Health and Safety Executive - HM Mines Inspectorate

Major Hazard Topic Inspection Guide

THE PREVENTION AND CONTROL OF EXPLOSIONS IN MINES

1. Purpose

This document sets out how inspectors will assess operators' compliance with the relevant statutory provisions in respect to preventing the formation of explosive atmospheres in mines and the control of ignition risks.

An ignition of flammable gas at a mine is reportable under RIDDOR. Explosions are a major hazard that has the potential to cause multiple fatalities, particularly if the gas explosion triggers a more powerful coal dust explosion. The last ignition of methane in a UK coal mine resulted in the evacuation of over 200 underground workers and put the mine out of operation for several weeks. There have been a number of serious mine explosions outside of the UK that illustrate the serious consequences that a mine explosion can have:

- Pike River, New Zealand – 29 men killed in 2010 after an explosion
- Upper Big Branch, USA – 29 men killed in 2010 after an explosion
- Soma Mine, Turkey - 301 men killed in 2014 after an explosion followed by a fire

The majority of explosions in mines occur due to a combination of:

- ineffective ventilation allowing explosive gas atmospheres to occur
- poorly designed and maintained equipment leading to either frictional or electrical ignition
- inadequate arrangements for controlling all ignition risks
- the propagation of a methane gas explosion into a coal dust explosion because of inadequate arrangements to maintain the correct level of incombustible matter in roadway dust.

2. Scope

The inspection will focus on the key hazard of explosions and the associated safety management systems for managing the risks. All coalmines will have a risk of firedamp emissions and a concentration of explosive gas developing, whether in the general body or within roof layers. Non-coal mines also have the potential for releasing pockets of gas such as methane, other hydrocarbons, hydrogen sulphide and carbon monoxide that have the potential to be ignited during mechanised cutting or drilling. Ignition of an explosive mixture of gas is also possible when explosives are being used. Hydrogen can also form explosive mixtures at battery charging stations.

The format of the inspection will follow the established Plan, Do, Check, Act structure, as defined in HS(G) 65 and summarised in HSE leaflet INDG 275.

The inspection will be undertaken in line with the HID Regulatory Model and will explore the following elements:

- has the mine operator identified all potential explosion hazards at the mine?
- has the mine operator completed suitable and sufficient risk assessments?
- have suitable preventative and mitigating barriers been put into place?
- have roles and responsibilities been allocated for the control measures identified?

- is there a suitable competency management system in place relevant to the control measures?
- are the measures to control the major hazards being monitored?

3. The intervention

The intervention team can if necessary ask the mine operator to provide copies of documentation in advance of the site visit. The on-site part of this stage of the intervention could take a day or more depending on the scope. Once the documentation has been re viewed the intervention team will select parts of the mine to inspect and evaluate the effectiveness of the safety management arrangements and risk control systems.

Inspectors should determine how well the mine operator is controlling the risk of an explosion. Topics to be assessed during the intervention could include:

Ventilation

This should take into account the suitability of mine design and layout and include assessment of:

- ventilation type i.e. homotropal airflow (same direction as mineral transportation) or antitropal airflow (opposite direction so has the potential for raising dust)
- the effect of any rising or dipping development gradients where gas could become trapped
- the positioning of any booster fans
- the application of gas layering calculations (if applicable)
- information on gas content of the seam or mineral being mined and any gas liberation rates
- the effect of barometric pressure on the mine environment
- the examination of and quality of ventilation records
- the implementation of any environmental monitoring
- the suitability of main and auxiliary fans
- standby arrangements
- recovery/de-gassing arrangements (if applicable)
- methane drainage arrangements (if applicable)
- the provision and maintenance of Sherwood Curtains on coalfaces (if applicable).
- suitable air doors, brattices and stoppings from old workings

Frictional ignition

Frictional ignition risk is defined as ‘the risk of a concentration of firedamp in the explosive range coinciding with an igniting source caused by frictional heat or sparks from cutting picks’. A risk assessment should identify if any preventative and protective measures are required at working faces and developments. There is a higher risk of frictional heat or sparks occurring where the strata being cut contains quartz, pyrites or ironstone. Pyritic sandstone is the most incendive type of rock likely to be encountered in a mine and strata such as this would have a classification of ‘high ITP’ (Incendive Temperature Potential) assigned to it.

