NSW GOVERNMENT

NSW Resources Regulator

PUBLIC CONSULTATION SUBMISSIONS

# FIRES ON MOBILE PLANT

NSW Resources Regulator

The following submissions were received by the NSW Resources Regulator in response to the public consultation ‘Fires on mobile plant’.

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# Hose Sleeve Burst Test Report

Date: 17/10/2012

Test conducted by: Todd Hagarty – Technical Engineer - Alfagomma Australia

## 1. Scope of the report

This test has been carried out to determine the hose burst protection of a range of three (3) protective hose sleeves when subjected to a variety of hose failure scenarios. The protective hose sleeves tested are:

- Sleeve sample type 1 - Alfagomma brand Texsleeve
- Sleeve sample type 2 - Hiflex Powerguard brand protection sleeve
- Sleeve sample type 3 - Aluminised Kevlar Prototype Sleeve

## 2. Test Sample Materials

Alfagomma brand Flexor 1SN –R1AT (12mm, 1/2") has been used in all test assemblies.

Each assembly has been assembled according to the manufacturers crimping standards.

*Image 1 – Crimping measurement check*

Two assemblies were constructed for each sleeve type allowing for the varying tests replicating the two most common field failures, pin hole and catastrophic hose burst.

**Pin Hole** - The first assembly in each test has had a 1mm hole drilled into one side of the hose to replicate a "large pin hole failure".

*Image 2 – Showing pin hole preparation on test sample*

**Hose failure** - The second assembly has had a small area ground down half way through the wall of the hose. This replicates the scenario of heavy wear upon the outer surface of the hose which may compromise the integral strength of the hose whilst under pressure. By pre testing the level of damage required to achieve failure at the desired 5000psi, we have been able to control the location of failure and direct the hose to fail.

*Image 3 – Showing wear damage preparation on test sample*

After each assembly has been prepared the appropriate sleeve has been attached for each test.

## 3. Test

Each test was conducted using a calibrated hose testing rig to AS1180.5 using ambient temperature water as the fluid medium.

All tests were conducted at a minimum pressure of 5000psi/345BAR and results recorded against each test.

*Image 4 – Showing calibrated test gauge reading*

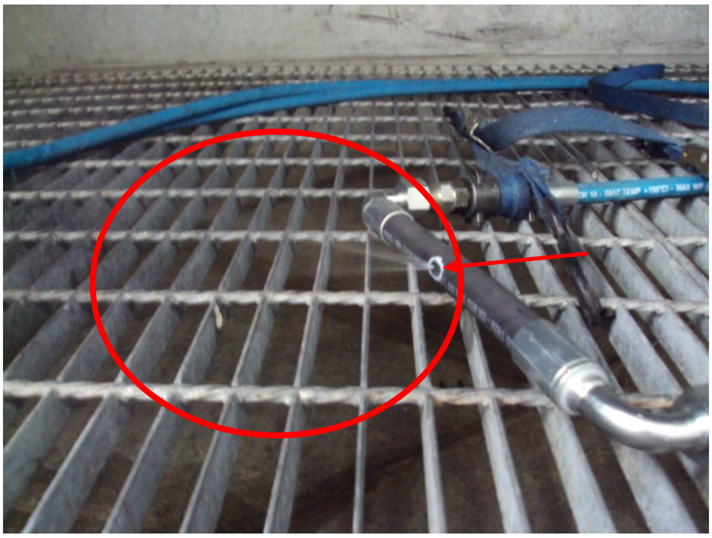

### 3.1 Pin Hole Tests

A control test was carried out using an assembly with no sleeve to confirm the spray pattern on an unprotected hose under this test condition.

Water initially flushed out of the hole at just a low pressure and as the pressure was increased, the speed and volume of escaping water increased.

This type of "spill spray" is considered very dangerous and hard to see and identify in working conditions.

*Image 5 – Showing pin hole spray pattern at 5000 PSI 345 bar*



The sleeves were tested in turn to ascertain the level of protection under the pin hole test.

**Sleeve sample type 1** – Sleeve contained the spray, allowing de-energised fluid to percolate the sleeve body, preventing any vigorous spray from spilling outwards. The volume of water has run along the length of the sleeve and formed slow drips through the material of the sleeve for the length of the test piece. The sleeve became saturated during the test.

**Sleeve sample type 2** – Sleeve contained the spray, allowing de-energised fluid to percolate the sleeve body, preventing any vigorous spray from spilling outwards. The volume of water has run along the length of the sleeve and formed slow drips through the material of the sleeve for the length of the test piece. The sleeve became saturated during the test.

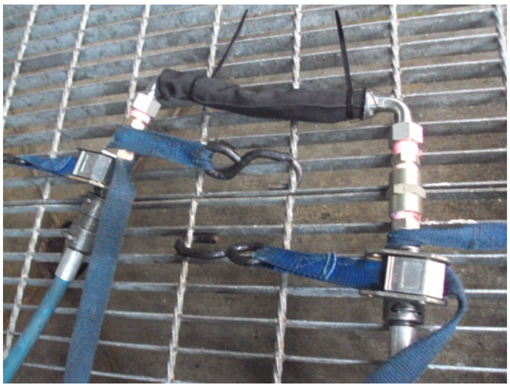
**Sleeve sample type 3** – Sleeve fully contained the spray and water has in turn slowly fed out the end of the sleeve near the test hose end.

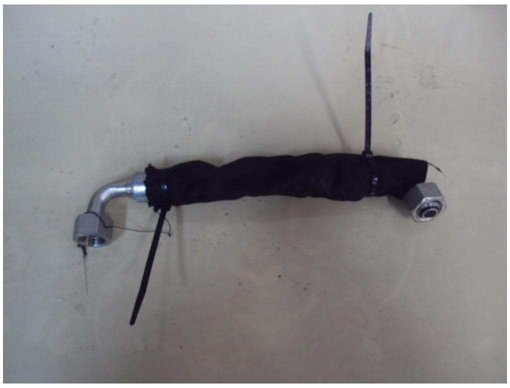
3.2 Burst Tests

**Sleeve sample type 1** –Hose burst was achieved Δ5250 PSI (360 Bar). The sleeve contained the majority of the spray from the failed hose. The sleeve suffered a small amount of tearing/stretching. This tearing however was minimal and has not created a complete hole in the material. The volume of water escaping the point of failure has run along the length of the sleeve and exited through each end of the sleeve. The sleeve became saturated during the test.

As a result the spray from the hose has been well contained within the sleeve.

*Image 6,7 & 8 – Showing test on sample type 1 and post test damage*





**Sleeve sample type 2** –Hose burst was achieved Δ5250 PSI (360 Bar). The sleeve contained the majority of the spray from the failed hose. The sleeve suffered a small amount of localised stretching to the material but this wear appears to be less severe than sleeve sample type 1.

This tearing however was minimal and has not created a complete hole in the material. The volume of water escaping the point of failure has run along the length of the sleeve and exited through each end of the sleeve. The sleeve became saturated during the test.

As a result the spray from the hose has been well contained within the sleeve.

*<u>Image 9,10 & 11 – Showing test on sample type 2 and post test damage</u>*

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**Sleeve sample type 3** –Hose burst was achieved Δ5250 PSI (360 Bar). The sleeve fully contained the spray from the failed hose. No tears or excessive stretching were visible in the area surrounding the hose failure. The fluid has been contained and forced to exit safely at low velocity through each end of the sleeve. The sleeve has remained dry on the outer surface.

As a result the spray from the hose has been well contained within the sleeve.

