

DRAGLINE FIRE AT BLACKWATER MINE - A CASE STUDY

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SUMMARY OF INCIDENT

At about 9 pm on Thursday 11 January 1996, there was an outbreak of fire in the front 'ring gear' area of DRE15, a Marion 8050 dragline. At the time of the fire occurrence, the dragline was down on maintenance with repair work being carried out on the No 3 lower swing bearing. The incident occurred at the far southern end of Blackwater mine, some 14 km south of the industrial area.

The outbreak of fire was on top of the tub in the area between the roller bearing circle and pinion rack between No 2 and No 3 swing shafts, and from this area toward the main centre pin. From the time of ignition, shortly after 9 pm, it took ten (10) Mines/Fire Rescue personnel, with assistance from 32 other mine employees, some three and a half (3.5) hours to bring the fire under control.

Considering the circumstances and loss potential of the fire situation, the fact that injury to personal was only of a minor nature, and the minimal equipment damage, is recognition to the quality of the response. The situation was made most difficult because of the inaccessibility of the fire to normal control methods.

Background and the sequence of events are outlined, as are the direct and contributing causes, the emergency services response and corrective actions as controls to minimise risk in future of such an event recurring.

DESCRIPTION OF EVENTS

A detailed assessment of sequence of events is given in Appendix A. This 'paints a picture' of lead up events, the outbreak of fire and steps taken to control the fire. Simplified drawings of the revolving frame plan (Figure 1) and swing pinion, rack and roller path area (Figure 2) are given to allow for a better understanding of the situation.

In summary, the sequence of key events were:

- Ring gear and revolving frame in dirty condition due to difficulty of access, resources to regularly clean, and some problems related to "lack of ownership".
- No 3 swing lower bearing failed, and subsequent mechanical attempts failed to remove it.
- Hot work permit completed and some precautions taken to prevent hot slag going down to ring gear.
- Air arc gouging carried out, slag ignited accumulated oil and grease, small fire thought to be put out by a DCP extinguisher. House fans put on to clear fume and allow for visibility to check out area. Alarm raised.
- Fire reignited and spread, house fans turned off.
- Fire/Mines Rescue personnel initially attempted to use water to cool area within revolving frame and to extinguish fire.
- Need to withdraw because of heat, then decision to use foam.
- Additional backup men/materials requested.
- Fire extinguished by gaining access from under rear of revolving frame and using a handheld foam branch, flooding the area between revolving frame and tub with foam and pushing it towards the fire.
- Fire started at 9:15 pm, declared to be out at 12:30 am, continued cooling operations until 4 am.

The extent of damage was:

- Minor revolving frame plate buckling in compartments between No 3 and No 2 swing shafts and toward the centre pin area.

- Secondary cable damage.
- The drag and hoist motors required removal and cleaning due to their blowers drawing in the heavy soot laden smoke.

To date there is little evidence of any permanent damage to the roller path or centre pin area.

Total cost of the incident was less than \$300,000. This comprised mainly the contract cleanup crew costs and electric motor cleaning.

The sequence of events was compiled from various sources including interview statements and two formal investigations involving operations and maintenance people, and an investigation/debriefing held with Blackwater Mine Fire Rescue and Mines Rescue Brigade members*.

KEY EVENTS - DIRECT AND CONTRIBUTING CAUSES

Direct causes of initial and subsequent fire

- Hot slag from the air arc gauging of the lower swing bearing ignited an accumulation of oils and greases between the ring gear (rack) and roller paths.
- After the initial fire had been extinguished with dry chemical powder (or at least smothered), it is strongly suspected that the activation of the house fans caused an air draught which blew away the dry powder coating on the lubricant. This would have increased the supply of oxygen and thus intensified the heat build up causing the lubricant to again reach ignition temperature (150°C - 200°C). This then caused the fire to spread over previously unburnt lubricant.