Cutting equipment can be fitted with suitable ignition prevention systems such as venturis, water sprays and on-board ventilation systems such as RAC drums, Globoid drums and scrubbers. The selection and settings for appropriate monitoring of the flows and pressures for any ignition protection systems should also be assessed to ensure that it is compatible with the calculated design requirements. There should be evidence of regular examination, testing and maintenance of any ignition prevention and suppression systems that the risk assessment has identified as being required.

Electrical and Mechanical Equipment

Regulation 7(1) of DSEAR requires areas where explosive atmospheres may occur to be classified into hazardous and non-hazardous workplaces. Any hazardous workplaces should also be classified into zones in which only suitable electrical and mechanical equipment can be used. All equipment must be well maintained and regularly inspected to ensure any protection concepts remain effective, for example it has correct flame proof gaps.

Spontaneous combustion, application of incombustible matter to mine roadways and provision of stone dust barriers

Where relevant, there should be an assessment of the spontaneous combustion potential of any coal seam being worked. If required, appropriate arrangements should be in place for the prevention, early detection and control of spontaneous combustion, for example:

- use and means of delivery of nitrogen
- positioning of instantaneous and tube bundle monitoring systems
- availability of a sufficient number of suitably trained and experienced spontaneous combustion prevention teams
- arrangements for the supply of suitable grouts and sealants
- the availability of cement pumping and injection equipment to either inject strata, apply coatings or erect stoppings
- adequate application of stone dust to roadways liable to contain coal dust that has the potential to cause an explosion
- a suitable stone dust/water barrier scheme that has maintenance procedures and means of checking that they remain adequate.
- adequate preparation for advance stopping sites (location and materials available)
- arrangements for heat detection surveys using a thermal imaging equipment.

Control of Ignition Risks

Ignition sources can vary and suitable controls should be in place to prevent ignition risks from being present when flammable gas may be present. The arrangements should include:

- schemes for searching for and preventing contraband from entering the mine
- schemes for controlling the use of specialised non-certified equipment such as cameras and thermal imaging equipment
- schemes for controlling hot work.

Electrical equipment and circuits, internal combustion engines and mechanical equipment should be isolated when the methane levels reach 1.25% by volume unless the electrical equipment is certified as Group 1 M1, (see ATEX and explosive atmospheres for further details).

4. Reporting findings and conclusions

Inspectors will summarise the outcome of the inspection with the operator, management team and the safety representatives at the mine whilst on site.

This summary will include the team's assessment on how the operator is complying with the relevant provisions, priorities for any further action and the operators' performance score in accordance with the **Performance Assessment Table** shown below.

Where further action is required to achieve compliance this will be taken in accordance with HSE's Enforcement Policy Statement.

5. Key legislative requirements for mines

Health & Safety at Work etc. Act 1974

Section 2(1), 3(1)