*Image 12,13 & 14 – Showing test on sample type 3 and lack of post test damage*

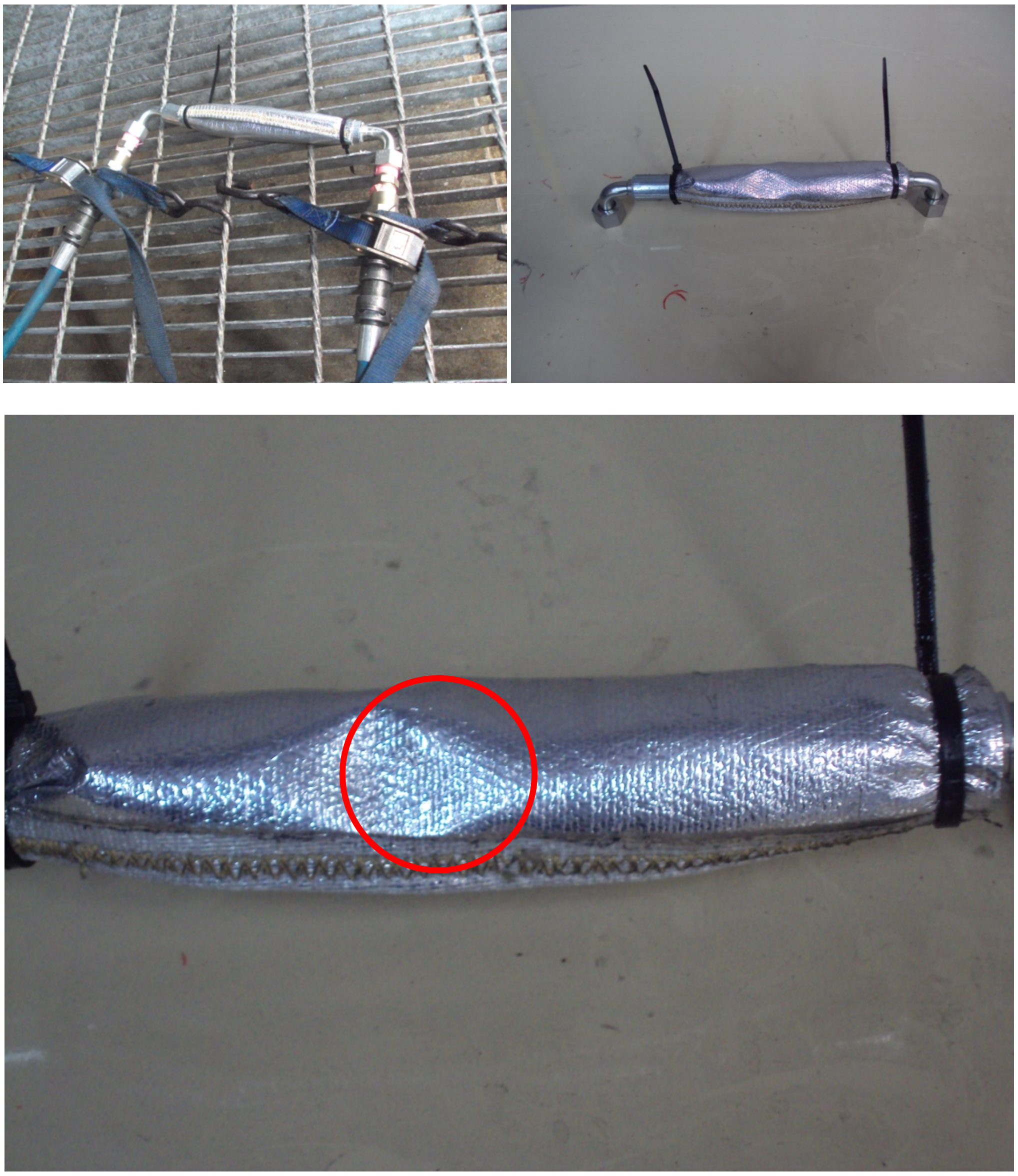
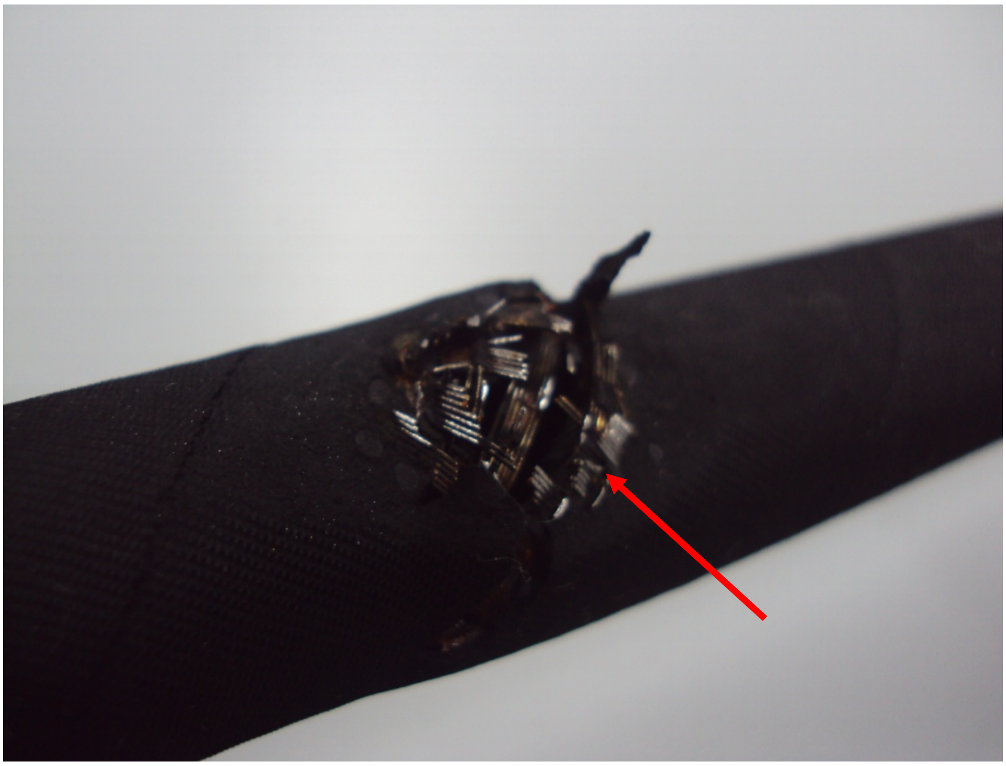


*Image 15 – Showing typical hose damage post burst test*



## 4. Conclusion

In conclusion, all three types of sleeve tested have successfully contained the spray experienced from both pin hole and catastrophic hose failure at minimum burst pressure range of 5000psi/344BAR to 5250psi/360BAR .

Sleeve sample 1 & 2 performed similar in nature due to their similar construction.

Sleeve sample 3 (Aluminised Kevlar Prototype Sleeve) out performed Sleeve samples 1 & 2 in that it successfully completely contained the explosive spray.

*Todd Hagarty*
*Technical Engineer - Alfagomma Australia*

# Hose Sleeve Heat Resistance Report

Date: 30/10/2012

Test conducted by: Todd Hagarty – Technical Engineer - Alfagomma Australia

## 1. Scope of the report

This test has been carried out to determine the heat protection and resistance properties of a range of three (3) protective hose sleeves when subjected to a steam of heated air supplied by an industrial heat gun.

This is to simulate the performance of these products in a heated environment as found in engine compartments, foundries and other high temperature areas of service

The protective hose sleeves tested are:

- Sleeve sample type 1 - Alfagomma brand Texsleeve
- Sleeve sample type 2 - Hiflex Powerguard brand protection sleeve
- Sleeve sample type 3 - Aluminised Kevlar Prototype Sleeve

## 2. Test method

- A 300mm length of Alfagomma brand Flexor 1SN –R1AT (12mm, 1/2”) was used in all test assemblies.
- 1 200mm length of 30mm sleeve of each sample type was used in all test assemblies.
- Heat was applied for a period of two (2) minutes using a Bosch industrial heat gun set at a temperature of 630$^{o}$C and maximum air speed (setting level III)
- The distance between the heat source and the test piece was measured carefully to duplicate exact test conditions in each test conducted.
- A calibrated laser guided infra red heat gun was used to measure surface temperatures of both the sleeve and hose covers on the test area immediately after the heat was withdrawn
- Ambient temperature at the time of testing was Δ24$^{o}$C

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*Image 1 – Showing test set up 100mm distance*


*Image 2 – Showing test set up 200mm distance*

## 3. Test results

**Test 1** – 100mm Un-sleeved test hose

- Surface temp 87.7$^{o}$C

**Test 2** – 100mm Sleeve sample type 1

- Surface temp of sleeve 204$^{o}$C
- Surface temp of hose 79.5$^{o}$C
- Hose sleeve melted at Δ50s test time

*Image 3 – Showing sleeve sample type 1 melting*

**Test 3** – 100mm Sleeve sample type 2

- Surface temp of sleeve 170.8$^{o}$C
- Surface temp of hose 117.1$^{o}$C
- Hose sleeve slightly shrunk and hardened as a result of testing

**Test 4** – 100mm Sleeve sample type 3

- Surface temp of sleeve 188.5$^{o}$C
- Surface temp of hose 83.4$^{o}$C
- Hose sleeve aluminised cover melted and Kevlar weave darkened on the outer surface only. Kevlar seemed unaffected by this change.