Contributing causes of start of fire

- The fact that a hot work method was required to remove swing shaft and bearing.
- Area on top of tub and between the ring gear and roller path was 'dirty' with a long term accumulation of lubricants (it is an area that is difficult to access for cleaning).
- Precautions taken to prevent ignition of accumulated lubricants found to be inadequate.
 - a rubbish bin base was used to contain hot sparks/slag this had a hole burnt in the bottom which could have caused the fire
 - immediate area around pinion inside the ring gear was not cleaned up
 - DCP extinguishers not a suitable type of extinguisher for this type of job (foam extinguisher should be used).

Contributing causes - difficulty to control fire

- Dirty compartments in revolving frame with accumulated spillage of Mobiltax F rope lubricant (some compartments were clean, some had 'mop' in them to soak up the lubricant). The high heat source under the revolving frame floor caused this to get very hot and most probably emitting toxic/flammable hydrocarbon vapour and residue. The fact that water was used on this initially would have served to cool it down (in hindsight, foam would have done just a good, if not better job).
- Restricted space where fire was seated. There was difficulty to get at it from any direction as the gaps in the roller path were very small to get at it from the outer, and the heat/risk too great to get direct internal access.
- There was no emergency lighting installed on the dragline. Once the power was cut, the whole area was in darkness until the mobile lighting was set up.

* Note: Fire Rescue personnel are those trained to Queensland Open Cut Mines Rescue proficiency, and Mines Rescue Brigade personnel are those trained to Queensland Mines Rescue Brigade (underground coal mines) proficiency.

- The electrical control set up for the fans/blowers was such that there was difficulty in operating correctly (inadequate labelling).
- The firefighting personnel had limited knowledge of the layout of the revolving frame compartment structure, the location of accesses and the general setup of the swing shafts, ring gear and roller path arrangement.
- There was no standard fire fighting procedure in place for controlling this type of fire in large equipment.
- There was an inadequate supply of foam, particularly in the early stages. The Fire/Rescue vehicle had 40 litres (probably enough) but the foam drum on the water truck was empty (rupture in drum).
- There was a delay in water supply between the fire tanker running out and the arrival of the water truck.
- Some initial delay due to supply of BA air bottles. (Only four are kept on the Fire/Rescue truck.) Once compressor set up, good supply (shows the value of compressor onsite).
- The use of hand held branches with the induction of foam at the nozzle made the foam generation exercise very laborious and slow, with having to carry 20 litre containers of foam detergent through compartments of the revolving frame.
- The twoway radio reception in the area was poor due to some problems with the system and the remote location of the dragline. This created difficulties with the relay of requests/instructions.
- At times there was no person in overall control (team leader) of the fire control operations. This led to some confusion with conflicting instructions. (Not intended as a criticism, as there were only two proficient Mines Rescue personnel onsite in initial stage.)

CORRECTIVE ACTIONS

As a result of the investigation, various corrective actions were recommended. Many of these have already been put into place and others are in various stages of implementation (as at June 1996).

The corrective actions recommended in the accident investigation report are outlined as follows:

- A review and upgrade of lubrication apparatus (design, maintenance, monitoring and calibration) is required to facilitate a higher degree of lubrication control. Spillages and/or accumulation of lubricants need to be controlled by a system for containment and/or regular cleanup and disposal.
- A review and assessment of alternative mechanical means (by component or process redesign) is required to enable ease of fitment and removal of swing pinion and similar bearings as a means to minimise the need for hot work in high fire potential areas.
- A review is required of hot work permits and procedures followed when doing work in high fire potential areas, particularly with respect to:
 - cleaning/protection to prevent ignition
 - procedure to follow up outbreak of fire
 - correct extinguishers available (eg need for at least two AFFF foam extinguishers on hand for lubricant or hydrocarbon fire potential)
- A system needs to be in place to deal with fire/explosion scenarios in large equipment and plant.

