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Fatal Accident Gretley Colliery

14 November 1991

May 1994

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DEPARTMENT OF MINERAL RESOURCES
NEW SOUTH WALES

COAL MINING INSPECTORATE

SYSTEM SAFETY ACCIDENT INVESTIGATION SUMMARY

FATAL ACCIDENT
GRETLEY COLLIERY
14 November 1991

SSAI Summary No 7 **MAY 1994**

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

Bruce McKensey
Chief Inspector of Coal Mines
May 1994

OVERVIEW

On Thursday, 14 November, 1991 at approximately 12.50 p.m. a longwall maintenance engineer sustained fatal injuries when a jet of hydraulic fluid, under extremely high pressure, escaped from a hydraulic cylinder and struck him in the abdomen.

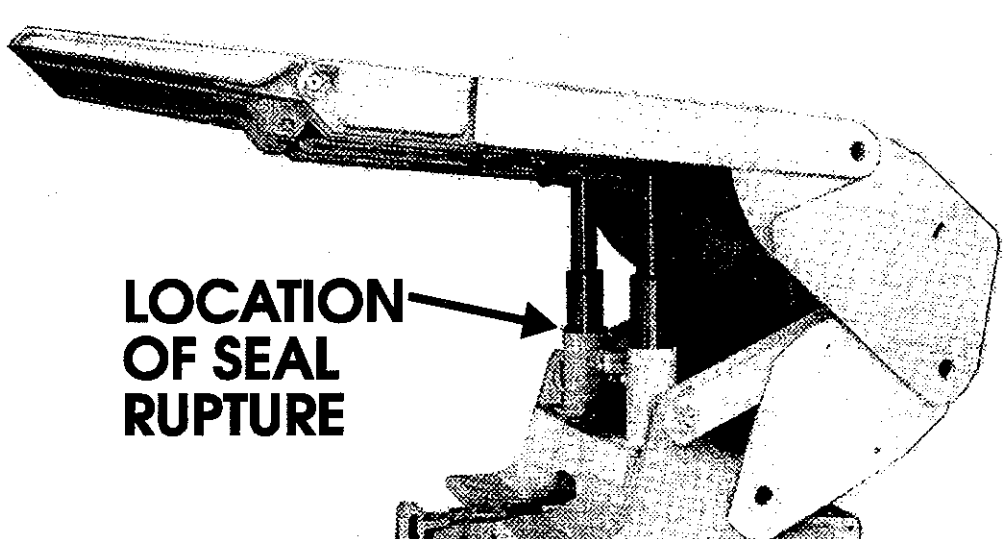
On 4 October 1991, a sudden, unplanned collapse of the roof onto the longwall roof supports, caused the partial and, in some cases, total collapse of the roof support chocks. The roof was subsequently supported and the shearer, face conveyor, roof supports and associated equipment were recovered. While the recovery was still in progress, the face conveyor and roof supports were being installed at a new face a short distance away.

During this installation, it was discovered that a number of the hydraulic legs installed in the roof support chocks had sustained varying degrees of damage. These legs were removed as they were identified and repaired legs fitted in their place. The practice of the repairer engaged for this work was to return legs to the mine with a plastic plug fitted to the top, inner cylinder power down port and a steel plug fitted to the main stage power down port in order to prevent contamination of the hydraulics in transit.