*Image 4 – Showing sleeve sample type 3 cover post testing*

*Image 5 – Showing sleeve samples post testing to 100mm*

**Test 5** – 200mm Unsleeved test hose

- Surface temp 72.3°C

**Test 6** – 200mm Sleeve sample type 1

- Surface temp of sleeve 102.2°C
- Surface temp of hose 64.9°C
- Hose sleeve slightly hardened as a result of testing

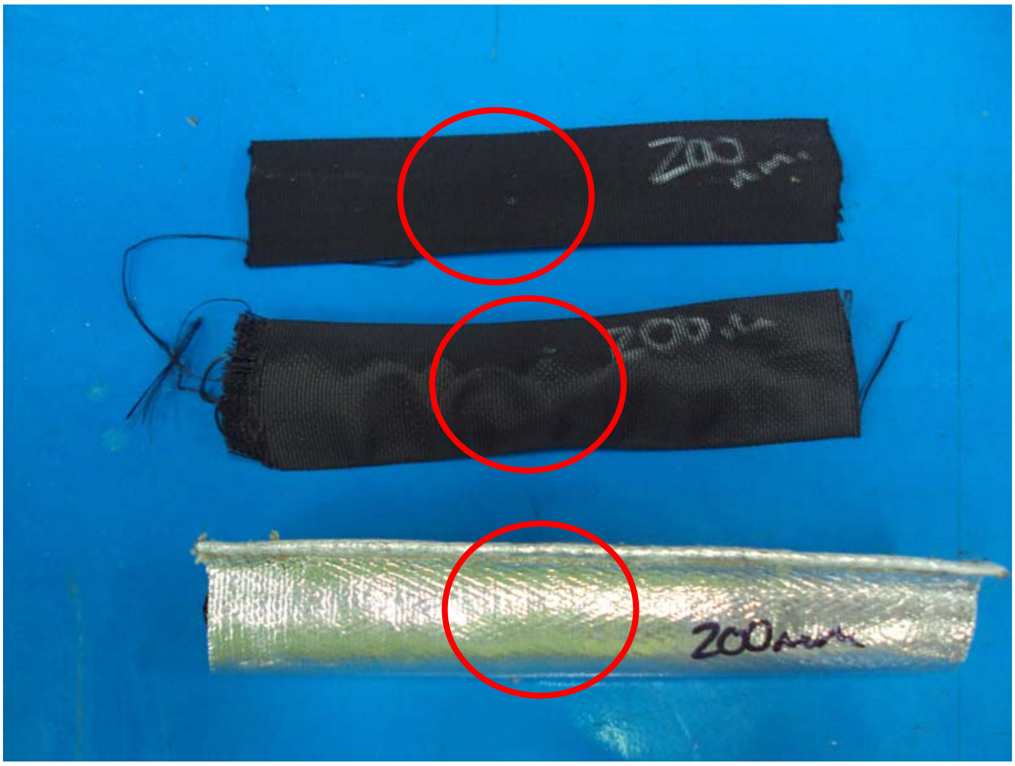
**Test 7** – 200mm Sleeve sample type 2

- Surface temp of sleeve 111.8°C
- Surface temp of hose 79.9°C
- Sleeve seemed unaffected by test

**Test 8** – 200mm Sleeve sample type 3

- Surface temp of sleeve 90.4°C
- Surface temp of hose 48.4°C
- Sleeve seemed unaffected by test

*Image 6 – Showing sleeve samples post testing to 200mm*



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## 4. Conclusion

Sleeve sample type 1 performed poorly in the 100mm test (test 2) and failed to provide any real protection having completely broken down during the test. In the 200mm test the sleeve provided some heat protection to the hose product within.

In both tests the sleeve sample type 2 product failed to offer any heat protection as it allowed the hose product to heat in excess of the control temperature. This is considered to be due to the fact the sleeve transferred some the heat to the hose product and that this could not be dissipated to open air cooling due to the sleeve covering. The failure of the sleeve sample type 1 in test 2 shows in evidence that the hose product will dissipate heat in the open air environment where the ambient temperature is less than the heat source. It is considered that the sleeve sample type 2 will remain structurally sound and keep a level of burst protection in heated environments.

In both tests sleeve sample 3 provided a level of heat protection to the hose product contained within, with the protection offered in the 200mm testing providing a very high level of heat protection.
It is expected that in an environment with elevated temperatures and radiant heat sources that the sleeve sample 3 (Aluminised Kevlar Prototype Sleeve) offers the greatest heat protection and it is considered that the sleeve sample type 3 will remain structurally sound and retain its burst protection properties.

*Todd Hagarty*
*Technical Engineer - Alfagomma Australia*


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NSW Resources Regulator

# Bulga Surface Operations

*Mine operators – From mine operators, the Resources Regulator seeks to understand the current use of HFDU and other fire-resistant fluids in mobile plant.*

1. **Are you currently using HFDU in mining plant?**

   No

2. **Are you currently using fire-resistant coolant?**

   No

3. **Are you using any other fire-resistant fluids?**

   No

4. **Why did you make the change or why haven't you made the change to fire-resistant fluids?**

   Bulga Surface Operations Lubricant Supplier does not have a HFDU product that is suitable for application in Surface mining equipment operation at high system pressures and high temperatures. Fuchs Lubricants, who are GCAA's contracted lubricant supplier has been engaged in a Global Research and Development Project since 2012 to formulate a HFDU for High Pressure and High Temperature system operating environments. To date a product has not been formulated that meets testing criteria. Fuchs have also communicated that by current estimates a HFDU would be 400% more expensive than mineral oil and will be more susceptible to degradation by moisture/water; pressure and high temperatures which causes oil oxidation.

   Fire Resistant Coolants – Bulga has not determined a requirement to move to a fire–resistant coolant based on incident data. Fire incidents with coolants as a source of fuel is have been investigated and the probability and consequence such incidents were very low. Some sites have laboratory tested lower percentage Glycol levels, with negligible improvements. Fire resistant coolants have not been recommended by OEM's and we are not aware of any product trials for validation of performance in surface mining environments i.e.: effect on cooling system components/materials, effect on engine materials; cooling efficiency etc.

   Other Fire-Resistant Fluids – Bulga has not determined a requirement to use other fire–resistant fluids from any fire incident investigation and through risk assessment results being low.

5. **What are the barriers to introducing fire-resistant fluids for mobile plant on mines?**

   Bulga Surface Operations barriers to introduction of are:

   - No validated safety case for change – Refer attached letter.
   - No HFDU product available on the market for high temp and high-pressure equipment systems
   - No HFDU product tested in mining operational conditions on equipment in NSW operations
   - No engineering analysis by OEM's on the effect of HFDU/Fire-resistant Coolants on plant componentry and the resultant financial change in the total cost of ownership of the asset.

- This estimated cost of the the HFDU product as a replacement to mineral oil will be 400% more expensive than current mineral oil used.

6. **If you have switched to HFDU, in some or all mobile plant, what was your experience in switching from mineral oil to HFDU or other substitutions that have been made.**

**6.1. Were there any issues with components, brakes, changes to the operations or safety of the plant?**

No change to HFDU made.

**6.2 Was cost a factor?**

Yes

**6.1.1. Are there additional costs associated with changeover and ongoing maintenance?**

**6.1.2. What is the cost of HFDU in comparison to mineral oil?**

This estimated cost of the the HFDU product as a replacement to engine oil will be 400% more expensive than current mineral oil used. Cost supplied by FUCHS Lubricants Glencore contracted supplier.

7. **Has the use of HFDU in mobile plants resulted in increased or decreased reliability of the plant?**

No change made.

8. **Were there any unintended consequences or new risks related to the introduction of fire-resistant fuels?**

Unknown until validation results are achieved through operation testing over the life cycle of componentry.

9. **What other fire reduction strategies do you have in place or are you considering implementing?**

Water jacketing:

- Bulga has no water jacketed engines on site.
- Retrofitting a water jacketed engine would need to be a readily available option from the OEM of the equipment, of which there is no current options.

Firewalls:

- Use of Barriers on excavators – between hydraulic pump rooms and engine bays.
- Turbo charger/exhaust manifold lagging.
- Double skinned exhaust boxes and exhaust pipes where possible/at component replacement.

