and political influences
- social and cultural influences.

Hazard identification techniques can be divided into two broad methodologies, comparative methods and fundamental methods.

Comparative methods tend to be based on knowledge gained from operating experience. The most commonly used of these methods is the hazard checklist. Checklists of this nature can be very extensive and provide an economical way of identifying a reasonable number of hazards relatively quickly. They are, however, inevitably general in nature and can therefore not be expected to address all the hazards associated with a specific installation. They can also be responsible for a false sense of security in that as long as all of the possible hazards on the list have been accounted for, further investigation of potential hazards may incorrectly be deemed to be unnecessary.

In contrast, fundamental methods tend to be laborious, time-consuming processes as they are meant as ways of generating possible hazards from first principles, using only the design of the installation as source data.

The two most commonly used fundamental methods for hazard identification are Hazard and Operability Studies (HAZOP) and Failure Modes and Effects Analysis (FMEA).

The HAZOP study is probably the most widely used hazard identification method. It is based on team sessions (usually multi-disciplinary) in which the design of new or existing plant is evaluated by considering the causes and consequences of deviations from the

intended operation. These 'deviations' are generated by considering a range of possible 'guide words' which prompt the team to consider the effects of altering a range of process variables.

The FMEA study is a systematic way of following through the effects of individual component failures on the process system as a whole.

Problems associated with fundamental methods of hazard identification are as follows:

- i) expense
 - methods tend to be time-consuming and laborious
- ii) lack of knowledge
 - methods often rely on personal experience of team members which may vary
- iii) formalised procedures
 - although fundamental methods are not as proscriptive as comparative methods, they still tend to rely on a formal methodology which can be repetitive and restrictive
- iv) limitation of hazard causes
 - hazard causes can often be restricted, particularly when considering them only in terms of process variations. External events, common mode failure and human error can suffer from lack of emphasis.

In conclusion, there are a range of hazard identification techniques, each with relative strengths and weaknesses. In addition to the main methods mentioned here, more specific methods are available for closer investigation of particular types of hazard. For example, task analysis allows specific emphasis to be placed on hazards arising from human error. Ideally a complete hazard analysis should include a range of contrasting methods to maximise the overall completeness of the results.

3.2 Evaluation of Hazards and Threats

Having identified the range of hazards which may be present on any given installation, the process of evaluating such hazards can begin. This is essentially carried out in three stages.

Firstly, an analysis of the expected frequencies of the hazards must be performed. Frequencies can be defined for initiating events at various stages of the hazard, often using relevant historical data from a data bank. This can then be processed using fault trees and event trees to define individual frequencies for the full range of hazards.

Secondly, having defined the range of hazard frequencies, engineering analysis must be carried out to establish the possible consequences of the hazards and evaluate the adequacy of defences and protective measures. This involves the application of engineering or scientific calculations to determine for examples of specific hazards what the expected effects might be. Such calculations might include modelling of gas dispersion, blast overpressures or fire dimensions. Further calculations may go on to consider the effects of such hazards on, for example, adjacent plant or structures, and would ultimately consider the effect on personnel.

Finally, having quantified the risks (ie determined both the expected frequencies and consequences) judgement can begin to be applied as to their acceptability or otherwise and to the adequacy of safeguards.

4 DEVELOPMENT AND APPRAISAL OF CONTROL MEASURES [2]

"The SMS should set out the safety objectives, the system by which these objectives are to be achieved, the performance standards which are to be met and the means by which adherence to these standards is to be monitored..." (1)

Hazard Identification and Risk Assessment will provide information on what is to be controlled by the SMS. This information coupled with the company safety policy should lead to the development of appropriate control measures.

Key elements in this process would be the use of acceptance criteria and cost benefit analysis to demonstrate compliance with the ALARP principle. Other valid inputs would include engineering judgement and safety reviews.

The areas where control measures are applied can be broken down into a number of 'typical' groupings. These are addressed in the following text.

4.1 Areas Requiring Control

Disaster Plans

Disaster plans deal with foreseeable disaster scenario's and should incorporate such things as individual responsibilities and lines of communication/command.

Plans should be subject to regular testing by simulation or exercise including external agencies who would be likely to be involved, eg coastguard.