The Mines Regulations 2014

Regulation 7 General duties of the mine operator

Regulation 8 Co-operation

Regulation 9 Health and Safety document

Regulation 10 Management structure

Regulation 11 Competence

Regulation 12 Instructions, rules and schemes

Regulation 15 Maintenance and inspection of equipment

Regulation 16 Records of persons below ground

Regulation 21 Application of regulations 22 and 23

Regulation 22 Explosive atmospheres

Regulation 23 Ignition risks

Regulation 54 Escape and rescue plan

Regulation 58 Surveyor

Regulation 59 Working plans, sections, ventilation plans and geological map

Management of Health & Safety at Work Regulations 1999

Regulation 3 Risk assessment

Regulation 5 Health and safety arrangements

Provision and Use of Work Equipment 1998

Regulation 4 Suitability of work equipment

Regulation 5 Maintenance

Regulation 6 Inspection

Regulation 12 Protection against specified hazards

Dangerous Substances and Explosives Atmospheres Regulations 2002

Regulation 5 Risk Assessment

Regulation 6 Elimination or reduction of risks from dangerous substances

Regulation 7 Places where explosive atmospheres may occur

Table 1

Performance scores

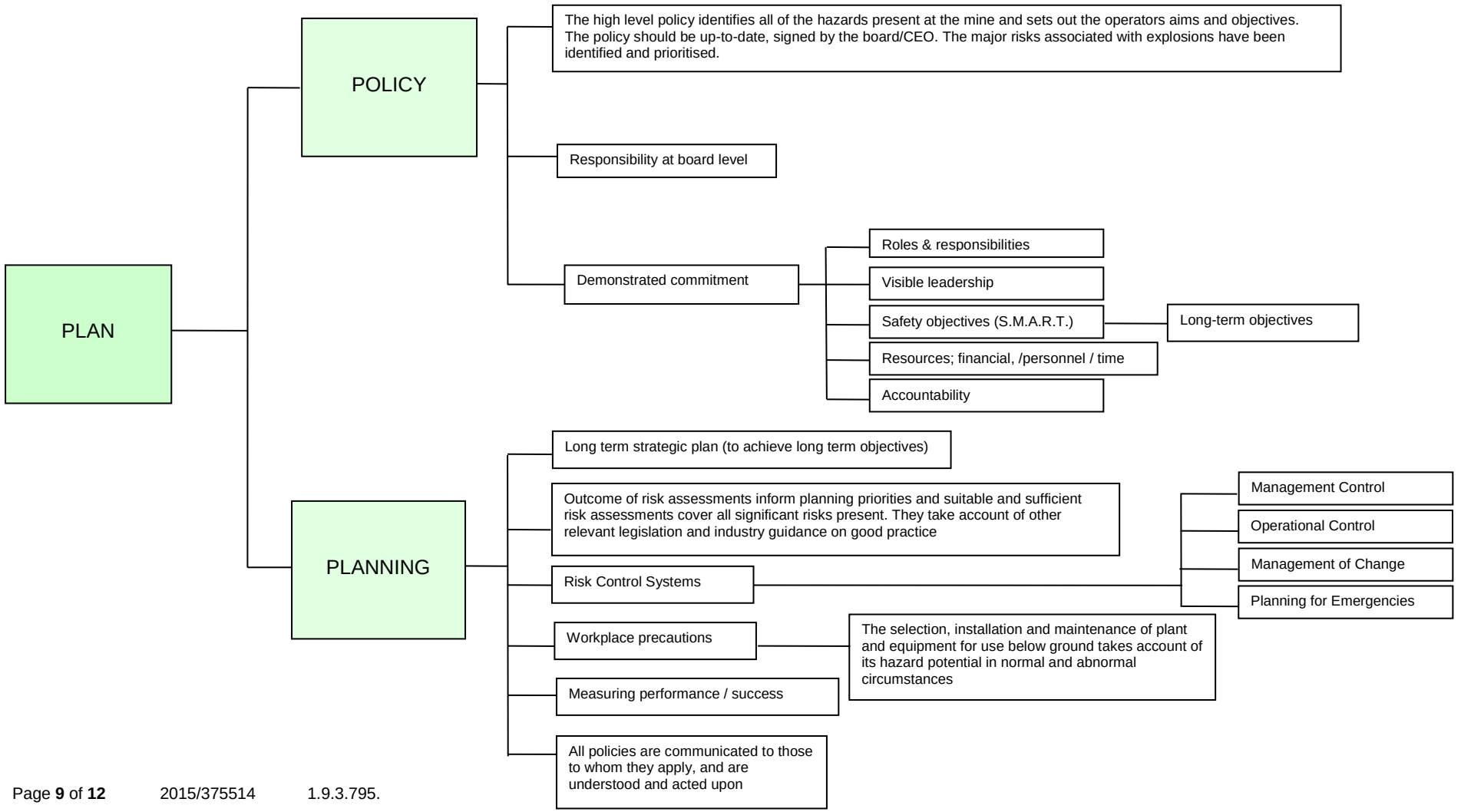
Following the intervention, Inspectors should performance score the mine operator's degree of compliance in accordance with the Table below.