Segregation Improvements:

- Hydraulic Hose segregation, clamping, rerouting to prevent hose rubbing and failure on equipment: on new equipment; post hose failure; shutdown events hose replacement as part of continuous improvement processes.

- MDG15 – compliance audits and maintenance of equipment to comply to Guideline
- MDG41 – hose testing/ hose tracking/ hose replacement schedules/hose audits/hoses sheathing

Maintenance Improvements:

- FMECA – Investigation on equipment failure events that lead to fire incident, to determine root Cause and Causal factors contributing incident. Recommendations and changes to Maintenance strategy to prevent or mitigate and reoccurrence of any fire incident if applicable.
- Implement strategy changes from hose audits.

14 September 2018

NSW Resources Regulator
Chief Compliance Officer

**By online submission**

Dear Sir/Madam,

**Re: Preventing Fires on Mobile Plant – Discussion Paper August 2018**

**Feedback Submission – Glencore - Bulga Surface Operations**

## Glencore

Glencore prides itself on its commitment to being an industry leader in Health Safety Environment and Community (HSEC) performance. We accept that the mining industry is a heavily regulated industry as a result of its potential HSEC impacts, however changes in regulation and policy should be underpinned by a number of key principles. These key principles include any changes in policy and regulation being evidence based and accurately costed.

## The Risk Based Approach

Extensive assessment is undertaken before any mobile equipment is introduced to operate at any of our sites as the health and safety of our personnel is paramount and a core value in our business. This assessment includes review against recognised standards and evaluation of the associated risks. The risk of fire forms part of these assessments at Bulga Surface Operations.

1. **Risks to Personnel** - Through Site Broad Brush Risk Assessment and Equipment Operational and Maintenance Risk Assessments, the risk to personnel is assessed. Risk to personnel resulting from equipment fire is mitigated through:
   a. Engineering controls incorporated in the design of the equipment. (i.e.) assessment against Mining Design Guideline (MDG) 15 and MDG 41;
   b. Failure Modes, Effects and Criticality Analysis (FMECA) – for each make and model of equipment to target failure modes and causal factors to develop appropriate maintenance and asset management strategies.
   c. Standards - Glencore through its engineering representatives was a major contributor in the development of AS 5062 -2006 - Fire Protection of Mobile and Transportable Equipment. The objective of this standard is to "formalise current good practice in reducing the incidence and severity of fires and to provide a consistent approach to fire risk reduction". Glencore believe that the adoption of this standard has contributed to reduction of fire incidence and severity of fires on mobile equipment.

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For and on behalf of the Bulga Joint Venture

d. Fire Systems – Design, installation and maintenance of on-board early fire detection and suppression systems on specific mobile plant; within Glencore these systems are designed to and have provided safe and orderly egress from equipment in the event of a fire incident;

e. Training - all relevant personnel are trained in the operation of mobile equipment fire detection and suppression systems fitted to plant; this forms part of all mobile equipment operator training plans; and,

f. Ongoing retraining and assessment of this competence.

2. **Personal Injury** – Bulga Surface Operations have had no recorded incidents where a mobile equipment fire has resulted in the injury of personnel.

3. **Equipment Loss** – In the 4 year period nominated (2014 to 2018), Bulga Surface Operations have not had a significant equipment loss incident relating to mobile equipment fires.

   If the above factors are considered as part of a risk-based approach to mobile equipment fires, and the requirements are specified, implemented and monitored correctly, the case for additional mitigation measures should not be required.

## Discussion Paper Data Observations

1. The Data Table used in New South Wales Resource Regulator (NSWRR) Discussion Paper (page 6) is not normalised, (i.e.) incidents per mobile equipment operating hour and comparison from year to year. Without normalisation of this data it is very difficult to draw conclusions regarding the relative split of incident and mine types.

2. The Data Table used in NSWRR Discussion paper does not normalise the number of machines or hydraulic capacity of equipment compared to other sectors. (i.e.) Open Cut mining equipment operates at higher hydraulic pressure and volume when compared to underground equipment and is operated in much greater numbers Machine type and category would also be relevant as part of analysis to determine any trends and to highlight equipment type.

   Equipment reliability predictions are one of the most common forms of reliability analysis, and are used to evaluate design and identify failure areas. Reliability predictions are based on failure rates, and are expressed as failures / million hours. We have calculated that at Bulga Surface Operations, mobile equipment has operated for approximately 1.86 million hours, in the period 2014 to 2018. Based on the NSWRR data there have been 315 fire incidents (Sept 2014 to June 2018), of these incidents 3 have occurred at Bulga Surface Operations. Using the engineering principle of reliability prediction, the failure rate is therefore 1.62 incidents/million hours (0.0000016 incidents/hour) or **Mean Time Between Failure** (MTBF) of 619,000 hours/ failure. With mobile plant operating at an average of approximately 5000 hours /year, this is an interval of one incident per 123 years. This failure rate is exceptionally low and is at a value of engineering tolerable risk where we would not normally apply any additional engineering controls and it is **As Low as Reasonably Practical** (ALARP).

3. Fires on Mobile Plant Vision – NSWRR have extrapolated the reduction of incidents in the graph (Page 7) on the basis of using temperature control and fire resistant fluid only, using the 2017 non-normalised data. This vision does not consider that there are other initiatives in progress that can address the causal factors of fire incidents and may be at least equivalent or more effective than the proposed mitigation measures or have better velocity to market.

4. Each incident of equipment fire will have a number of causal factors. Without understanding the specific causal factors/protection erosion factors of each incident, which can vary between equipment type and OEM model, a generalised investment for mobile equipment is not favourable.

5. The review of a single year of non-normalised data does not provide sufficient clarity to support the magnitude of mitigation measures proposed.

Bulga Surface Operations recommends a much more comprehensive review and analysis of the NSW incident and equipment data, which has been obtained by the NSWRR, and that this review when conducted is shared with all stakeholders prior to any further consultation on the future direction of fire prevention on mobile equipment.

## Existing Mitigation Measures

MDG15 *Mobile and Transportable Plant for Use on Mines and Petroleum Sites* was developed to improve the safety of surface mining equipment. Guidance in the document includes the requirement to segregate electrical and hydraulic lines, the securing of these lines and electrical circuit protection. These measures greatly minimise the risk of fire whilst also improving equipment reliability. Based on the data available to Glencore from the NSWRR (Quarterly Report April – June 2018 Page 5) there appears to be good performing sites who have had no or a low number of incidents, and other sites with multiple incidents.

However, as explained above this data is not been normalised to a failure rate common measure. From detailed data analysis, the insights gained would be to understand the key mitigations that are occurring at the good performing sites and compare them to the poor performing sites. Both in design and in maintenance.

The application of this MDG requirement adds significant cost to equipment procurement but clearly provides the benefits of reduction on fire incidents and reduces any fire consequence. MDG15 compliant equipment in use in NSW is different in specification to that used elsewhere in the world as a result. OEM's are recognising that this is world's best practice, and as a result we are seeing more OEM's adopting MDG15 principles into equipment engineering designs and factory equipment builds.

Similarly MDG41 *Guideline for Fluid Power System Safety at Mines* has been implemented across the NSW mining sector. Implementing the requirements of this guideline has increased the reliability of hydraulic hoses through correct hose selection, Quality Assurance (QA) of hose construction, hose life monitoring and hose sheathing. The application of this MDG is a financial investment that provides a greater level of safety for personnel working near hydraulic hoses and a reduction in hydraulic hose failures. Ultimately, implementing this guideline has resulted in a reduction in fire incidents where release of fluids from hydraulic hoses is a contributing factor.

Initiatives are undertaken, where practical, to reduce the maximum surface temperatures on mobile plant. Specifically, shielding of hot surfaces is undertaken where possible (i.e.) turbo lagging; double skinned exhaust housings etc.

In summary, significant initiatives have already been implemented to minimise the risk of fire on mobile equipment. These factors need to be recognised when considering any future mitigation measures, especially when compared to other Australian States and internationally.

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## Availability of Suitable Fire Resistant Hydraulic Fluids

In 2012 Glencore initiated a Global Research and Development Project with Fuchs Lubricants to develop fire resistant hydraulic (HFDU) oil product for use in mining equipment. Fuchs has developed an HFDU formulation for testing in mining equipment in high operating temperature/high pressure (450 Bar) systems. This product was submitted for testing by Bosch in Germany as recently as 2018.

Fuchs have communicated to Glencore that the formulation did not meet the Bosch testing criteria. If laboratory testing requirements are achieved, the product would then have to undergo extensive field operational testing and validation in the operational environment before release to the market. This would take some years.

