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GUIDELINES

MDG 3002

SSAI No 5

Fire on a compressor

Appin Colliery

26 September 1991 and

Code for air compressors – Underground use

December 1993

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MINERAL RESOURCES

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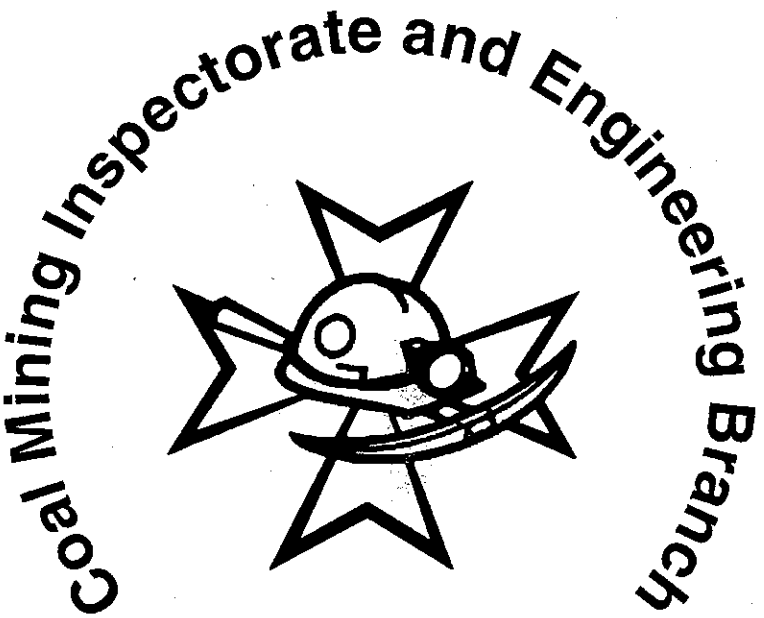
New South Wales



SYSTEM SAFETY ACCIDENT INVESTIGATION SUMMARY

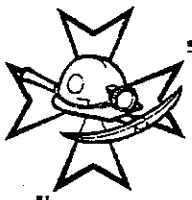
FIRE ON A COMPRESSOR APPIN COLLIERY 26 SEPTEMBER 1991

and

CODE FOR AIR COMPRESSORS - UNDERGROUND USE

MDG 3002

SSAI SUMMARY No. 5



DEPARTMENT OF MINERAL RESOURCES
NEW SOUTH WALES

COAL MINING INSPECTORATE

SYSTEM SAFETY ACCIDENT INVESTIGATION SUMMARY

FIRE ON A COMPRESSOR
APPIN COLLIERY
26 SEPTEMBER 1991

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CODE FOR AIR COMPRESSORS - UNDERGROUND USE

SSAI Summary No 5

DECEMBER 1993

Foreword

In 1991 the Coal Mining Inspectorate of the New South Wales Department of Mineral Resources adopted a methodology for accident investigation known as System Safety Accident Investigation (SSAI). This has been employed since that time to form the basis for the investigation of fatalities and more serious accidents occurring in the coal mining industry in New South Wales.

The SSAI methodology looks not only at direct cause(s)of an accident but also surrounding systems which may have contributed to the accident environment. The exact circumstances of any individual accident probably will never occur again, so preoccupation with those exact circumstances is likely to be of limited benefit in future prevention. Broader examination of systems which may have failed, or been less than adequate to ensure safety, in the accident environment are therefore brought within the ambit of the investigation.

The methodology looks not only an accident itself but also covers the period of time until a stable situation exists. The investigation may, therefore, also cover situations where rescuers may be put at risk.