- A inline foam inducer needs to be part of fire equipment to enable remote handheld firefighting to be carried out more efficiently (negate need to carry foam containers).
- A high expansion foam generator fitted with appropriate ducting and hood considered to be the best system for controlling such a restricted space fire.
- A assessment of foam types and supply stockholdings required to ensure optimal shelf life, suitability and distribution on minesite.
- It is essential that the foam firefighting systems be fitted to at least two water trucks and be maintained in emergency readiness.
- There is a need for emergency services personnel to have a degree of familiarity with layouts by:
 - having plans prepared and displayed and included in fire/rescue manual, and
 - from time to time emergency services personnel to ensure they are familiar with layout of large equipment and plant.
- There is a need to identify compartments within the revolving frame (and tub) by a system of numbering for purposes of locality identification.
- There is a need for a clearly identified location and well known method of actuating an emergency power cut off system internally (operator cab) and externally.
- An emergency lighting system should be installed on draglines and other heavy equipment. A system of area emergency lighting needs to be a part of the emergency services equipment.
- There was some concern that the people involved in controlling the fire may have been at risk due to unburnt hydrocarbon combustible vapours reaching flash point temperature within the revolving frame. Further investigation should be carried out to determine the probability of this occurring, and what preventative measures would be necessary.
- All emergency services personnel, when at work or responding to fires or other emergencies, wear suitably designed fire resistant clothing (long sleeve shorts and trousers and availability of coats).
- There are some variances in techniques and some degree of unfamiliarity by Mines Rescue service (underground team) trained personnel in Open Cut site emergency procedures. This needs to be corrected by introducing a system of cross training.
- An assessment and review of the emergency team call out system needs to be done. There was some lack of urgency/confusion in the early stages as to what resources were needed to control the situation. It is recommended that a callout category system be implemented.

CONCLUSION

The incident highlighted the fact that there was potential for serious injury to firefighting personnel, and considerable damage resulting in a significant period of downtime and cost of repair. The fact that there were only minor burn and smoke inhalation injuries, and virtually no component and structural damage, is a credit to all persons involved.

A total of 42 Mines and Fire Rescue personnel and bystanders took an active part in controlling the fire. These people are to be congratulated for their commitment and courage in tackling such a difficult situation.

Dragline 15 restarted operations on 30 January, it being down for 19 days.