Local Emergency Plans

Prompt, effective, emergency response can go far to reduce injuries and the extent of plant damage. There is insufficient time during an emergency to decide who is in charge, allocate duties, train personnel or decide who to contact for help and advice. These requirements need to be identified beforehand, and suitable systems and procedures developed and tested, which address the following:

- who is in command during emergencies and those with specific duties
- personnel should be clear of their duties and be trained if necessary
- guidance for dealing with the consequences of foreseeable events on an installation or associated installation

Other needs are:

- provision of assembly areas, and method of evacuation
- an emergency control centre
- up to date information of emergency services from within or external to the organisation
- exercises to test systems
- procedures for implementing changes in the light of the review of the exercise or drill

Operating Procedures

The risk assessment can reveal critical areas where control is necessary and where human activities and actions are directly or indirectly involved.

Task Analysis will help in the development of and ensure appropriate and safe operating procedures are in place.

Procedures allow for methodical execution of tasks under normal, abnormal and emergency conditions. The following should be included in the development of procedures:-

- emphasis on safety-critical tasks
- a method of ensuring compliance with procedures
- provision for use of procedures in training

Maintenance

Maintenance is essential to protect plant operators and the plant itself. Clear and specific guidance is required which must address:

- routine maintenance requirements
- safety-critical maintenance tasks
- the keeping of accurate maintenance records
- statutory maintenance requirements
- monitoring routine maintenance completion targets
- permit for work requirements
- permit for work procedures
- specialised safe systems of work
- the safe handover of plant
- method for ensuring that work is carried out in accordance with all procedural requirements

Training

Another key area which needs to be carefully addressed by the SMS is training. History has shown failure in this area to be a major contributor to accidents, incidents and loss. There is an increasing awareness today about how essential training is to safety. Not only on direct safety related activities such as how to use safety equipment, or how to put out a fire with the appropriate fire extinguisher, but "indirectly" related activities such as skill or task training which is essential to the overall and complete safety of the system.

Training should provide the knowledge and skills necessary for each person, in the organisation to carry out their duties effectively and safely.

Training Characteristics

All training should have the following characteristics:

- Analysis of the particular job:-
The job should be analysed correctly to determine the appropriate needs.

- Specification of knowledge and skills:-
The job or task should be studied carefully to determine the knowledge and skills required.
 - Determination of the training objectives and development of measures of job proficiency:-
What the training programme sets out to do and development of a standard or measure of proficiency to measure against are required.
 - Construction of the training programme:-
Construct a programme which includes instructions, practice material, achievement testing.
 - Evaluation of the training programme:-
Mechanisms are required to ensure that training achieves the objectives. The programme also needs to be periodically reviewed to ensure it meets the current requirements of the job (ie it evolves and does not remain static)
- Some types of training are:-
- Safety training
 - Management training
 - Skill training
 - On the job training
 - Refresher courses

An area of Management training often overlooked is that which applies to the management of safety. This training should be directed towards the development of skills necessary for the:

- review and development of the SMS and safety management policy
- management of policy implementation
- organisation and control of safety related activities
- application of control measures at the workplace

The training of employees must be undertaken in order to ensure that they can carry out their duties proficiently and competently and in accordance with safety standards.

Safe Systems of Work

Safe Systems of Work are the backbone of the SMS. For efficient and effective implementation they should be clearly understood and concise.

Permits for Work

The most widely known aspect of a Safe System of Work is the permit system.

The procedures and style of the PTW have been shown to be vital to the control of any activity where there is danger and risk.

Contractor Control

The control of contractors is amongst the most testing aspect of any SMS. The significance of this is increasing with the number of contractors and sub contractors being used by companies today. Before appointment of contractors it is advisable to audit their SMS and determine their ability to work safely.

Contractors can present significant safety problems. Typical measures to control these problems are listed below:

- be certain that contractors are competent to undertake the required work.
- be assured of the contractor's safety record.
- be certain that the contractor's workforce are adequately trained, both in the short and long term.
- inform the contractor of the hazards involved in undertaking the work, and of the company rules and regulations with which they must comply.
- ensure that supervision of the work is adequate, by both the contractor and the company.
- clearly identify the responsibilities of company staff with regard to dealing with the contractor.
- ensure that safety responsibilities are specified in contract documentation.