Fuchs have advised Glencore that the fire resistant hydraulic oil product is susceptible to degradation through oxidation, the catalyst being pressure and heat in the operating environment. The oxidisation produces sludge and varnishes which damage equipment, reducing component life and increasing costs.

The development of a fire resistant hydraulic oil, which performs at the high pressure and high operating temperatures of mineral oil, is still to be achieved for the surface mobile plant application. Underground equipment operates at lower temperatures, and larger, higher pressure equipment is usually electric driven. Fuchs report that a major disadvantage of any current specification fire resistant hydraulic oil is a higher level of susceptibility to degradation via oxidation.

Fuchs have advised Glencore that the cost of a suitable fire resistant hydraulic oil if, and when developed, would be estimated to be 400% more to purchase and have a higher operating costs from increased machine degradation than the presently used mineral oil.

Fuchs Lubricants do manufacture a fire resistant HFDU product that is suitable for low pressure, low temperature applications such as steel mills and equipment with lower temperature and pressure operating specifications and environments.

## Availability of Surface Temperature Limited Options – High Power Engines

The major OEM's Glencore has contacted have all been engaged in some form of work in the area of limiting temperature of surfaces; some of these are the same OEM's for underground coal mobile equipment. If such a measure were mandated to the levels suggested, components would either have to be suitably shielded or double-skinned, or contained in a water jacket. Extensive design, production and testing work would need to be undertaken before any changes to equipment specification of the magnitude proposed are released commercially.

Where available, high horsepower marine engines specifically designed to operate at low temperatures have been used in mining application for many years. Glencore, have some in operation however these machines have not been immune to equipment fire incidents. Where engine bay area is limited, a marine style engine configuration may not physically fit and cooling systems to support such engines may require complete redesign. All these factors have an effect on equipment weight, weight distribution and mobile equipment productivities. Currently there is a limited appetite from the respective OEM's to undertake this work for specific engine applications for the NSW mining industry.

The comparison to underground coal equipment in the discussion paper is problematic as it effectively compares equipment of less than 300 HP engine power to surface engines of up to 4,000 HP. The challenge in these larger engines is that they are significantly more complex which can contribute to engine failure risks and maintainability issues, and will be more expensive to purchase and operate.

## Inappropriateness of a Regulated Approach

Glencore are heavily reliant upon the original equipment manufacturers (OEM's), equipment suppliers and fluid suppliers in the development and supply of information regarding the mitigation measures proposed in the discussion paper. Glencore has engaged with a number of companies to gauge the level of information readily available to calculate, estimate and verify any information on the proposed strategies.

Glencore highlights that there is limited options or no product information regarding suitable fire resistant hydraulic oil products and temperature limiting modification for external surfaces of mobile equipment engines.

Glencore recommends that validation for a regulated approach would include an evaluation of commercial competitiveness, equipment suitability, equipment availability, cost-benefit analysis and adverse unintended consequences of control solutions to be undertaken by mine operators to either use of fire resistant hydraulic oil or limit maximum temperature of engine/drivetrain components on mobile equipment used in the NSW mining industry.

**Commercial Competitiveness:** Any mitigation measures proposed need to be assessed for their commercial competitiveness such that costs of such products are not artificially inflated due to limited supply and market circumstances. The NSW mining industry needs to remain globally competitive; the cost of any legislative mandates/requirements need to be fully understood as will their effects on all the NSW stakeholders.

**Equipment Suitability:** Mobile diesel equipment must be fit-for-purpose for each specific operation's needs. Performance specifications, maintenance availability, reliability and maintainability are important considerations when purchasing mobile equipment. Equipment may be available to meet some specific requirements, however in the operational application if the requirements achieved are outweighed by the above mentioned functional and performance requirements, the equipment suitability criteria is not achieved.

**Adverse, Unintended Consequences of Control Solutions:** The proposed control measures are hypothetical and have not been tested and verified on equipment of this capacity and operating environments. The resulting effects of these measures are not known but may include increased equipment weight, changes to engine emissions, increased cooling package loading, increase in sound attenuation requirements, an increase in maintenance requirements, increased reliability issues and increased or new personnel safety hazards.

This valuation has clearly not been conducted at this time.

Glencore believe that there is considerable risk in drawing comparisons of technologies from other industry and environments and proposing them without any validation, particularly when these measures would significantly increase costs and could create unacceptable risks.

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## Conclusion and Recommendations

Bulga Surface Operations has actively considered, implemented and continues to investigate mitigation strategies to address fire hazards on mobile plant. These strategies include surface temperature control and the use of fire-resistant fluids. Given the evidence of this work and their findings, Bulga Surface Operations strongly believe a regulated approach is not appropriate.

However, from the data provided in the discussion paper and other NSWRR reports, there are areas of the industry that would benefit from education and guidance around leading practice in the mitigation and elimination of causal factors for fires on mobile plant. One such reference for designers and Operators is EMESRT Design Philosophy 4.

Bulga Surface Operations appreciates the opportunity to provide feedback and welcomes future consultation and involvement to improve industry performance. For information regarding our submission, please contact Tom Griffiths on 026570 2504 or 0448 325 670, tom.griffiths@glencore.com.au

Yours sincerely

Geoff Kelly
Operations Manager
Bulga Surface Operations
Glencore Coal Assets Australia

CEMENT CONCRETE
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14 September 2018

Anthony Keon
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Dear Anthony

**SUBMISSION: PREVENTING FIRES ON MOBILE PLANTS**

Thank you for the opportunity to comment on the discussion paper titled "Preventing Fires on Mobile Plants". CCAA appreciates the ongoing commitment to include the industry in these policy discussions.

CCAA is the peak body for the $15 billion heavy construction materials industry in Australia, comprising hard rock quarries, sand and gravel extraction sites, cement production and distribution facilities and concrete batching plants. We have over 90 members, accounting for 90% of total industry output and employing 110,000 Australians directly and indirectly.

Heavy construction materials are vital to delivering the infrastructure required to support the NSW population and economic growth. Without these materials we would not have our homes, schools, hospitals, roads and almost all aspects of the built environment that we depend on.

Ensuring the health and safety of workers and contractors is fundamental to our members. For this reason, they invest in a myriad of safety systems and approaches that seek to manage hazards in the workplace. In doing so, our members adopt a risk based approach that ensures workers are protected so far as is reasonably practicable when undertaking tasks in the workplace.

**CONCERNS WITH DATA**

CCAA considers that the rationale for action in relation to fires on mobile plants is currently lacking. This is because the problem definition has been poorly defined, largely due to deficiencies in the analysis of incident data provided in the discussion paper.

For example, the discussion paper uses incomparable datasets, equating 3.1 fire events per month over a seven year period, with 6.2 fire events per month over a more recent 2.5 year period. The time periods chosen here indicate that there has been sample bias in the way that the data has been selected and interrogated.

Additionally, there has been no effort to correlate incident data with production intensity. For example, an increase in incidents could correlate with increasing industry activity however, there has been no effort to investigate this causation in the discussion paper.

It would also be useful to better understand the nature of these incidents, the safety actions taken in response and if any injury was caused. This information is critical to our understanding of the impact of an incident and the appropriate actions required to prevent future incidents.

**OPERATIONAL CHALLENGES**

The priority for any intervention needs to be on managing risks in a proportionate way. Our members advise that synthetic anhydrous fluids (HFDU) and fire-resistant coolants/fluids are not generally used in mobile plants at quarries. This is due to a number of factors, including the cost and availability of these products, as well as its compatibility particularly with old equipment. CCAA members are concerned that a shift toward these controls would result in financial costs and technical challenges that may be difficult to overcome.

Conversely, CCAA members consider that the risks associated with fires on mobile plants are being sufficiently managed in quarries through investment in systems that prevent injury, such as fire suppression systems, computer based maintenance scheduling and emergency response planning.

**NEED FOR A RISK BASED APPROACH**

CCAA considers a one size fits all approach to be inappropriate in the case of fires on mobile plants. As outlined in the consultation paper, the risk to workers from coal based activities (both above and below ground) is higher than for other extractive activities. Given the lower risk profile for quarries, CCAA believes that a risk based approach should be taken, one that acknowledges the differing level of risk and requirements for preventive controls across the various sectors.

CCAA would not support a regulatory response to this issue, particularly given the lack of conclusive data to determine the extent of the problem and the technical challenges posed. We would however support guidance material that provides information to the different sectors on best practice solutions to reduce the risk of fires on mobile plants.