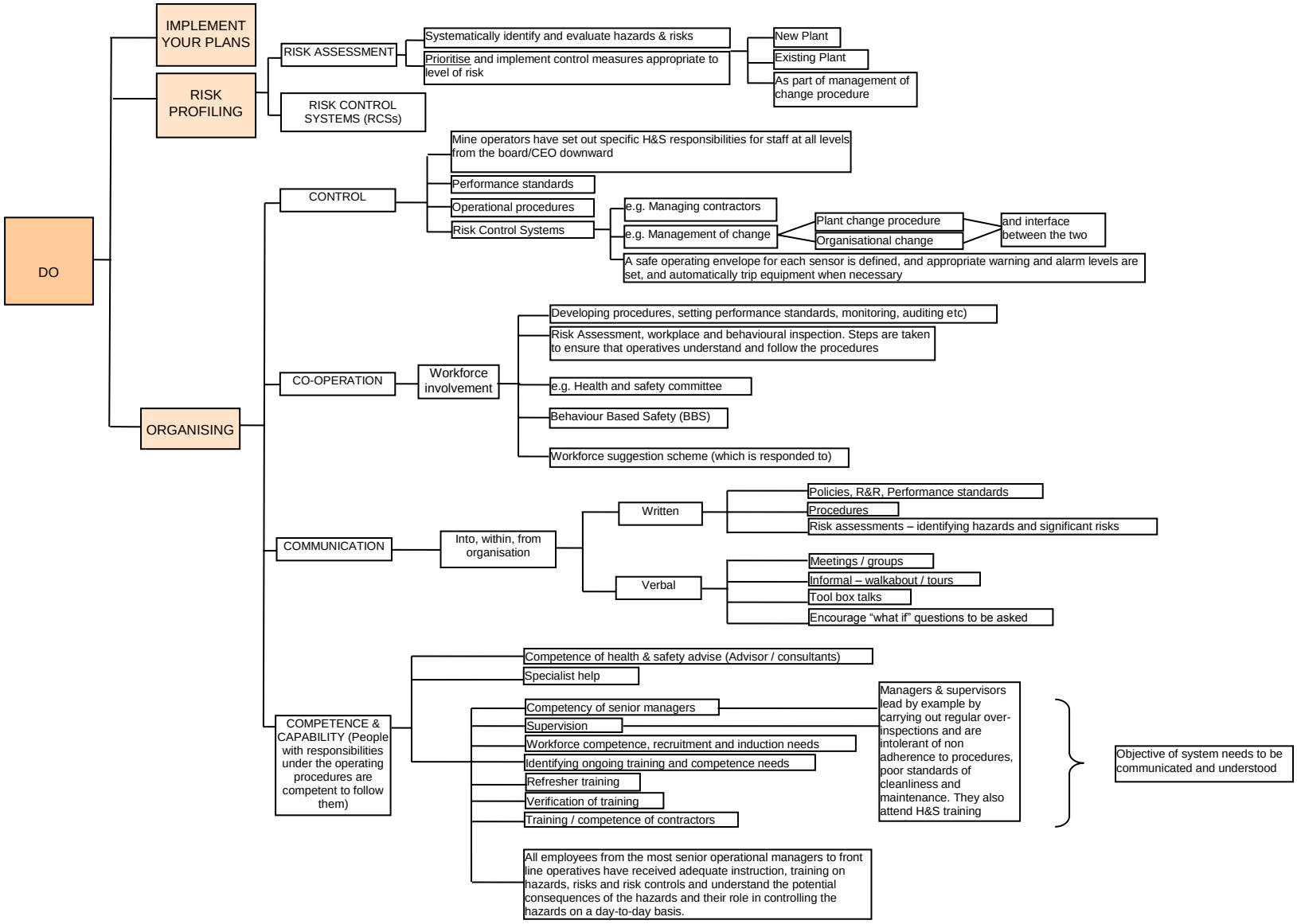
EMM RISK GAP					
EXTREME	**SUBSTANTIAL**	**MODERATE**	**NOMINAL**	**NONE**	**NONE**
TOPIC PERFORMANCE SCORE					
60	**50**	**40**	**30**	**20**	**10**
Unacceptable	**Very Poor**	**Poor**	**Broadly Compliant**	**Fully Compliant**	**Exemplary**
Far below relevant minimum legal requirements. Degree of non-compliance extreme and widespread. Failure to recognise issues, their significance, and to demonstrate adequate commitment to take remedial action.	Substantially below the relevant minimum legal requirements. Degree of non-compliance substantial. Failures not recognised, with limited commitment to take remedial action.	Significantly below the relevant minimum legal requirements. Degree of non-compliance significant. Limited recognition of the essential relevant components of effective health and safety management, but demonstrate commitment to take remedial action	Meets most of the relevant minimum legal requirements. Degree of non-compliance minor and easily remedied. Management recognise essential relevant components of effective health and safety management, and commitment to improve standards.	Meets the relevant minimum legal requirements. Management able to demonstrate adequate identification of the principal risks, implementation of the necessary control measures, confirmation that these are used effectively and subject to review.	Exceeds the relevant minimal legal requirements. Management committed and proactive in devising and implementing an effective safety management system to achieve 'best practice' and beyond legal requirements. Actively seeks to further improve standards.
EMM INITIAL ENFORCEMENT EXPECTATION					
Prosecution / Enforcement Notice.	Enforcement Notice / Letter.	Enforcement Notice / Letter.	Letter / Verbal warning.	None.	None.