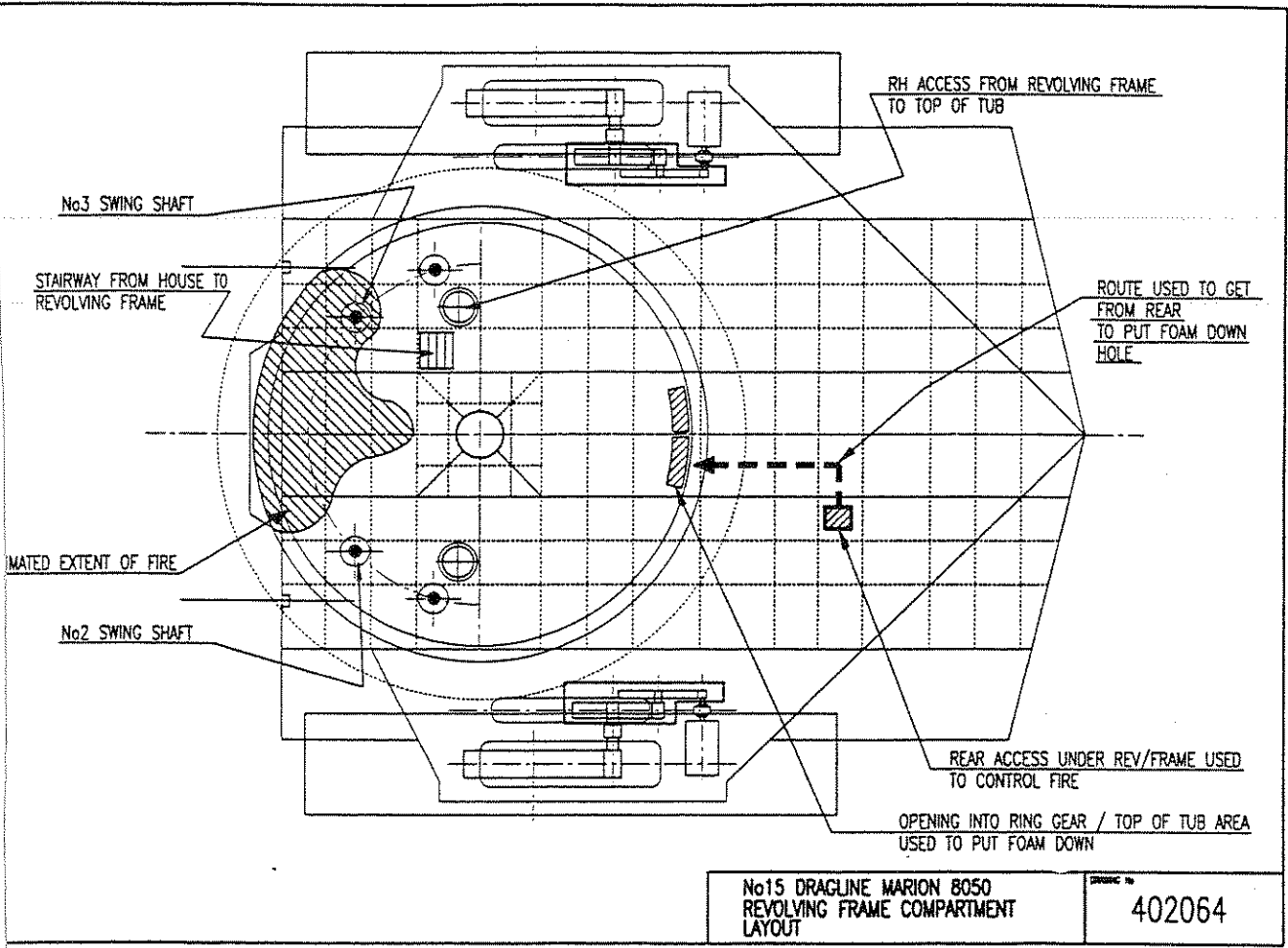


Figure 1 Layout of Dragline 15 revolving frame and top of tub

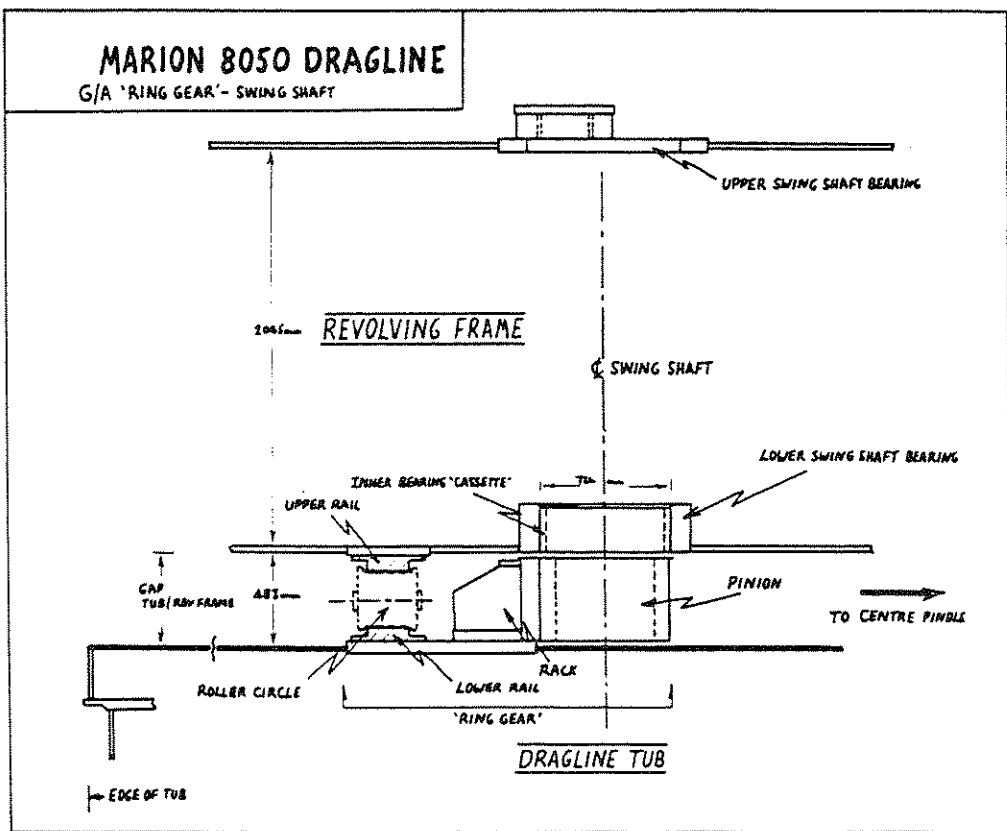


Figure 2 Dragline 15 'ring gear' / swing shaft arrangement

APPENDIX A

FIRE AT DRAGLINE 15 - 11/12 JANUARY 1996

TIMELINE SEQUENCE OF EVENTS

This summary of sequence of events has been compiled from records of a formal investigation meeting 11 January 1996, a meeting with Blackwater Fire Rescue (FR) and Mines Rescue Brigade (MR) members involved, (19 January 1996), formal statements taken from people directly involved and from informal discussion.

The intent is to 'paint a picture' of the lead up to and steps taken to control the fire.

a) Key Background Events / Situations Prior to 11 January 1996

- ⇒ Dragline 15 is a Marion 8050, 48 cu m size dragline constructed at Blackwater mine in 1976.
- ⇒ Prior to the past six or seven years or so, it was considered a 'clean' machine, being regularly cleaned the revolving frame/tub area by cleaners and trades assistants during maintenance days.
- ⇒ With changes to labour arrangements and more stringent availability of labour, (Open Cut Work Mode natural attrition etc) there were less resources to carry out this duty including the need to allocate dragline crews to other necessary duties during shutdown periods.
- ⇒ Significant leakage/spillage of Mobiltax F (used for wire rope lubrication) some "ten to twelve months ago". This was not adequately cleaned up in revolving frame area. May have been leakage to top of tub.
- ⇒ Reported by crews/maintenance personnel of ongoing problems with lubricant apparatus (oil lubricating etc).