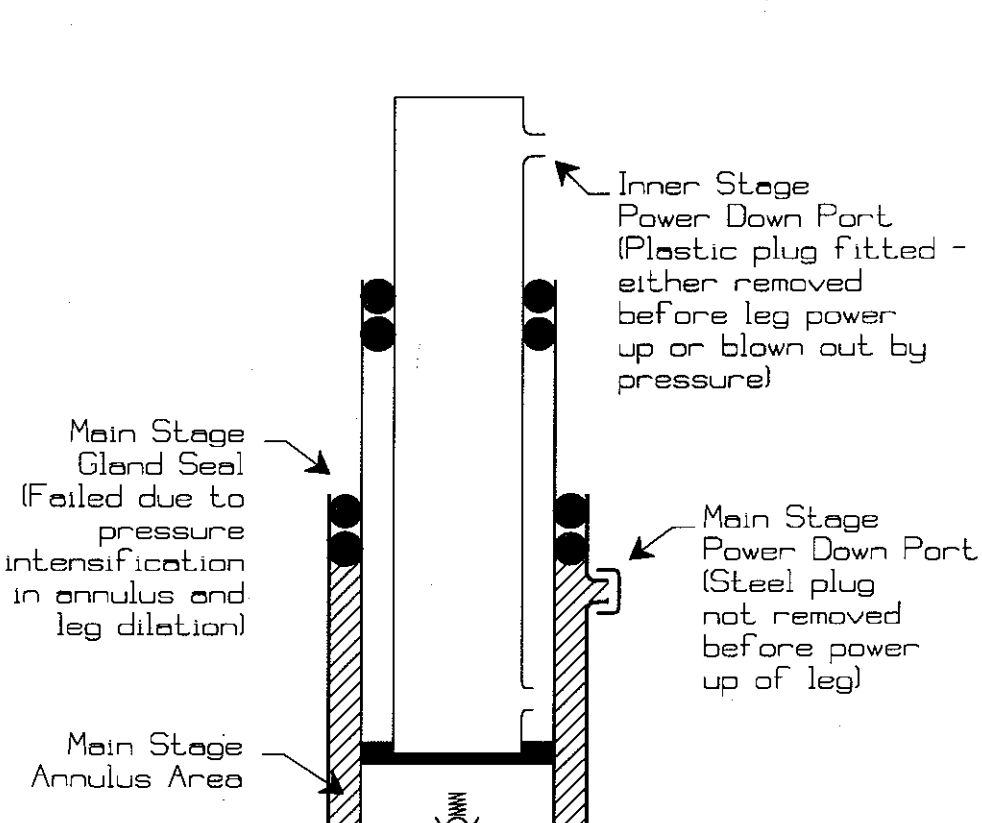
While a repaired leg was being installed, the victim was attempting to push the leg away from him to enable the top pin on the leg to be correctly located in the canopy. This placed him in close proximity to the leg as it was powered up by a fitter assisting in the leg installation.

The steel plug on the main stage power down port had apparently been inadvertently left in place and the leg only hosed up to the extent of connecting a hose to the power up port. When operating hydraulic pressure, (5,000 psi) was applied to the bottom of the cylinder to raise the leg to the canopy, fluid on the opposite side of the main stage piston was unable to escape. Intensification of pressure occurred in the main stage power down annulus which resulted in leg dilation and the rupture of the seal at the gland in the top of the cylinder barrel.

The location of the seal rupture and emission of hydraulic fluid under high pressure is shown overleaf.



The area ratio of the main stage piston to main stage power down annulus was such as to create a pressure of up to 60,000 psi within the annulus. A schematic of the type of dual extension, double acting hydraulic roof support leg involved is shown below.



Investigation

Investigation of this incident was conducted as a 'System Safety Accident Investigation' commissioned by the Chief Inspector of Coal Mines, and to a scope and mandate determined by the Chief Inspector.

System safety accident investigation was originally developed by the United States Department of Energy. The investigation process utilises a number of 'tools', which, in turn, are used to examine preliminary investigation observations, information from interviews and other information in order to determine direct and indirect causes of an accident.

The investigation was conducted by a selected team comprising:

Mr. Leo Roberts, Senior Inspector of Mechanical Engineering
Mr. Tony Ryan, District Inspector of Coal Mines
Mr. Gordon Jervis, Inspector of Mechanical Engineering
Mr. Chris Ellicott, Training Development officer
Mr. Clayton McLelland, Hydraulics Engineer - B.H.P. Steelworks:- Port Kembla.

The 'System Safety Accident Investigation' commenced on 25 November 1991 and was concluded on 18 December 1991. Note that the investigation was not continuous over this period and that the full investigation team was assembled only for the periods: 25 through 27 November, 5 December, 9 through 11 December and 18 December 1991.

The Judgements of Needs produced as a result of the investigation are reproduced below. These summarise findings of the investigation and provide identification of areas of concern for the safe management of similar installations to that involved in the fatality.

Investigation Outcome

In addition to the investigation conducted by the Inspectorate, a parallel investigation was conducted by the Newcastle Wallsend Coal Company Pty Ltd (the mine owner). That Company subsequently produced a training video and booklet concerning 'Hydraulic Safety'. With the Company's kind permission the booklet was reproduced by the Inspectorate and distributed to industry.