Design Procedures

"Design as part of the strategy for prevention must start from the principle that the operator, user or potential victim is an equal partner in the design of the task, equipment and procedures. Safety precautions must become an accepted part of the whole strategy, rather than something to be bolted on later." (6)

Inadequately engineered schemes can be identified as an underlying cause of accidents, and it is therefore essential that a systematic and consistent approach to all new designs is taken. Such an approach might encompass:

- specification of risk assessment techniques
- specification of design criteria to ensure hazards are maintained ALARP
- control of design changes
- specification of standard codes
- application of QA techniques
- need for design review and approval
- verify design through appropriate control of construction, commissioning and testing

Modification Procedures

The modification of plant, if improperly executed, can significantly increase the risk of accidents occurring. Procedural control of these activities is required. Factors which should be taken into account in the development of such control are:

- identify who is responsible for undertaking a project.
- carry out risk assessment at the proposal stage of all activities to determine the safety implications associated with the execution of the change, and with its effects on other plant and operations once implemented.
- have approval by an appropriate authority for all identified stages of a project.
- ensure that amendments to documentation, procedures and training are addressed.
- control handover of modified plant.

- ensure that operational information is kept up to date.

Personnel Selection

Personnel are the key to all operations.

To be sure personnel operate in the required manner they need to have the desired aptitude, experience, skills or theoretical learning for their role(s). The appointment of competent persons in health and safety is a requirement of the EC Framework Directive (Reg 6).

This indicates the importance of selecting the correct people for the job(s) they are to perform.

5 IMPLEMENTATION OF CONTROL MEASURES [3]

This is the stage of the SMS that can often be difficult. Putting into practice the necessary control measures in the 'real world' will require a committed and enthusiastic management team.

Management efforts to ensure compliance with the company safety policy and standards should address the following:-

- Identify each and every individual's safety responsibility and accountability and ensure that they are aware of and are clear on the safety expectations of the organisation.
- Promote safety and safety culture.
- Promote adherence to approved systems and procedures by example and coaching.

6 SAFETY MONITORING [4]

Monitoring is a vital part of the SMS and is an important mechanism for maintaining and reducing errors and weaknesses in the SMS. It is only by monitoring the SMS that information regarding performance is available for objective decision making.

Paying 'lip service' to monitoring or monitoring superficially leads to false security.

This may be illustrated by the following extract

There were many inadequacies in the Permit To Work system on Piper Alpha despite the

fact that a "Corporate audit in the last quarter of 1987 had looked at hundreds of permits which had been sent in from piper and had reported no deficiencies"

- it was revealed that many problems existed with the permits and the PTW system

Legislation

There is a requirement for much greater involvement of all employees and/or their representatives in Safety Management especially monitoring. Applying the historical view to the OSD and regarding them as industrial police may be no longer applicable.

In the new regime, OSD have indicated that operators will be expected to regulate themselves. The starting point for OSD being the requirement that self regulation is being implemented, eg measures of compliance with safety case.

A key aspect of this would be evidence of both internal and external audits.

7 AUDITING

Audits are an integral part of a comprehensive SMS. They should provide a structured, objective measure of performance against SMS standards.

Audits can be carried out on total systems or on specific areas of the SMS. The latter would typically be in response to particular events or trends which may be developing.

The frequency of audits will, to an extent, be determined on the findings. The timing should be aimed at ensuring that systems do not deteriorate below a minimum acceptable standard at any time.

When auditing large, complex organisations it is often beneficial to use a modular approach as illustrated in Table 1. This modular approach allows appropriate "targeting" of audit activity and avoids confusion from interpretation of a general audit to a specific area (7).

8 ACCIDENT, INCIDENT, NEAR MISS - REPORTING AND INVESTIGATION [5]

Reporting and Investigation of accidents and near misses is a major source of information for use in the continuous review of the SMS. Although the information only comes available after an unwanted occurrence, ie it is reactive, the information gained can be used to great benefit. In particular, the reporting and investigation of near misses can provide a great deal of information.

The example below helps to illustrate near misses in a dangerous occurrence scenario.

- * Crane driver drops a load (dangerous occurrence)
- it hits a person standing below (an accident)
- no one is standing underneath at the time (near miss - chance factors)
- a co worker pushes a person out of the way (near miss - human recovery)
- the area under the crane is restricted (near miss - management control)
- the crane design has an automatic stop device (near miss - technical safeguard) (8)

As shown from the dangerous occurrence there can be one accident yet four possible types of near misses.

This illustrates that findings from near misses will offer more to safety improvement. A significant aspect of the investigation is then the identification of actions and allocation of responsibility for implementing actions.