- ⇒ No 3 lower swing bearing housing (see Figure 1 for location) had previously been 'difficult' to repair being jammed into place. For this and other jammed bearing housings there was a procedure of air gouging to remove the inner and outer bearing casings.
- ⇒ The area on top of the tube and between the roller path and rack in Marion draglines is difficult to clean due to low headroom (480 mm) and the design of the access ports necessitating access to only about 5 metre of roller/rack circumference at any time.

b) Sequence of Events Thursday / Friday 11 and 12 January 1996

Night Shift 0500 Thursday 11 January

- ⇒ No 3 lower swing bearing failed - dragline shut down (prevented dragline swinging)

Day shift 0700/1500

- ⇒ Attempt made to repair using standard procedure (unbolt bearing casing, lift shaft into compartment with crane, cover hole with plate, lower assembly back down on timbers, remove cassette). Attempt failed as bearing casing jammed in place.
- ⇒ Attempt made to use 50 tonne jack from underneath plus crane - bearing housing moved approximately 25 mm.
- ⇒ Decision made to revert to the procedure of cutting the bearing out (this method has been used on previous occasions when a bearing housing is jammed) and repair insitu.

Afternoon shift

- 1530 ⇒ Afternoon shift maintenance crew arrive at DRE 15
- 1530/2030 ⇒ Swing shaft removed from pinion and lifted out of hole and laid down in dragline house.
- ⇒ Area in No 3 swing compartment of revolving frame prepared for hot work (air gouging) and hot work permit filled out.