**CONCLUSION**

CCAA appreciates the ongoing and transparent nature with which the Resources Regulator engages in consultation and is grateful for the opportunity to comment on this paper.

I am happy to be contacted with regards to this submission and look forward to further engagement on this issue going forward.

Yours sincerely,

**MONIQUE ANDREW**
**State Director NSW**
**CEMENT CONCRETE & AGGREGATES AUSTRALIA**

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13 September 2018

Mr Anthony Keon
Chief Compliance Officer
Resources Regulator
516 High Street | Maitland NSW 2320
PO Box 344 HRMC NSW 2310

*Delivered by email: Anthony.Keon@planning.nsw.gov.au*

Dear Anthony

**RE: RESOURCE REGULATOR DISCUSSION PAPER – FIRES ON MOBILE PLANT**

We write in response to your correspondence of 5 August 2018, where you indicated fires on mobile plant has been identified as a compliance priority and fires in mining environments are potentially catastrophic events. In this correspondence you provided the "*NSW Resources Regulator Preventing Fires on Mobile Plant Discussion Paper August* 2018" (the Discussion Paper). You further identified the Discussion Paper was, in part, a first step in consultation regarding the usage of possible engineering and/or substitution mitigation strategies of fire resistant fluids and surface temperature controls.

The industry participants in which a response to the Discussion Paper is sought are Mine Operators, Original Equipment Manufacturers (OEM) and Manufacturers of Fire Resistant Fluids. However, due to the significance of the issues that arise, we take the opportunity to respond to the Discussion Paper for which comment is sought.

We commend the Regulator on the development of the Discussion Paper and the industry consultation process that, as a first step, has been embarked upon.

The identification and evaluation of causation factors in plant fires has been vital in being able to identify the existence of possible controls, both engineering and substitution, that will mitigate their occurrence.

We ask the Regulator to make available to the stakeholders in the industry as much of the submission response information as possible so informed decisions can be made about the effectiveness and the extent of the implementation of relevant engineering controls such as water jacketing and other surface temperature control methods, and the effectiveness and extent of utilisation of HFDU's and other fire resistant fuels.

The number of fires that have been occurring in the industry and the possibilities of the catastrophic outcomes make considerations of addressing these issues imperative.

We note the information sought through the Discussion Paper invites Mine Operators, OEM's and Manufacturers of Fire Resistant Fluids to provide the information but does not compel a response on this most important safety issue. We submit it is vital that the quality of information provided needs to be assessed. If the quality of that information is insufficient then, should the Regulator have open to it, responses should be compelled or the Regulator should commence its own direct analysis by undertaking a possible audit of the current rate of adoption of HFDU's and other fire resistant fuels where it is practical to do so. In addition there should be an audit of the current rate of adoption of water jacketing and other surface temperature control methods.

We submit that HFDU's and other fire resistant fuels should be mandatorily required to be used where they can be substituted for existing fuels or fluids. Even though we are unfamiliar with the current levels of adoption of these HSDU's and other fire resistant fuels in the industry, it is our understanding they are inadequate and will remain so without definitive action including requiring the same via regulation.

We do note one specific issue, one which our ISHR's have identified, which is that poor maintenance housekeeping is an important consideration where maintenance work has been undertaken and the fluids have not been sufficiently cleaned up at the conclusion of same. This leaves some porous materials liquid soaked, which has contributed to a heating and/or fire incident when the plant is put back into service. We ask that this type of issue not be forgotten in the consideration of the Discussion Paper responses and actions that the Regulator may require or suggest to the industry so as to reduce the occurrence of mobile plant fires on mining operations.

Yours faithfully

**PETER JORDAN**
**DISTRICT PRESIDENT**
**CFMMEU Northern Mining & NSW Energy District**

**ANDY HONEYSETT**
**DISTRICT PRESIDENT**
**United Mine Workers Union South Western District**

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13th September 2018

Chief Compliance Officer
New South Wales Resources Regulator
New South Wales Department of Planning and Environment

Re: **Preventing fires on mobile plant – Discussion paper August 2018**

Dear Sir/Madam,

The Construction and Mining Equipment Industry Group of Australia (CMEIG) has reviewed the New South Wales Resources Regulator's discussion paper (dated August 6th 2018), titled Preventing Fires on Mobile Plant[1].

In brief:

- CMEIG supports the Resources Regulator's efforts to continue dialogue on the topic of preventing fires on mobile plant. We also encourage the Resources Regulator to create a forum to collectively discuss this important topic in greater detail, such that the complexity of this topic can be given due consideration

- CMEIG has significant practicability concerns about a broad-brush approach to fire-resistant fluids and/or surface temperature control on all mobile plant operating in New South Wales mines. We also highlight the risk in taking such an approach, of proposing controls that involve inherent trade-offs, and may in themselves create additional hazards without addressing the root cause of fires on mobile plant

- CMEIG believes it may be pragmatic to normalise, and then analyse each fire incident, establishing the root cause on a case-by-case basis. Such analysis should consider the role of inspection, operation and maintenance practices, operator and maintainer training and experience, as well as the role of machine modifications.

We look forward to engaging further with the Resources Regulator. In the interim, we respectfully offer the following commentary for consideration.

### *Analysis of fire incident data*

CMEIG notes the reference to an average of 6.2 fire events per month reported between September 2014 and May 2017, in comparison to the stated data collected between 2001-2008 showing an average of 3.1 fires reported per month. To the extent the Resources Regulator has not already done so, we suggest that it would be prudent to consider this apparent increase in light of the following potential contributing factors:

- resource industry activity and cumulative active field population of mobile plant between 2001-2008, and between 2014-2017 (i.e. whether a higher field population and mining more tonnes may contribute to higher average fires reported per month)

- any differences in the approach to data collection and reporting between the two afore-mentioned time-frames

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[1] Preventing Fires on Mobile Plant Discussion paper August 2018, New South Wales Resources Regulator https://www.resourcesandgeoscience.nsw.gov.au/miners-and-explorers/safety-and-health/topics/fires-on-mobile-plant

- field population of types of machines relative to number of fires reported on each machine type (i.e. testing whether there are certain mobile plant types or applications or environments resulting in higher relative, and absolute fire incidence – this may then allow a more pragmatic, solution-oriented approach)

- age (and operating hours) of machines at the time of fire incident (i.e. understanding the role of an ageing fleet, extending service life in lieu of replacing dated machine fleets, and the role of extended maintenance intervals in the New South Wales mining downturn between 2014 and 2017).

CMEIG respectfully suggests that analysis of fire incident data should additionally consider:

- specific machine types and models represented in the fire incident data available to the regulator, and more importantly, in respect of which the equipment manufacturer may have (or can work) on case-by-case solutions

- analysis of the root cause of each fire event i.e. the role of potential contributing factors including:

    - inspection, operational, maintenance and 'housekeeping' practices inconsistent with those recommended by the original equipment manufacturer

    - contribution of machine modifications or configuration changes to that which was originally supplied or recommended by the original equipment manufacturer.

***Fire suppression systems***

While CMEIG acknowledges the Resources Regulator's previously stated position that mobile plant fire suppression systems are focused on minimising consequences of fires, rather than preventing fire occurrence, we urge that fire suppression systems continue to be considered an important part of the suite of controls to minimise risk of injury due to fires on mobile plant. We note fire suppression systems are relatively simple to implement in comparison to the proposals from the Resources Regulator, and query whether their effectiveness has contributed positively to current health and safety outcomes in the fire events observed by the Resources Regulator.

***Surface temperature control***

CMEIG notes the Resources Regulator's reference to surface temperature control. We understand this is referring to designing mobile plant engine systems with additional cooling capacity to control surface temperatures, including through the use of water cooled exhaust systems.