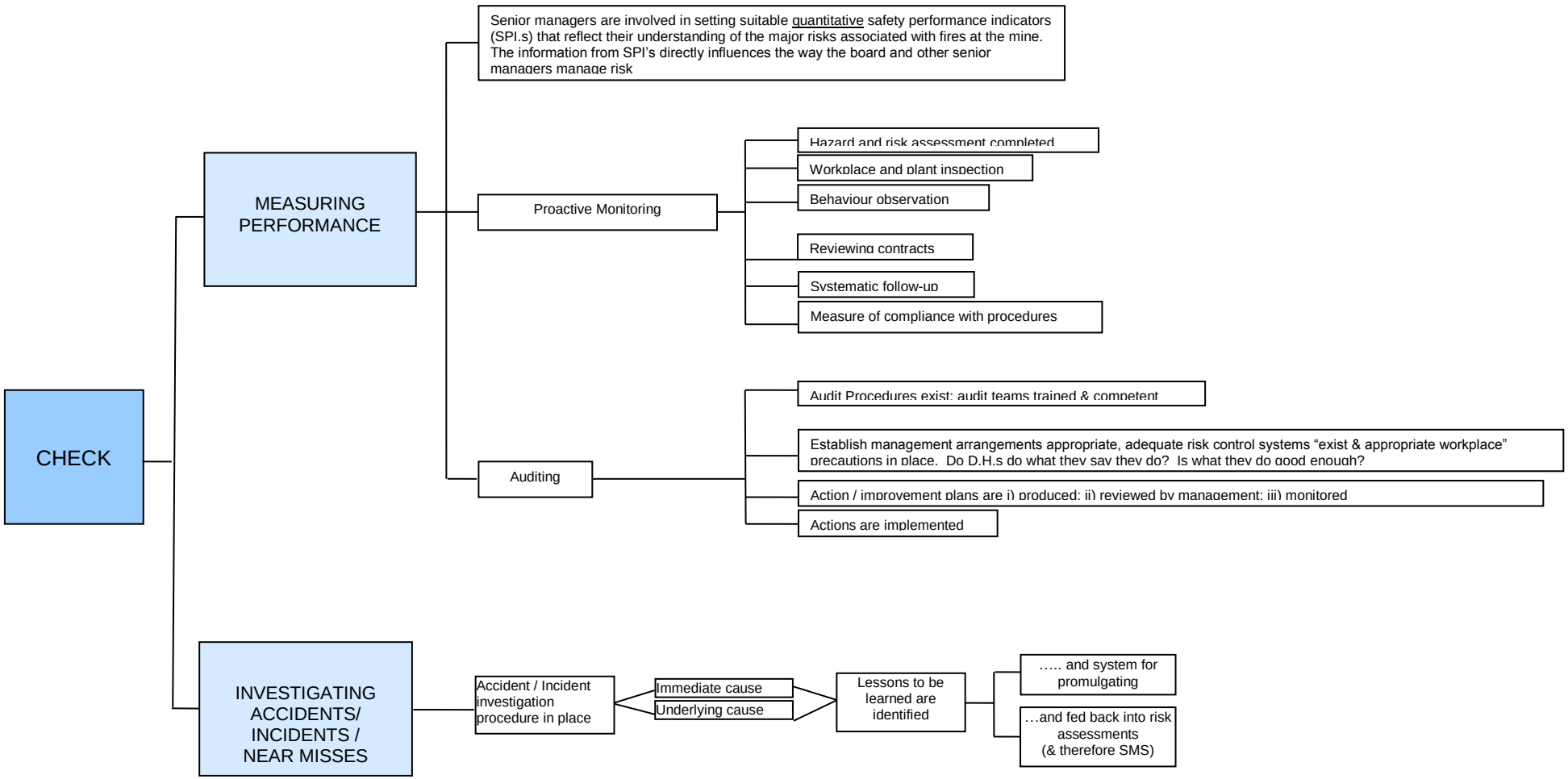
Plan	1. There is a health and safety policy that is dated and signed that identifies major hazards, including explosions, and sets out the mine operator's aims and objectives. 2. The mine operator has put in place a suitable management structure and set out specific H&S responsibilities for staff at all levels to control the risk of the major hazards present, including explosions. 3. The mine operator and those appointed to the management structure understand the prevention of explosions principles 4. The arrangements include clear procedures for those with H&S roles or responsibilities in relation to: • how explosion hazards are identified and prioritised, including where applicable the implementation of zones classified under regulation 7(1) of DSEAR? • how explosion risk assessments will be completed, implemented and reviewed? • who is responsible for the selection and use of any explosion prevention and protection procedures that are required? • who is responsible for the selection of suitable plant and equipment to ensure it is suited to its operating environment i.e. takes into account its potential to cause an explosion in normal and abnormal circumstances? • who is responsible for determining the optimum location of any monitoring of the presence and concentration of flammable gas, determining appropriate action levels and the calibration of monitoring devices? 5. Managers and supervisors at all levels accept their responsibilities in relation to controlling explosion risks and lead by example by ensuring that explosion control measures to reduce the level of any flammable gas to as low a level as reasonably practicable are implemented and properly maintained. 6. All employees from the most senior operational managers to front line operatives have received adequate instruction and training on explosion hazards, risks and risk control systems and understand: • the importance of ensuring that prevention of explosion control measures are properly followed • the function of consultation between managers and workers in the drawing up the method of work • the role of monitoring in identifying the adequacy of explosion control measures • the actions to take if flammable gas is found • the potential consequences of any explosion control measure failure. 7. The mine operator has in place a written escape and rescue plan in the event of an explosion emergency situation below ground. 8. Adequate arrangements are in place for informing and consulting staff (the Safety Representatives and Safety Committees Regulations 1977 and the Health and Safety (Consultation with Employees) Regulations 1996 (as amended)