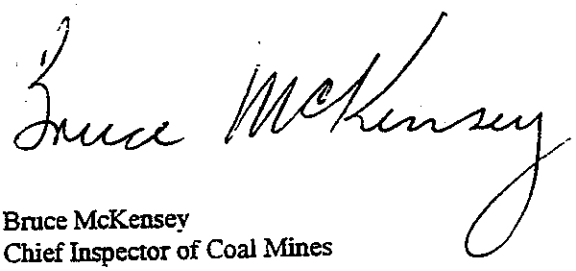
The structured nature of information arising from SSAI processes makes it a potentially very valuable tool for others to use in assessing systems which may be similar to those examined in an investigation. In order that some positive outcome may result from what are otherwise distressing incidents, the Coal Mining Inspectorate is distributing summaries resulting from SSAI's which it has conducted. This is being done as an information transfer to industry of lessons learned in the course of investigations.

These summaries are being distributed pursuant to Clause 39(4) Coal Mines Regulation (General Welfare and First Aid - Underground Mines) Regulation 1984 or Clause 36(4) Coal Mines Regulation (General Welfare and First Aid - Open Cut Mines) Regulation 1984.

It is important to recognise distinctions between a system based investigation (such as SSAI) and what is commonly recognised as the type of investigation traditionally undertaken by bodies such as the Inspectorate - a legal investigation. System investigations are conducted on a 'no fault', 'no blame' basis - that is to say the potential culpability of individuals, or liability of organisations, are not taken into account. This contrasts with legal investigations where individual culpability, or organisational liability, are a preoccupation.

In addition, material presented in an SSAI report may be based on the collective opinion of the investigating team and formed from best available knowledge. This is particularly the case in situations in which there are no witnesses to an accident. An investigating team's opinions may be formed on considering the balance of material available to the team and so are unlikely to constitute 'matters of fact' in a legal sense.

It is also important to recognise that the SSAI process stops short of solutions. The 'Judgements of Needs' produced by SSAI are only intended to highlight areas of concern in which application of management or technical expertise may be warranted in order to prevent further accidents.



Bruce McKensey
Chief Inspector of Coal Mines
June 1993

OVERVIEW

A fire occurred on a rotary screw air compressor located near the pit bottom as the end result of a series of deficiencies in the management systems for dealing with items of fixed equipment. Oil leaks within the compressor had gone unidentified, misunderstood and unrectified. The protection system, designed to trip power in the event of overheating, was called upon to operate and failure of the contactor controlling power to the machine resulted in the machine continuing to run resulting in a significant fire.

Maintenance of the compressor was a problem area for several months prior to September 1991. The defects were manifested by tripping out of the compressor, caused mainly by oil loss through leaks in the hosing, piping and oil cooler areas.

On 25 September 1991 during the evening shift, a deputy inspected the compressor station where he observed an oil leak on the compressor. He did not consider the matter serious enough to warrant stopping the machine.

The compressor ran for a period after a deputy's inspection and at 0230 on 26 September the control officer notified the shift engineer that the compressors were not running. The engineer directed a leading hand electrician to attend to the matter. On his way to the compressor station he noticed that the outlet on the transformer controlling the No 2 compressor was off. He then walked to the compressor station, restarted the No 1 compressor and examined the No 2 compressor observing nothing amiss, he then returned to the transformer, approximately 100 metres outbye. Here he reset the No 2 outlet and walked a short distance back inbye towards the compressor, when the power tripped at the high tension end of the transformer.

He observed that the high tension had tripped on overload and concluded that a fault must exist on the No 2 compressor. He therefore reset the high tension of the transformer, reset the No 1 outlet controlling the No 1 compressor and tagged out the No 2 outlet feeding No 2 compressor.

He examined the panel of the No 2 compressor and found the contactor welded in. He then deployed an electrician to dismantle the contactor whilst he obtained new contact tips. The contactor was then re-assembled and tested for freedom of movement several times to establish that there had been no mechanical reason for the contact tips to have welded together. once satisfied with the operation of the contactor, he reset power at the transformer and returned to the compressor which he restarted. He remained at the compressor for approximately five minutes, with the compressor operating normally.