We emphasise that the design of complex machine systems requires consideration of a multitude of requirements such as safety, serviceability, maintainability, reliability, energy demands, and ultimately end user acceptance – the design process inherently involves the difficult task of balancing these various considerations. As such, we suggest due consideration be given to the following:

- mobile plant design and development is often an iteration to designs previously proven in use over an extended period of time (including from a safety critical control system (i.e. brakes, steering etc) perspective). Development activity typically limits content change in successive iterations to ensure safe, reliable products. Significant changes such as the proposed surface temperature control may compromise this approach, potentially introducing new and/or unforeseen risks

- mobile plant component selection is based on compatibility and suitability for the intended use. Please note that while we acknowledge the Resources Regulator's assertion that marine configurations of some engines used on mobile plant exist, we suggest that the following factors need to be considered:

    - some manufacturers of mobile plant are also engine and component manufacturers. In other cases, the manufacturers of a specific mobile plant may be an integrator relying on third-party suppliers of engines, powertrains, cooling systems and other components, all optimised to work together. Further, not all suppliers of components provide marine engine configurations

    - in many cases where marine configuration engines are available, they are typically not retrofittable for the engine models and engine configurations used on mobile plant in the mining environment. By way of example, marine engines differ in engine and turbocharger configurations, as well as in their ability to be integrated into mobile plant chassis and powertrains

- many marine configuration engines (particularly larger marine engines) are designed to be reliant on a captive body of water for cooling i.e. raw, cool water from the body of water on which the marine vessel is traversing, is either pumped through the marine engine block and expelled through the exhaust, or circulated through a heat exchanger and expelled from the vessel. The absence of a large body of cool water or the difficulty of rejecting heat to an external body of water may make the use of specially designed marine engines impracticable for mobile mining machines

- cooling systems on typical mobile plant in the mining environment are balanced to manage the temperature contribution of a number of fluid powered systems – hydraulic implements, brakes, steering, engine and other circuit cooling requirements to name a few. Scavenging the energy demands of these systems and still providing the required level of heat rejection raises the following issues:

    - including heat rejection from exhaust systems on mobile plant where thermal energy is currently dissipated to the environment through convection and radiation, would require significant cooling package size increases to heat exchangers and engine radiators

    - including the afore-mentioned heat rejection may require a larger engine package. This has carry-over effects to the design of the entire machine. By way of example, a larger engine package to provide surface temperature control will itself need further cooling, and constitutes greater space-claim and weight penalty to the machine structure, while producing lower performance in an overall larger machine dimension. Furthermore, where poor inspection and maintenance practices are a contributor to fires, the additional complexity and maintenance burden introduced in this example, and the potential for leakage of the increased volumes of circulating coolant, may actually increase the likelihood of a fire

- we note the engine and machine research and development, testing and validation likely required for surface temperature control may share similarities with activities undertaken by various manufacturers of mobile plant to achieve USA Environmental Protection Agency Tier 4 Nonroad Diesel Engine Emissions Levels

    - the afore-mentioned has collectively been a multi-billion-dollar investment for CMEIG members, involving extensive redesign of mobile plant. We also note that the technologies available to achieve lower engine emissions levels can require and/or result in higher surface temperatures. We therefore suggest that any efforts to address surface temperature controls at a regulatory level in New South Wales would require consultation with the New South Wales Environmental Protection Authority (currently proposing USA Tier 4 Nonroad Diesel Engine Emissions Levels in New South Wales surface coal mines) to ensure consistency of approach

    - the level of complexity and focused design (noting as mentioned previously, that this design focus would require trade-offs in various other aspects) would ideally need to be supported not just by the New South Wales Resources Regulator, but the broader Australian, and global earthmoving machinery markets. Where this is not supported globally, consideration should be given to the potential resulting costs impacts on that market

- we also note certain regions within New South Wales, including parts of the Hunter Valley have strict noise control requirements. Achieving these requirements typically requires extensive use of sound control methods and sound suppression material. Cooling systems (and in particular cooling fans) are commonly a significant contributor to noise emissions and the significant addition of heat rejection to cool exhaust components may be contrary to the strict noise control requirements. Sound suppression methods and material also have the potential to raise mobile plant under-hood surface temperatures, contrary to the Resource Regulator's stated objective.

***Comparing underground coal mobile plant with other mobile plant***

CMEIG notes the Resources Regulator's reference to the relatively low incidence of fires on mobile plant in the underground coal environment relative to all other mines. As noted by the Resources Regulator, diesel mobile plant for underground coal mines demonstrate certain characteristics including surface temperature control, and use of a number of explosion protection techniques. We note that these characteristics are primarily aimed at the potentially catastrophic risk profile due to ignition of specific coal types, rather than the lower risk profiles inherent in other mobile plant applications.

We suggest the following considerations are relevant:

- we query whether the lower incidence of fires on diesel engine mobile plant in underground coal mines is contributed to by:

    - a lower duty cycle for these machines (i.e. whether these machines are operated continuously over a typical shift or as support equipment, in comparison to other non-coal mobile plant that are primary production machines)
    - a lower population of these machines relative to other mobile plant resulting in lower incidence of fires
    - acceptance of lower performance and lower reliability for these machines in comparison to other mobile plant
    - relatively strict adherence in underground coal applications by end users, to original equipment manufacturer inspection and maintenance instructions due to the afore-mentioned explosion risk profile in underground coal mines

- expanding on what has been outlined previously, we note the different approach to diesel engine emissions and noise control requirements applicable to the underground coal environment

- we also note the relative simplicity and smaller size of diesel mobile plant in underground coal, including the use of simple, lower power engine packages versus those used in other mining applications. By way of example, we note that underground coal mobile plant engine power is typically around 250 hp or less. In comparison, underground non-coal machines can be upwards of 700 hp and surface mining machines can be upwards of 4000 hp. We suggest the cooling system sizing and heat rejection requirement for the latter two examples would be substantially greater than that which applies to the underground coal mobile plant example. We also note it is a common market expectation for the non-coal machines to sustain >85% typical availability rates.

***Fire-resistant fluids***

CMEIG suggests that consideration of the possible adoption of fire-resistant fluids should take the following into account:

- the relative cost of using these fluids in comparison to mineral oil. The discussion paper estimates the cost can be three to five times that of mineral oil. We suggest the overall cost and complexity of their use may increase further when considering the following:

    - availability of these fluids in the bulk quantities required for broad adoption by end users
    - fluid storage and management, particularly where different machine makes and models require incompatible fire-resistant fluid types

- the limited market interest to-date, to support their broad adoption on new machines/designs. There is limited knowledge of the impact of these fluids on seals, pumps, filters and other hydraulic system components, and the potential impact on safety related hydraulic systems such as brakes and steering. We suggest fire-resistant fluid usage may involve trade-offs in terms of:

    - fluid operating temperature range limitations (in some cases, operating temperature is limited to <60°C)
    - fluid operating life limitations (in some cases, as low as 5-20% of the lifetime of mineral oil)
    - need for frequent top-up to compensate for evaporative losses for some water-based fluids
    - need for frequent hydraulic system maintenance and filtration (i.e. some fire-resistant fluids demonstrate high levels of detergency)
    - accelerated wear of hydraulic systems components and in particular, Aluminium, rubber and plastic components (in some cases, this can result in a 50% reduction in component life)
    - hydraulic system performance reduction in comparison to mineral oils
    - different operating pressure requirements, and potential aeration and cavitation issues

- complexities in providing a unique solution for the New South Wales resources market:

    - retuning machine hydraulic systems to run fire-resistant fluids for one market relative to the willingness of other markets to adopt a similar approach

    - potential environmental impact and cost of purging mineral oil from those machines destined for the New South Wales Resources industry
    - managing the supply chain for fluid power components, to separate and purge mineral oil from hydraulic system components where these components are normally supplied 'wet' with mineral oil

- potential carcinogenic and health-related considerations in handling certain fire-resistant fluids

- not all fluids have fire-resistant substitutes (e.g. diesel, transmission oils, final drive and gear oils, engine oils, coolant etc.)

- fire-resistant hydraulic fluids still burn under certain conditions e.g. when in the form of an oil spray, or in the case of water-based fluids, when the water content evaporates

- not all fires are caused by fluids (e.g. electrical fires, tire fires)

- where maintenance and inspection issues are an underlying cause of fire, fire-resistant fluids may not (or perhaps only partially) address the issue. In conjunction with the afore-mentioned issues, the proposed approach may prove limited in effectiveness, and potentially even counterproductive.

***Summary***

In closing, the approach proposed in the Resources Regulator's discussion paper poses difficulties and concerns for reasons such as identified in this response. Instead, CMEIG suggests that a more targeted approach should be pursued. To that end, we would be pleased to engage in further discussions with the Resources Regulator and other concerned parties (i.e. machine users) to collectively review industry data in detail, discuss potential contributing factors, and then consider what additional measures, if any, could be implemented (or may already be implemented, or in the process of being implemented) to help further address those contributing factors.

We appreciate the Resources Regulator's consideration of this response and look forward to the opportunity to engage further.