SENIOR MANAGEMENT (A)	MIDDLE MANAGEMENT (B)	SUPERVISOR /FOREMAN (C)	OPERATOR/ TECHNICIAN (D)	MODULE
1A	1B	1C	1D	Organisational Structure (1)
2A	2B	2C	2D	Management Standards (2)
3A	3B	3C	3D	Training Programme (3)
4A	4B	4C	4D	Engineering and Design (4)
5A	5B	5C	5D	Procedures and Work Systems (5)
6A	6B	6C	6D	Control of Material and Equipment (6)
7A	7B	7C	7D	Workforce Involvement (7)
8A	8B	8C	8D	Accident/Incident Investigation (8)
9A	9B	9C	9D	Occupational Safety Management (9)
10A	10V	10C	10D	Monitoring and Review of Safety Management (10)

Table 1: Modular Structure of Audit Plan of Contents - Modules 1A to 10D

Finding Root Causes

Finding root causes after reviewing accidents/incidents/near misses should always be part of the procedure. You will often only be aware of the symptoms of the real problem. Examples of accidents and their root causes after analysis are shown in Table 2.

ROOT CAUSES	MANAGEMENT FAILURES	SCENARIO WHERE IDENTIFIED
Lack of strategic communication system (Communication)	No effective two way communication system	Challenger Herald of Free Enterprise Kings Cross Clapham Junction Camelford Piper Alpha
	Confused reporting lines	Challenger Three Mile Island
	Poor information exchange	Kings Cross Clapham Junction Camelford Piper Alpha
	Insufficient employee involvement	Piper Alpha
Lack of technical understanding (Training)	Expert knowledge not present	Challenger Camelford
	Poor organisation and planning	Herald of Free Enterprise
	Management failed to resolve technical problems	Flixborough
	Inappropriate written procedures	Chernobyl
Management structure	Inadequate definition of roles and responsibilities	Challenger Herald of Free Enterprise Kings Cross Clapham Junction Flixborough Camelford Piper Alpha
	Inadequate safety organisation	Challenger Herald of Free Enterprise Kings Cross Clapham Junction
	Complicated decision making process	Flixborough

Table 2 Finding the Root Causes of Accidents

9 WEAKNESS IN MANAGEMENT OF SAFETY [6]

As the SMS overview illustrates monitoring, reporting and investigation are devices for identifying and highlighting weak areas in the SMS. The key to taking benefit from this information is that resulting actions are identified and responsibility for implementation allocated.

10 REVIEW OF THE SMS [7]

The SMS should be reviewed periodically or in response to specific information. Any review should incorporate information from:

- (1) Monitoring/Audit activities
- (2) External sources
- (3) Accident/Near Miss reporting and investigation

Items 1 and 3 have been described in some detail previously. Item 2 is discussed below.

New or External Information

The SMS must be acutely aware of external changes which will influence the behaviour of the system such as:

- R & D
- Recent legislation
- Case studies and reports of accidents/disaster (The Cullen report indicates the importance of this)
- Latest Safety literature and current best practices

Keeping the SMS evolving and changing in line with increasingly higher safety standards, public expectations and heightened awareness is essential (ie the system must evolve and cannot remain static). There are no 'tablets of stone' in a dynamic SMS - it is a 'living' system.

Therefore there should be appropriate mechanisms in place to ensure that the SMS is receptive to new information

11 THE DYNAMIC, EVOLVING, AND IMPROVING SAFETY MANAGEMENT SYSTEM

The main elements of the SMS are summarised as figure 2. This illustrates (at a glance) the dynamics of the system.

The diagram is centred around the systematic reappraisal of the SMS - it illustrates the importance of this aspect of the system - it is the **hub** of the SMS - It indicates that the system must remain dynamic and continually evolve and improve.

Developing the SMS

The development stages in a SMS start with risk assessment this will lead to the appraisal (assessment) of what control measures are required - and the development of the required control measures.

When the control measures have been developed the next stage is putting in place mechanisms for ensuring proper implementation of the control measures, which leads to a method of monitoring the performance of the complete SMS.

Improving the SMS

The diagram shows that monitoring; accidents/near miss reports; and new information (including research & development, recent legislation, case studies of other disasters/accidents and safety literature) - will all input to a systematic reappraisal or scrutiny of the SMS.

The scrutiny and reappraisal of the system will in turn lead to one - a few - or all of the following:-

- The identification of new hazards and hence risk assessment of the new hazards
- The improvement of existing control measures and the development of new or extra control measures
- Improvement of the implementation mechanisms and thereby improving the monitoring of safety

CONCLUSION

The SMS is an integral part of other management functions and requires the same degree of thought and attention to detail. The system must be dynamic, evolving and improving.

Within an effective SMS, accidents may be few and far between; this may lead to complacency. This emphasises the need for monitoring by auditing or inspection.