Some time later, at approximately 0400 the oil loss within the compressor became critical, resulting in the under-lubrication of the screws. Load increased on the motor due to inadequate lubrication and heat began to build up within the system. The thermal relay at the discharge from the driven screws open circuited which should have interrupted supply to the motor by tripping the contactor. However, either because the contactor had welded in upon start up at approximately 0300 or because the increasing load and current had caused the contactor to weld in, it failed to break the current to the motor.

With the contactor welded in, the compressor continued to run and excess friction within the screws heated the compression chamber to a temperature which ignited the oil/air mix being compressed. This ignited mixture then passed into the air receiver and burnt out the oil separator and allowed the flames to propagate into the delivery line, where the flame caused the flexible (hydraulic hose) connector to the air line to char and rupture. At the same time there was a fire at the delivery flange which burnt through the control lines allowing oil to spray over the machine and which quickly spread the fire to the oil cooler where most of the accumulated leakage was located.

The loss of oil caused the rotors to seize, resulting in tripping of the low tension circuit breaker at the transformer. By this time however, the fire was of high intensity and the whole of the oil cooler assembly was red hot. The fire was being fed by the residual oil in the oil circuit heating, pressurising and finding its way to the leaks in the oil cooler.

Smoke and products of combustion backed up against the ventilating current and alerted a crew of men deployed to reclip a nearby belt. These men made their way outbye, discovered the fire and set about extinguishing the fire using extinguishers located nearby. Initially four extinguishers were used, but the intensity of the fire allowed the flames to re-ignite each time an extinguisher was exhausted. The men then fetched more extinguishers from outbye.

A worker went to the transformer supplying the compressor and tripped the low tension and high tension ends of the transformer, then returned to the fire to find that the lights in the compressor station were still lit. The men did not use water to cool the oil cooler which was red hot and reigniting each time an extinguisher was exhausted.

Their fear was that power was still on to the compressors and that there was a risk of electrocution.

A deputy some 2 km inbye from the fire site, was notified by the control officer that he was to urgently return to pit bottom. on his way back he was directed by the control officer to isolate power to the compressor but no reason was given and no reason was asked for. On his way he stopped and isolated power to the reciprocating compressors along the road. On travelling to the pit bottom he was told that there was a fire which could not be extinguished and that power could not be isolated. He went to transformers near the diesel servicing bay and switched them off. He then went to the compressor cutthrough to find workmen applying stonedust to the oil cooler of the compressors. The f lames had been quenched at this time, but the whole of the oil cooler was still red hot.

Soon afterwards another deputy arrived and advised that he had isolated power to that side of the mine. A decision was then made to use water to cool the compressor. This they did, bringing the fire under control. The time was approximately 4.50 am, the fire having burnt for approximately 50 minutes.

The tube bundle monitoring system was supposed to have a lag time of 1 8 minutes at tube No 5 located in the compressor station cutthrough. The printout showed that there was at least 80 minutes delay in registering the carbon monoxide concentration when the fire was at its peak. The undermanager being unaware of the lag in the monitor, asked the control officer what the carbon monoxide reading was on tube No 5. He was advised that the reading was 3 parts per million so he hesitated and did not order general evacuation. However, this reading related to a sample taken at about 3.40 am before the fire had started.

INVESTIGATION

Investigation of this occurrence was conducted as a 'System Safety Accident Investigation' to a scope determined by the investigating team.

The investigation team was:

Mr Michael Carr	Inspector of Coal Mines
Mr John Bout	Inspector of Mechanical Engineering
Mr Kevin Reed	Inspector of Electrical Engineering

The investigation was commenced on 26 September 1991 and concluded on 8 November 1991. The investigation was not continuous during this period.

It was decided that the investigation of events would start from 30 July 1991 which was the last time the oil separator element was changed. This decision was based on expert advice from the compressor service engineer that rotary screw compressor internal fires often result from problems related to a dirty oil separator element. This date also accommodates a period of known 'nuisance' oil leaks and supposed repeated overheat trips on the compressor prior to the fire.