JUDGEMENT OF NEED # 1

ACCIDENT INVESTIGATION RESULTS		Date: 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:**	FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: OPERATIONAL RISK REVIEW	**Areas of Implication:**	MINE AND MINING INDUSTRY

JUDGEMENT OF NEED:
There is a need for the mine and the industry to conduct systematic reviews of existing procedures for operations involving high pressure hydraulic roof support systems. Such reviews should identify and develop controls for risks related to not only high pressures but also equipment/material handling systems in operation, installation and maintenance phases. Controls developed should include planning, procedural barriers, and training of operators together with appropriate review processes.

RELATED FINDINGS:
- the victim was in close proximity to the failed gland seal in order to manually guide the leg to its location in the canopy;
- the canvas gaiter prevented a visual check on leg travel which may have revealed that the inner leg extended too early for normal operation;
- the leg was installed toward the end of shift which may have provided some time pressure and perhaps contributed to the apparent oversight in not removing the steel transport plug;
- there appeared to be a lack of formal documentation and planning covering the installation leading to heavy reliance on a single individual (the victim) for the successful and safe conduct of the work;
- the absence of well defined procedures may have contributed to the apparent omission to remove the steel plug from the main stage power down port prior to powering up the leg;
- there appeared to be no mechanism for ongoing review of safety in relation to high pressure hydraulics;
- there appeared to be a lack of any procedural check (between operators) and procedure support material (check list) prior to application of hydraulic power to the support leg;
-- transport systems, both to and in mine, have over a period of time led to the use of steel plugs to seal repaired legs in order to mitigate damage to staple-lock cylinder ports. Plastic plugs were found unsuitable for this purpose;
- the support leg manufacturer's written procedure was not strictly followed in that the leg was not fully hosed up prior to powering up (this may have in part been due to both less than adequate hazard identification in the written material and an apparent failure by the end user to supplement such material - see also Judgement of Need # 5);
- there does not appear to have been a formal hazard assessment and control process undertaken to unambiguously identify risk associated with retained steel (or perhaps plastic) plugs on support legs;
- overpressure protection provided by the hydraulic circuitry was effectively disabled;
- no physical or personal protective equipment barrier to protect the victim from discharge of hydraulic fluid appeared to be in place; and
- there appeared to be no system for danger tagging, or otherwise, identifying the need to fully hose up support legs prior to application of hydraulic power.*

DISCUSSION OF FINDINGS:
In the absence of overpressure protection integral to the support leg the team identified the absence or failure of a range of procedural, physical and management system related controls to have contributed to the accident outcome. The team further considered that the most effective means for mining operations to effectively redress the potential for a similar occurrence was via a risk oriented review of existing operations and equipment.

*Note: In relation to this finding 'hosing up' is not deemed total protection against intensification.

JUDGEMENT OF NEED # 2

ACCIDENT INVESTIGATION RESULTS		Date: 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:**	FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: EQUIPMENT DESIGN/ RISK REVIEW	**Areas of Implication:**	MANUFACTURERS/ SUPPLIERS

JUDGEMENT OF NEED:

There is a need for manufacturers/suppliers of high pressure hydraulic roof support systems to undertake equipment design risk reviews in order to identify hazards inherent in such equipment. Results of such reviews should lead directly to the incorporation of integral safety barriers to identified risks.

RELATED FINDINGS:

- pressure generated in the main stage power down annulus (resulting from apparent failure to remove a steel plug from the main stage power down port prior to application of hydraulic power) caused dilation of the support leg barrel and subsequent failure of the main stage gland seal;
- effective operation of overpressure protection systems was dependent on proper fitting of hoses to all leg ports prior to power up;*
- while the team considered that the design factor of safety was inadequate to contain pressures generated under the circumstances prevailing at the time of the accident, it may be unrealistic to expect cylinder design (as a containment) alone to cater for all potentially generated pressures;
- the absence of purpose designed mechanical aids for face equipment installation/removal may place personnel in close proximity to hydraulic pressure hazards during power up;
- forces identified as being required to install roof support legs probably exceed reasonable ergonomic limits in the absence of purpose designed aids;
- there appears to be a need for the routine provision of integral, fail-safe protective devices (such as hydraulic fuses) for overpressure protection within legs and which are not dependent on the performance of human reliant procedures for effective operation;
- identification of all potential high pressure hazards may only be ensured through rigorous risk based evaluation and incorporating design data available only to manufacturer's;
- there was no physical barrier present to arrest escaping fluid under pressure;
- there was no facility present to limit pressure to the support leg for installation purposes;
- there was no fail-safe pressure relief device integral to the main stage power down annulus;
- there was no yield plug type pressure relief device fitted externally to the cylinder on the main stage power down port;
- there was no monitoring/indication of overpressure;
- the equipment manufacturer has been in the process of developing a protective device which may have assisted in the accident situation. That research has, however, not yet been comprehensively applied in the field.

DISCUSSION OF FINDINGS:

The team identified the absence of integral overpressure protection within the power down annulus of the support leg to be a critical factor in the accident. The absence of such protection left the operation of protective systems present in the hydraulic circuitry dependent on a human based procedure (fully hosing up the leg prior to power up). The team further considered that the most effective means for equipment manufacturers/suppliers to redress the potential for a similar occurrence was via a risk oriented review of hydraulic system design with an emphasis on potential failure modes of protection systems.

*Note: In relation to this finding 'hosing up' is not deemed total protection against intensification.

JUDGEMENT OF NEED # 3

ACCIDENT INVESTIGATION RESULTS	**Date:** 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:** FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: CODES, STANDARDS AND REGULATIONS	**Areas of Implication:** INDUSTRY/ REGULATORY AUTHORITY

JUDGEMENT OF NEED:

There is a need to consider review of existing regulatory and standard based controls for high pressure hydraulic roof support systems with respect to installation, maintenance and operational aspects of such equipment.

RELATED FINDINGS:

- there appears to be no specific coverage within AS or ISO standards of hydraulic legs as per the accident application;
- the team had some doubt as to the applicability of current Australian standards during maintenance operations;
- while there is provision under the current CMRA to invoke Codes relating to hydraulics none have been specified to date;
- a notice issued by the Chief Inspector of Coal Mines on 1 February 1991 and requiring protection against pressure intensification applied only to new systems installed after 1 August 1991.

DISCUSSION OF FINDINGS:

The team considered that there appeared to be a paucity of definitive material, either in the form of regulations, or codes or standards, covering the operation, installation and maintenance of hydraulic powered roof supports. The absence of such material was seen as contributing to a lack of guidance for operators.

JUDGEMENT OF NEED # 4

ACCIDENT INVESTIGATION RESULTS	**Date:** 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:** FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: HIGH PRESSURE HYDRAULICS TRAINING	**Areas of Implication:** MINE/ INDUSTRY/ TRAINERS

JUDGEMENT OF NEED:

There is a need to review the appropriateness of training currently being received by those in the industry with respect to appreciation of the potential dangers associated with high pressure hydraulic roof support systems. This includes on-site, formal and manufacturer conducted training.

RELATED FINDINGS:

- while both the victim and the fitter assisting him had undergone formal training, such training may not have effectively addressed safety and procedural issues with regard to installation of hydraulic roof supports;
- interviews conducted with tradesmen at the mine indicated a widespread lack of appreciation of pressure intensification hazards (the main criterion for the need to fully hose up support legs prior to power up was broadly considered to be prevention of contamination);
- specific training undertaken by the victim (including specialised hydraulic system training) was not sufficient, in itself, to prevent the accident; and
- there appeared to be no system in place to identify the lack of appreciation of pressure intensification and provide supplementary instruction.

DISCUSSION OF FINDINGS:

While the team recognised that systems of training are likely to be of limited benefit in prevention of accidents involving procedural 'slips' they nonetheless considered that an apparent widespread lack of appreciation of pressure intensification hazards required some redress. The team also considered that training initiatives should be secondary to the risk management processes indicated in Judgements of Needs #'s 1 and 2.