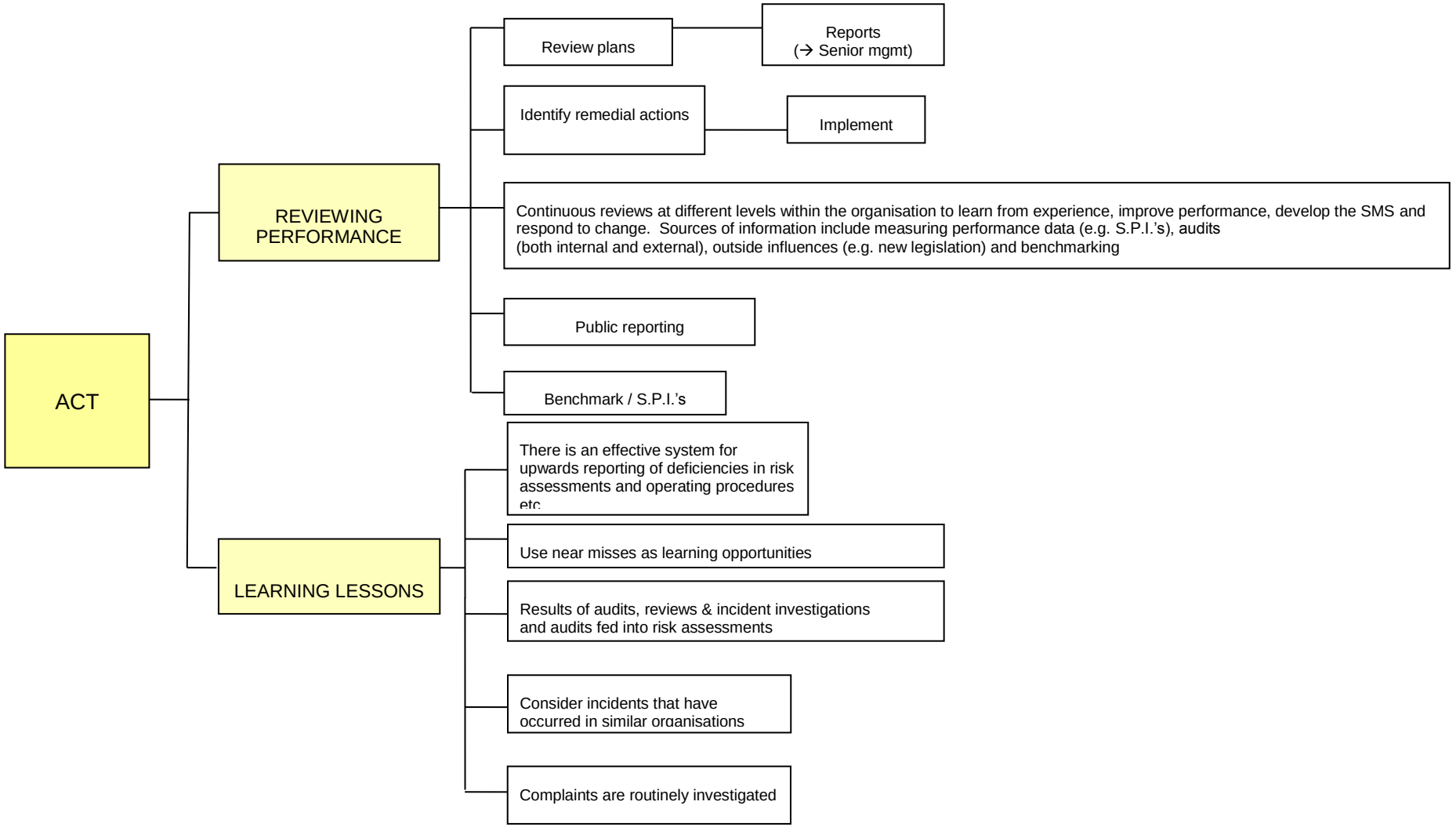
Do	1. The mine operator has put in place a suitable management structure and set out specific H&S responsibilities for staff at all levels including: • who defines the frequency of the inspection and monitoring regimes? • do managers and supervisors have sufficient resources to implement the plan? • are staff competent to deliver their responsibilities? • is any periodic independent oversight applied? 2. How is the workforce involved in the design and implementation of explosion risk control rules? 3. Are all procedures and any changes communicated to those to whom they apply? 4. The explosion control measures required by the risk assessment have been implemented. 5. Is there an effective system for upward reporting of deficiencies in risk assessments, operating procedures design documents and control measures?
Check	1. Are there monitoring systems for: • routine inspection of premises, plant and equipment? • checking management arrangements for preventing an explosion are implemented and effective? • ensuring staff understand and follow the procedures that are in place to control the risk of an explosion ? 2. Complaints and incidents are investigated. 3. Is there an effective reporting system for near miss incidents? 4. Is there sufficient monitoring of information that could indicate that the likelihood of an explosion has increased? 5. Are there any arrangements for independent third-party audit? 6. Are structured periodic audit arrangements are in place to ensure arrangements are monitored to measure their performance? 7. Is the audit programme risk-based and targeted at major hazard risk control and safety management systems?