- Thursday A/S ⇒ Boilermaker requested one person to be observer and another to 'man' a dry chemical
(cont) 2030 ⇒ powder (DCP) extinguisher.
- 2050 ⇒ The electricians [one of the electricians was a trained Mines Rescue proficiency MR1*] arrive at dragline to do electrical work at electrical control room at rear of dragline house.
- 2100 ⇒ Air arc gouging started
- 2100/2115 ⇒ Cutting of bearing, red glow noticed down hole, development of flame/smoke. Attempt to put out with DCP extinguisher. Thought to be out.
- 2115 ⇒ MR1 advised by boilermaker of existence of fire. MR1 raised alarm with Warehouse Emergency Communication as precautionary measure.
- 2115/2130 ⇒ MR1 turned on house fans (motor blowers also initially linked in) to attempt to clear smoke (thought fire was out at this stage).
- ⇒ Activation of fans seen from front of dragline to reactivate fire (sparks/flames).
- ⇒ Fans switched off (after one minute)
- ⇒ Smoke too dense to fight fire inside revolving frame, attempt to fight from outside through roller path.
- ⇒ MR1 called shovel/truck crew to assist with directing the Fire/Rescue vehicle to dragline site.
- 2115 ⇒ MR2 (in Main Workshop) heard MR1's emergency call for Fire/Rescue back up and need for breathing apparatus (BA) sets at DRE 15 site.
- 2116 ⇒ MR2 and an apprentice left industrial area with Fire/Rescue vehicle (after confirming location of DRE 15)
- 2130 ⇒ Fire/Rescue arrived at DRE 15. Grader from shovel/truck spread had waited at intersection and guided them into area)
- 2115 ⇒ QAS Officer heard alarm from his residence on site and manned ambulance. [QAS officer a proficient Mines Rescue - (MR3)]
- 2135 ⇒ Ambulance arrived at DRE 15.
- 2130/2140 ⇒ Three proficient BA personnel at DRE 15 (MR1, MR2 and MR3) all donned BA suits to inspect.
- ⇒ House fans (one blower only) put on MR1 and MR2 entered revolving frame (R/F), (MR3 as backup) for approximately 1 minute to inspect fire - decision that could not get direct access to fire from there. Area very hot and full of smoke.
- ⇒ From outside flames were observed to be coming out of roller path on a "seven to eight" metre front between No 3 and No 2 swing shafts.
- 2140/2235 ⇒ MR1 and MR2 retreated. Turned house fan off.
- ⇒ Decision made to apply water to attempt to get at fire and generally cool area down.
- ⇒ Two hoses rolled out, one to the front of the dragline to direct onto the rollers (first aid hose) and the other into the house (1 ½ inch hose).
- ⇒ Power to DRE 15 was isolated by MR1 prior to 'water on' (Isolated by manually tripping earth continuity). Machine in total darkness - no emergency lighting fitted.
- ⇒ Water applied to roller path from outside and also inside R/F by MR1 and MR2 around the No 3 swing bearing area. Water ran out, too hot - steam - had to retreat (Note: the fire trailer tank is only 1000 litre capacity).
- ⇒ Mine water truck arrived, hoses set up via pump unit on fire rescue truck trailer.
- ⇒ Additional hose (2½") run into house.