JUDGEMENT OF NEED # 5

ACCIDENT INVESTIGATION RESULTS	Date: 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:** FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: PROVISION OF ADEQUATE INFORMATION	**Areas of Implication:** MANUFACTURERS/ SUPPLIERS/ INDUSTRY

JUDGEMENT OF NEED:

There is a need to review the provision of information regarding high pressure hydraulic roof support systems and in particular the unambigous identification in such information of hazardous conditions which may be induced or encountered under all modes of installation, operation or maintenance. There is also a need for end users to critically evaluate such information, supplement it as appropriate and ensure effective dissemination to those requiring it.

RELATED FINDINGS:

- relevant equipment manuals were available both on the surface and adjacent to the accident;
- documented procedure (supplied by manufacturer) appeared to not adequately address materials transfer and identification of hazardous conditions;
- manufacturer's procedure was not strictly followed in that all ports were not hosed up prior to application of hydraulic power;
- the appeared to be no specific identification at the mine of the hazards associated with not removing all steel transport plugs prior to application of power to a leg;
- specific plan for changing legs, other than manufacturer's instructions, was not documented;
- manufacturer's instructions did not appear to be routinely utilised by site personnel;
- manufacturer's written material contained no specific mention of the possibility of pressure intensification in relation to operation or installation;
- the team considered the identification of potentially hazardous conditions within the manufacturer's published material to be less than adequate.

DISCUSSION OF FINDINGS:

The team considered that the lack of unambiguous identification of the potential for pressure intensification in the absence of a fully hosed up support leg within the equipment manufacturer's published material may have contributed to the accident outcome. In addition, there appears to have been no effort on the part of the end user to redress such a lack of unambiguous hazard identification.

JUDGEMENT OF NEED # 6

ACCIDENT INVESTIGATION RESULTS **Date:** 14/11/91

Location: GRETLEY COLLIERY

Type of Accident/Incident: FATALITY/HIGH PRESSURE HYDRAULICS

General Issues: REPAIR/TRANSPORT PRACTICE

Areas of Implication: REPAIRERS/ OVERHAULERS/ INDUSTRY

JUDGEMENT OF NEED:

There is a need for repairers/overhaulers of high pressure hydraulic roof support systems to review practices, consistent with good quality assurance and control , for repair and testing together with adequate transport arrangement to ensure the integrity of repaired systems. Alteration to equipment manufacturer's practices should be subject to a rigourous risk review.

RELATED FINDINGS:

- repaired leg was found to be within manufacturer's specified tolerances;
- repairer used steel plugs for sealing of power up and main stage power down port (plastic plug was used to seal inner stage power down port);
- it was understood by the team that the use of steel plugs was introduced primarily to overcome damage in transit problems associated with plastic plugs in staple-lock ports (with associated damage to ports, loss of plugs, contamination and loss of fluid);
- it was further understood by the team that the equipment manufacturer has from time to time used steel plugs to seal ports of repaired legs;

DISCUSSION OF FINDINGS:

The substitution of steel for plastic plugs as part of repair, and as a means of transport protection of ports, is an issue. The team considered it possible that had a plastic plug been fitted to the main stage power down port then it may have failed safely. While the plug substitution was successful as a means to prevent port damage, possible other consequences may not have been adequately assessed.

JUDGEMENT OF NEED # 7

ACCIDENT INVESTIGATION RESULTS	**Date:** 14/11/91
Location: GRETLEY COLLIERY	**Type of Accident/Incident:** FATALITY/HIGH PRESSURE HYDRAULICS
General Issues: SAFETY SUPPORT SYSTEMS	**Areas of Implication:** MINE AND MINING INDUSTRY

JUDGEMENT OF NEED:

There is a need to review the adequacy of current material safety data systems in covering the full range of potential hazards presented by material such as hydraulic fluid under high pressure with potential for injection. There also appears some need for review of transport systems for injured persons in relation to compatibility with stretchers currently in use (such a review could also well include consideration of timely availability of analgesic agents).

RELATED FINDINGS:

- the stretcher on which the victims body was placed was found to be imcompatible with an item of mine transport;
- alternative, compatible transport was, in this case, readily available;
- material safety data sheets available at the mine for the hydraulic fluid in use did not identify the potential for injection of that fluid under pressure and first response treatment measures;

DISCUSSION OF FINDINGS:

While the team recognised that the above issues did not have any bearing on the accident outcome, in this instance, they felt that such issues should be considered for the sake of completeness and to prevent the possibility that they do influence the outcome of future incidents.