Act	1. Are there effective arrangements for reviewing performance? 2. Has an improvement plan been established? 3. Have procedures been reviewed and amended as a result of accident/incident outcomes? 4. Has remedial action addressed deficiencies identified? 5. What safety performance indicators are in place?


PLAN
POLICY
The high level policy identifies all of the hazards present at the mine and sets out the operators aims and objectives. The policy should be up-to-date, signed by the board/CEO. The major risks associated with explosions have been identified and prioritised.
Responsibility at board level
Demonstrated commitment
Roles & responsibilities
Visible leadership
Safety objectives (S.M.A.R.T.)
Long-term objectives
Resources; financial, /personnel / time
Accountability
PLANNING
Long term strategic plan (to achieve long term objectives)
Outcome of risk assessments inform planning priorities and suitable and sufficient risk assessments cover all significant risks present. They take account of other relevant legislation and industry guidance on good practice
Risk Control Systems
Management Control
Operational Control
Management of Change
Planning for Emergencies
Workplace precautions
The selection, installation and maintenance of plant and equipment for use below ground takes account of its hazard potential in normal and abnormal circumstances
Measuring performance / success
All policies are communicated to those to whom they apply, and are understood and acted upon


DO
IMPLEMENT YOUR PLANS
RISK PROFILING
ORGANISING
RISK ASSESSMENT
RISK CONTROL SYSTEMS (RCSs)
Systematically identify and evaluate hazards & risks
Prioritise and implement control measures appropriate to level of risk
New Plant
Existing Plant
As part of management of change procedure
CONTROL
CO-OPERATION
COMMUNICATION
COMPETENCE & CAPABILITY (People with responsibilities under the operating procedures are competent to follow them)
Mine operators have set out specific H&S responsibilities for staff at all levels from the board/CEO downward
Performance standards
Operational procedures
Risk Control Systems
e.g. Managing contractors
e.g. Management of change
Plant change procedure
Organisational change
and interface between the two
A safe operating envelope for each sensor is defined, and appropriate warning and alarm levels are set, and automatically trip equipment when necessary
Workforce involvement
Developing procedures, setting performance standards, monitoring, auditing etc)
Risk Assessment, workplace and behavioural inspection. Steps are taken to ensure that operatives understand and follow the procedures
e.g. Health and safety committee
Behaviour Based Safety (BBS)
Workforce suggestion scheme (which is responded to)
Into, within, from organisation
Written
Verbal
Policies, R&R, Performance standards
Procedures
Risk assessments – identifying hazards and significant risks
Meetings / groups
Informal – walkabout / tours
Tool box talks
Encourage “what if” questions to be asked
Competence of health & safety advise (Advisor / consultants)
Specialist help
Competency of senior managers
Supervision
Workforce competence, recruitment and induction needs
Identifying ongoing training and competence needs
Refresher training
Verification of training
Training / competence of contractors
Managers & supervisors lead by example by carrying out regular over-inspections and are intolerant of non adherence to procedures, poor standards of cleanliness and maintenance. They also attend H&S training
All employees from the most senior operational managers to front line operatives have received adequate instruction, training on hazards, risks and risk controls and understand the potential consequences of the hazards and their role in controlling the hazards on a day-to-day basis.
Objective of system needs to be communicated and understood


CHECK
MEASURING PERFORMANCE
Senior managers are involved in setting suitable quantitative safety performance indicators (SPI.s) that reflect their understanding of the major risks associated with fires at the mine. The information from SPI's directly influences the way the board and other senior managers manage risk
Proactive Monitoring
Hazard and risk assessment completed
Workplace and plant inspection
Behaviour observation
Reviewing contracts
Systematic follow-up
Measure of compliance with procedures
Auditing
Audit Procedures exist: audit teams trained & competent
Establish management arrangements appropriate, adequate risk control systems "exist & appropriate workplace" precautions in place. Do D.H.s do what they say they do? Is what they do good enough?
Action / improvement plans are i) produced; ii) reviewed by management; iii) monitored
Actions are implemented
INVESTIGATING ACCIDENTS/ INCIDENTS / NEAR MISSES
Accident / Incident investigation procedure in place
Immediate cause
Underlying cause
Lessons to be learned are identified
….. and system for promulgating
…and fed back into risk assessments (& therefore SMS)


ACT
REVIEWING PERFORMANCE
Review plans
Reports (→ Senior mgmt)
Identify remedial actions
Implement
Continuous reviews at different levels within the organisation to learn from experience, improve performance, develop the SMS and respond to change. Sources of information include measuring performance data (e.g. S.P.I.'s), audits (both internal and external), outside influences (e.g. new legislation) and benchmarking
Public reporting
Benchmark / S.P.I.'s
LEARNING LESSONS
There is an effective system for upwards reporting of deficiencies in risk assessments and operating procedures etc
Use near misses as learning opportunities
Results of audits, reviews & incident investigations and audits fed into risk assessments
Consider incidents that have occurred in similar organisations
Complaints are routinely investigated