* Note: The various emergency response personnel are designated as MR (Mines Rescue Brigade proficiency) and FR (Open Cut Fire Rescue proficiency)

- Thursday A/S (cont)**
- ⇒ Attempt to re enter R/F second time, too hot, did not get past first compartment by ladder, oil/grease/water on R/F floor observed to be boiling ("bubbling") water directed down No 3 swing shaft hole and left running down this.
 - ⇒ MR1, MR2 and MR3 went to rear of dragline house to open rear house doors to ventilate. House was full of smoke, nil visibility. MR1 had good 'local' knowledge and opened doors by 'feel'.
 - ⇒ Retreated out of dragline after opening doors (2235)
 - 2155 MR2 made request to the Stripping and Field Maintenance supervisors for need for additional manning, and BA back up (stated he also requested Blackwater Mine Fire/Rescue to be put on alert).
 - 2200 Safety Systems Coordinator (SSC) received phone call at home from the Stripping supervisor with a request for more man power and BA cylinders. SSC contacted FR1 and FR2.
 - (2155 - 2205)
 - 2215 ⇒ SSC, FR1 and FR2 arrived at mine. Picked up two BA sets plus two spare bottles from Fire/Rescue shed. SSC sought directions to DRE 15 from Stripping supervisor.
 - 2235 ⇒ SSC, FR1 and FR2 arrived at DRE 15.
 - ⇒ SSC returned to industrial area to set up the compressor to recharge the BA cylinders, organise back up and coordinate support services.
 - (at DRE 15) 2235 ⇒ FR1 and FR2 donned BA suits, accompanied MR2 into dragline house, smoke started billowing out of revolving frame.
 - ⇒ Decision made to use foam to deluge area. Call for more foam as only two containers on fire rescue truck
 - ⇒ MR2 received QAS attention for smoke inhalation
 - ⇒ Two drums (40 litres) of foam directed down R/F access stairway into revolving frame in direction of what thought to be manhole access to top of tub. When two containers depleted, retreated to outside. Appeared to have a positive effect on fire (less smoke)
 - 2255 ⇒ FR1 checked out foam supply on water truck - drums found to be empty due to being cracked. Waited for delivery from Warehouse.
- Night Shift 2300**
- ⇒ Discussion on an alternative method to fight fire.
 - ⇒ There was a conflict of opinion as to the best access to top of tub. Decision made to maintain water at front roller path, continue putting foam down No 3 swing shaft hole and then to investigate the rear entry (from under back of dragline) as a means of getting into the revolving frame at a point further away from the fire (less heat) and to find a hatch to access the ring gear / top of tub
 - 2330 ⇒ Two BA teams (4 people) in dragline
 - (1) FR1 and FR2 put 4 to 6 drums foam down No 3 swing shaft hole - little positive effect apparent.
 - (2) MR1 and MR2 ran a hose up through rear entry into revolving frame (from under rear of dragline) and located (see Figure 1) an opening accessing the ring gear and top of tub
 - 2345/2400 ⇒ All remaining stocks of foam and powder delivered from Warehouse plus 1 x 205 litre drum from Service Bay (this was decanted by bystanders into 20 litre drums).
 - 2400 ⇒ Both teams retreated. Decision made to fight fire from rear of revolving frame.
- Friday 12 January**
- 0005/0010 ⇒ SSC instructed the Warehouse Emergency controller to contact Curragh Mine and Blackwater Fire Brigade for additional quantities of foam. The Preparation Plant supervisor left site to collect.

Friday 12 cont

- 0040 ⇒ Curragh/Fire Brigade advised quantities of foam available and permission to use.
- 0020 ⇒ SSC requested the Warehouse Emergency controller to call out Fire/Rescue squad members from list (FR3, FR4, FR5 and FR6 contacted and travelled to site)
- 0010 ⇒ FR1 and FR2 entered rear hatch (see Figure 1) and commenced putting foam down rear access to tub. MR2 carried drums of foam from entrance hatch to tub access (assisted by MR1 from ground). "Five or six" drums of foam were put down onto top of tub and pushed forward to source of fire. Conditions at rear reported to be hot.
- 0030 ⇒ FR1 and FR2 retreated - foam branch had blocked. MR2 again received QAS treatment. Fire believed to be near extinguished at this stage.
- 0045 ⇒ FR3 et al arrived on site (via South Blackwater access road and back gate). FR1 and FR2 resulted and re entered and put "four to five" additional drums down hole - retreated. Foam was observed coming out of the front of the dragline through the roller path.
- 0100 ⇒ FR3 and FR4 entered rear of dragline and retrieved foam branch and hose.
 - ⇒ Good continuous supply of air bottles at this stage.
 - ⇒ Smoke had cleared enough and ventilation was good enough to re enter dragline house at this point. Significant amount of heat coming out of the access ladder ways and the centre pin area.
- 0110/0230 ⇒ FR3, FR4, FR5, FR6 took turns in entering and checking revolving frame area.
 - ⇒ Revolving frame compartments filled up from LH side ladder way (four to six drums) - retreated into house. Re entered when advised a lot of heat around centre pin area (thought to be a flare up of fire), 2 drums put in this area.
- 0230/0445 Ongoing activity to ensure whole area cooled.
- 0445 ⇒ All clear given to Warehouse Emergency controller
- 0445/0700 ⇒ Clean up of area, gear, ongoing observation.