The Events and Conditions Chart followed each of the witnesses through significant actions from the start of nightshift on 26 September 1991 to the extinguishing of the fire. For the period preceding nightshift, 26 September 1991, a more generalised event charting was followed.

The team performed two Change Analyses on the underground compressor operation.

CHANGE ANALYSIS No 1

The team had to create a 'standard' of underground compressor operation management which they felt was a reasonable expectation for the mine in order to examine any causal elements in this area. The team defined an 'Expected Underground Compressor Operation Management System Standard' that included elements of planning, organising, directing and controlling underground compressor operation management. This in turn contained elements related to identifying, assessing, eliminating or controlling, and ameliorating such risk. This 'standard' was then compared to the situation before and during the occurrence period.

CHANGE ANALYSIS No 2

This was done comparing the requirements of relevant standards, Acts and Regulations with the occurrence situation. This analysis established the intent of relevant provisions; the occurrence situation; and the significance of any difference with respect to the Occupational health and Safety Act (1983) and the Coal Mines Regulation Act, 1982 and Regulations.

Findings arising from examination by each of the 'tools' were then grouped into related findings. These related findings were used as a basis to determine the 'Judgements of Needs' arising from the occurrence and presented in the following section of this report.

JUDGEMENT OF NEED # 1

Accident Investigation Results Date: 31st August, 1993

Location: **Appin Colliery**

Type of Accident: **Fire underground**
Date of Accident: **26th September, 1991**

General Issues: **COMPRESSOR SITING AND INSTALLATION**

Areas of Implication: **Mine and Mining Industry**

JUDGEMENT OF NEEDS:

There is a need to implement a code of practice for the installation of compressors at mine sites.

Related Findings:

1 Ventilating to intake resulted in smoke coursing inbye into the working sections.

2 Stonedusted ribs and roof may catch fire during a prolonged compressor fire.

3 Oil on floor and leaking from compressor added to risk.

4 A history of temperature trips caused by oil loss was identified. Proximity to track road was contributory.

5 Power for lighting came from a 'remote' transformer not from the transformer feeding the compressors, generating confusion, delaying the extinguishing of the fire.

6 There was no means to communicate. This absence created delays in seeking guidance and assistance.

7 Lack of clearance around compressors impeded firefighting.

8 The fire burnt undetected for a period of time.

9 Carbon monoxide was being 'pumped' into the air reticulation system by the compressor's internal fire.

10 The 'hydraulic' bullhose ruptured on the delivery line.

Discussion of Findings:

The use of a documented code of practice was felt to be necessary for the safe installation of compressors.
The team recognises that there is no code of practice controlling the installation of compressors.
The implementation of a code of practice should remove all identifiable risks associated with compressors.

JUDGEMENT OF NEED # 2

Accident Investigation Results Date: **31st August, 1993**

Location: **Appin Colliery.**	Type of Accident: **Fire Underground.** Date of Accident: **26th September, 1991.**
General Issues: **OPERATION - CODES AND GUIDELINES**	Areas of Implication: **Mine and Mining Industry**

JUDGEMENT OF NEED:

A There is a need to conduct a Risk Assessment on the operation of compressors underground in coal mines.

B There is a need for the implementation of a code of practice for the operation of compressors.

Related Findings:

1 There was no previous Risk Assessment evaluation carried out to identify the risk of fire underground as a result of using compressors underground.

2 No formal procedures were in place to manage the operation of the compressor apart from maintenance and inspection requirements.

Discussion of Findings:

1 The completion of a Risk Assessment should identify and eliminate hazards associated with the use of compressors underground.