The current move to goal setting legislation offshore should be a driving force in the move to proactive management of safety.

Simple compliance with prescriptive legislation will not be an acceptable policy.

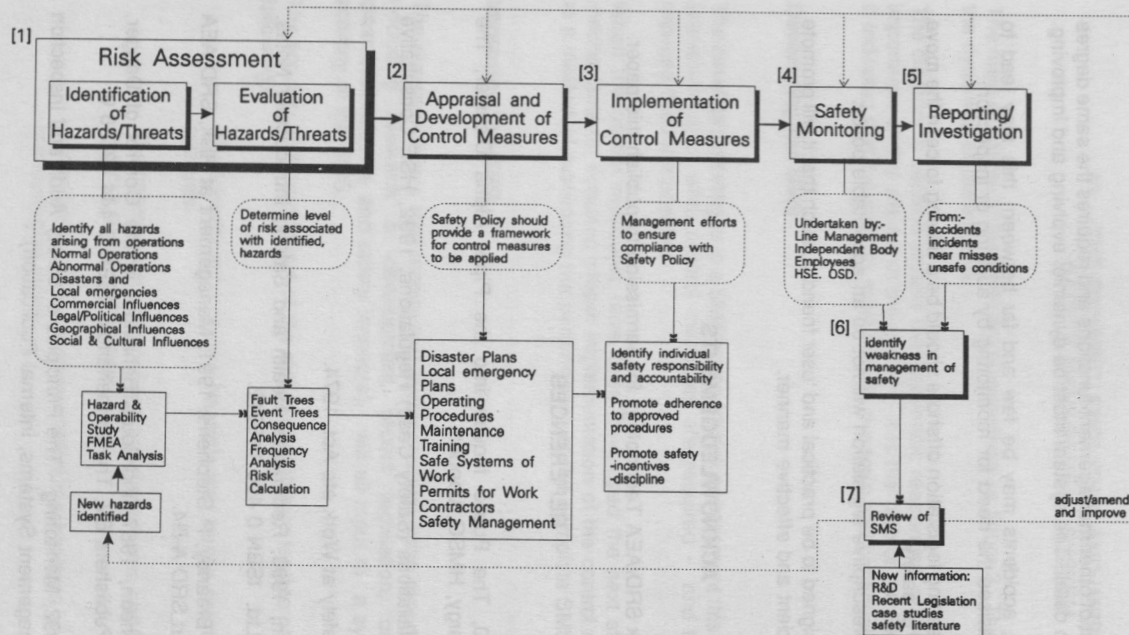
Any system should be designed to be practical and 'user friendly', such that it will promote a safety culture in an efficient and effective manner.

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Key [1] Text reference number
 — Development and Function stages
 Feedback

Fig. 1. SAFETY MANAGEMENT SYSTEM OVERVIEW

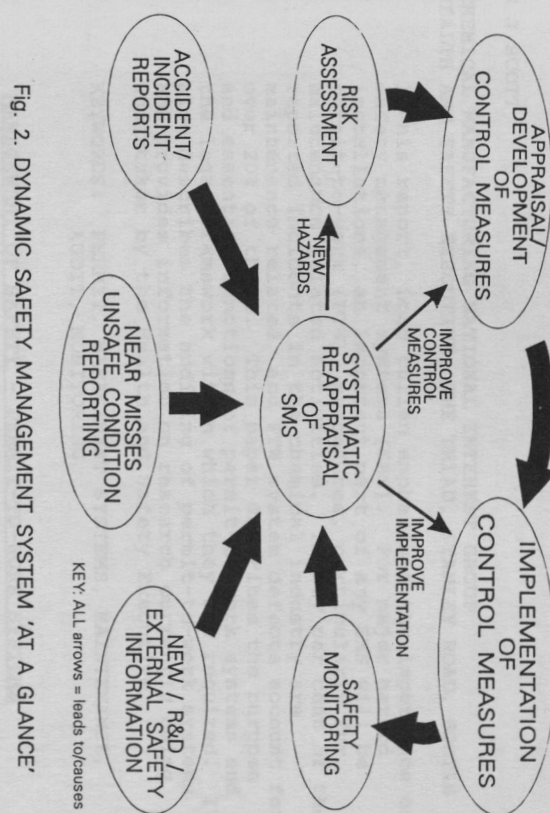


Fig. 2. DYNAMIC SAFETY MANAGEMENT SYSTEM 'AT A GLANCE'