Day Shift

0700/1500

- ⇒ Revolving frame cordoned off as area cooled and smell/possible noxious gases dispersed.
- Preliminary reports made by Registered Mine Manager to Mechanical Inspector of Coal Mines and Inspector of Coal Mines. Report made to BHPAC Corporate Management.

Afternoon shift

1530

- ⇒ Inspection made of revolving frame by Mechanical Inspector, Registered Mine Manager and others. Atmosphere readings taken, proven to be normal levels of O₂ and nil detectable contaminants.

Saturday 13 to Monday 29 January

- ⇒ Clean up/repair operations.
- ⇒ Much of the period of downtime was taken up by a team of contractors removing the accumulated lubricants and cleaning the revolving frame compartments, and top of tub area. The hoist and drag electric motors had to be sent offsite for cleaning and overhaul.

Monday 29 January - Afternoon Shift

- ⇒ Dragline 15 started operations - some 'excitation' problems for three shifts.

APPENDIX B

ASSESSMENT OF EMERGENCY SERVICES RESPONSE

These comments were recorded in the Mines/Fire rescue response investigation/debriefing held on 19 January.

What went right

- > Alarm raised promptly and correctly.
- > Good response from Warehouse Emergency controller on afternoon shift and night shift. Good competent assistance from 'bystanders'.
- > Good initial response by workers on machine.
- > Quick response by emergency services personnel on site
- > Good response from QAS. (QAS officer having BA proficiency was of benefit as could act as backup)
- > Good choice to use BA's right from start.
- > Effective use of bystanders such as fitters, apprentices etc and generally people to 'fetch and carry'.
- > Choice of fire extinguishing method (water/foam).
- > Control of emergency situation left to emergency services personnel. Management personnel present.
- > Power isolation done timely and well.
- > BA compressor available onsite was of benefit, but need to upgrade.
- > Sufficient foam stock (backup quantities not required).
- > No injuries sustained.
- > Training of rescue teams, backup system worked.
- > Fire training of employees proved its worth.
- > Fire contained before maximum damage sustained.
- > De-briefs were held.
- > Good cooperation from other minesites/fire brigade.

What needs to be done differently, or what went wrong

- > Location/access to dragline (extreme southern end of mine, 14 km) provided difficulties.
- > Small number of available rescue personnel on shift/site (two) when alarm raised.
- > Need for cross training between open cut fire rescue and underground mines rescue teams to bring underground trained members 'up to speed' with open cut systems and procedures.
- > Back chat over twoway during emergency. Need for pulse tone or similar system.
- > Poor radio reception in area (main twoway station out of service).

- > Lack of familiarity of dragline by emergency services personnel.
- > Poor labelling of fan switches.

- > Poor identification of isolation points on machine. Lack of knowledge of how to isolate (isolation was effected by MR1 - an electrician).

- > Lack of emergency lighting.
- > No single person as coordinator in early stages.
- > Ran out of water, waiting for water trucks.
- > Foam tanks empty on large water tanker.
- > Needed to consider backup at earlier stage - need for a priority call out system.