2 The implementation of an operational code of practice should eliminate unsafe compressor operation.

JUDGEMENT OF NEED # 3

Accident Investigation Results Date: **31st August, 1993**

Location: Appin Colliery. Type of Accident: **Fire Unground.**
Date of Accident: **26th September, 1991.**

General Issues: **OPERATION - EXAMINATION AND MAINTENANCE** Areas of Implication: **Mine and Mining Industry.**

JUDGEMENT OF NEEDS:

A There is a need for persons engaged in the examination and maintenance of compressors to understand their operation.

B There is a need to review the S103 schemes at the mine.

C There is a need to review the application of the maintenance procedures at the mine.

Related Findings:

1 Repairs to the electrics of the compressor were carried out without proper investigation of the reason for the failure.

2 The significance of excessive oil consumption of the compressor was not appreciated.

3 Tripping of the compressor was not considered significant enough to warrant reporting.

4 Oil leaks on the compressor were not reported in writing - verbal report only was given by deputy.

5 S103 inspection requirements are generalistic.

Discussion of Findings:

Maintenance and examination of the compressor was inadequate and failed to prevent fire occurring.

JUDGEMENT OF NEED # 4

Accident Investigation Results Date: 31st August, 1993

Location: **Appin Colliery.**	Type of Accident: **Fire Underground.** Date of Accident: **26th September, 1991.**
General Issues: **DESIGN**	Areas of Implication: **Mine and Mining Industry**

JUDGEMENT OF NEEDS:

A There is a need to review design standards for contactor switching and control and monitoring systems related to compressors.

B There is a need to consider compelling the use of fire resistance non-toxic lubricants in rotary screw compressors.

Related Findings:

- Contactor welded in twice in succession
- Protection/control philosophy failed
- No assessment had been made of the suitability of the protection system
- Oil loss into the air circuit is not automatically controlled in the event of separator failure.

Discussion of Findings:

The failure of electrical contacts combined with ongoing oil losses resulted in the fire occurring when the compressor overheated. The use of mineral oil fuelled the fire.

JUDGEMENT OF NEED # 5

Accident Investigation Results Date: **31st August, 1993**

Location: **Appin Colliery.**	Type of Accident: **Fire Underground.** Date of Accident: **26th September, 1991**
General Issues: **FIREFIGHTING/EMERGENCY**	Areas of Implication: **Mine**

JUDGEMENT OF NEEDS:

A **There is a need to review the mine's emergency procedure.**

B **There is a need to re-train all officials regarding emergencies.**

Related Findings:

- A delay in ordering general evacuation occurred.
- Information was not communicated clearly or quickly.

Discussion of Findings:

- Lack of real time monitoring of gas limited ability for extent of fire to be understood.
- Lack of communication to the site did not allow sufficient information to be obtained and disseminated by control officers.

JUDGEMENT OF NEED # 6

Accident Investigation Results Date: **31st August, 1993**

Location: **Appin Colliery.**	Type of Accident: **Fire Underground.** Date of Accident: **26th September, 1991**
General Issues: **LEGISLATION**	Areas of Implication: **(a) CMRA** **(b) OHSA**

JUDGEMENT OF NEEDS:

A There is a need to ensure that requirements of the Coal Mines Regulation Act and the Occupational Health and Safety Act as indicated in Change Analysis No 2 are complied with.

B There is a need to asses whether specific requirements should be legislated regarding use of compressors underground.

Related Findings:

COAL MINES REGULATION ACT

- The owner failed to safely lay out the mine plan
- The equipment was not in a safe working condition
- Persons did not fully understand their duties and tasks
- The undermanager did not enforce observance of the Act
- The deputy did not correctly report the defect
- The undermanager hesitated in evacuating the mine

OCCUPATIONAL HEALTH AND SAFETY ACT

- Safe working place and environment was not provided (duties of care)
- Less than adequate training was identified.

Discussion of Findings:

Whilst legislation is minimal regarding compressors used in mines, failure to comply with certain aspects of this existing legislation allowed the unsafe situation to compound into a dangerous occurrence.