Sincerely,

David Birrell
CEO – CMEIG

NSW Resources Regulator

# Drill Rigs Australia

*Email submission from Eddie Banner, General Manager, Drill Rigs Australia*

Drill rigs fit into the same category as mobile plant. Because of the extreme temperatures and high air pressures these machines operate under they are very susceptible to fires, which can be far more extreme because of the mixing of oil and high-pressure air atomization. i.e. Blown hoses fanning over engine turbos exhaust etc. Hydraulic hose rating, quality, age, clamping are of major concern on a lot of drill rigs.

NSW Resources Regulator

# Freudenberg

*Original Equipment Manufacturers – From Original Equipment Manufacturers, the Resources Regulator seeks to understand the specifications for the equipment in relation to the use of HFDUs and other fire-resistant fuels.*

1. **What HFDU/fire-resistant fuel ready plant is currently available for the Australian mining market?**
2. **How compatible is HFDU with currently operating mobile plant?**
3. **Can HFDU be directly substituted for mineral oil in currently operating mobile plant?**
4. **Is there currently any intention to implement surface temperature control design methods for mobile plant used on underground metalliferous mines and surface mines?**

   **4.1 What would be the cost difference of surface temperature-controlled vehicles compared with those currently used?**

   **4.2 Is it feasible to retrofit existing vehicles with surface control measures such as water jacketing and what would be the additional cost?**

5. **What consideration is given to the potential of fires on mobile plant in the design and engineering of mobile plant?**

   *"Potential for increased fire risk through un-monitored use of Diesel Exhaust Filters on mobile plant/specific risks in underground coal mines".*

   Executive Summary (full reply in separate document: Mobile Plant Fire Risks- DEF's

   - Increasing incidence of fires on mobile plant in NSW mines
   - Fires on mobile plant can occur when fluids interact with hot surfaces
   - Hottest part of mobile plant is exhaust
   - This communication relates to high temperature DEF's (Diesel Exhaust Filters) not low temperature DDEF's (Disposable Diesel Exhaust Filters)
   - Exhaust temperatures are higher on modern engines with DEF's (Diesel Exhaust Filters)
   - Exhaust temperatures increase when DEF's become blocked
   - All DEF's block over time

   **5.1 Could more be done in the design of mobile plant to eliminate the risk of fires?**

***"Potential for increased fire risk through un-monitored use of Diesel Exhaust Filters on mobile plant / specific risks in underground coal mines".***

*It has been noted in the NSW Resources Regulator discussion paper on preventing fires in mobile plant that incidence of fires has increased over time and that fires usually occur when fluids interact with hot surfaces.*

*The hottest part on diesel powered mobile plant is generally the exhaust system. Exhaust temperatures on diesel engines have increased over time as more sophisticated engine technology has allowed for more efficient combustion. Furthermore, the use of Diesel Exhaust Filters (DEF's) inherently increases exhaust restriction as particulate matter / ash is trapped. There is then a direct correlation between the restriction (system pressure) and exhaust temperature (and thus exhaust surface temperature).*

Low temperature Disposable Diesel Exhaust Filters (DDEF's) operate after temperature / flame / spark reduction scrubbers. All exhaust componentry pre scrubber is water-jacketed and regulated and robust controls exist to ensure surface temperatures cannot become elevated. This discussion focuses on high temperature DEF's.

High temperature DEF technologies are most commonly used in underground (non-coal) environments due to increased exhaust contaminant exposure risks, ever-stringent emissions legislation means they are also found across open-cut sites.

The use of high temperature DEF's on mobile plant has the potential to increase fire risk through;

1) Elevated exhaust temperatures / pressures over time.
2) Uncontrolled regeneration (oxidation) of particulate matter that has been trapped by the DEF.

The main materials used to make DEF's are ceramics like Silicon Carbide and Cordierite due to their high particulate filtering capabilities (Approximately 99% by mass). All rely on oxidation to convert soot to CO2 and H20, thus ensuring collected soot does not increase exhaust backpressure. If for some reason oxidation is not taking place (aging catalytic coatings / extended low duty cycle operation) , backpressure (and exhaust temperature) will rise. Even with effective oxidation taking place, lube oil ash that can't oxidise eventually plugs up DEF's, backpressure increases and cleaning is required. If this is monitored with an electronic backpressure / temperature logging device and protocols are in place to action system changes accordingly (i.e. stop the vehicle and perform maintenance), risk of increased backpressure leading to elevated surface temperatures is minimized.

In practice, logging systems are often poorly maintained (pressure lines blocked), disregarded by operators or absent altogether. Operators then frequently rely on machines being down on power as an indicator that DEF may be blocked. By this time exhaust backpressure can be enormous and likewise exhaust temperature. It is not uncommon that bodywork adjacent to blocked DEF's (and inlet pipework) is extremely hot and the general area is devoid of paint having burnt off from radiant heat. The area then represents a major ignition source for hydraulic fluids and/or other mediums. **It is recommended that fire prevention on mobile plant guidelines include a section on robust monitoring of DEF systems to ensure adjacent surface temperatures are not excessive.**

Outside the steady rise in backpressure / temperature over time as described above, all DEF's can have intermittent periods of uncontrolled regeneration where temperatures rise dramatically. This refers to when particulate matter and liquid phase hydrocarbons build up without oxidizing for a period of time and then when conditions are right, all oxidise at once. This could be due to an engine idling for an excessive period, not oxidizing soot. It could be due to a poorly maintained fuel system providing excessive diesel. It could be due to worn engine components allowing too much oil to pass through (and on to DEF). There are many and varied combinations of conditions that can lead to uncontrolled regeneration.

These events are easily seen when exhaust temperature is logged for extended periods on in-use vehicles. Short term temperature spikes can be seen, normally in conjunction with a high pressure condition which often then resolves after the high temperatures oxidise the soot / hydrocarbons. In many cases, the exhaust temperature at DEF outlet can raise a few hundred degrees higher and thus surface temperatures adjacent to DEF / exhaust raise accordingly. In extreme cases uncontrolled regeneration can cause temperatures high enough to melt the ceramic filter substrate (1000 degC +). **Again, regular monitoring of DEF systems is critical to ensure uncontrolled regeneration is not elevating exhaust / surface temperatures.**

One area of research that DEF manufacturers are looking in to is the potential for safe and effective use of high temperature ceramic DEF's in coal mining environments (moving away then from traditional Disposable DDEF's). The major concern here is that the uncontrolled regeneration phenomenon as listed above is magnified in the case of coal mining vehicle engines. Engine cylinder / exhaust temperatures are lower due to engines being de-rated so soot oxidation is slower. Coal mining vehicle duty cycles are also lower than non-coal, coal Loaders can spend half of their time idling. Water jacketing of DEF's / exhaust componentry further reduces exhaust temperature.

The potential for uncontrolled regeneration / elevated exhaust temperatures can then be far higher. The elevated surface temperatures being not only a potential ignition source for fugitive hydraulic (and other) fluids but also the far more dangerous coal dust and methane.

Water jacketing the DEF will certainly somewhat mitigate the elevated surface temperature risk but should an extreme uncontrolled regeneration occur, it may not be sufficient (acknowledging the 150 DegC surface limit in coal mines). To combat these risks some OEM,s have gone down the path of metal based partial flow DEF's rather than ceramic filters. These filter some of the particulate (50-70%) and remainder is then captured by a disposable filter element downstream (which then lasts longer in service). Whilst the risk is lower, the potential for catastrophic uncontrolled regeneration of partial flow filters still exists.

See figures 1-3 of partial flow DEF's that have undergone catastrophic uncontrolled regeneration below.

Fig. 1 Toyota Landcruiser Partial Flow DEF subject to catastrophic uncontrolled regeneration.

Fig. 2 Close up of where molten stainless steel sintered metal core has burnt through steel casing of DEF.

Fig. 3 Melted core of truck DEF after uncontrolled regeneration

To this point there is yet to exist a test regime that can assure with 100% certainty that an extreme uncontrolled regeneration event (which may occur once a year due to a combination of in-use conditions), will not result in an elevated surface temperature or other unsafe condition (eg molten ceramic). It is for this reason that MSHA (USA) make a clear distinction between high temperature DEF's being used in non-permissible (non-explosive) environments and low temperature Disposable DDEF's being used in permissible (explosive) environments.

NSW Resources Regulator

# FUCHS Lubricants

*Manufacturers of fire-resistant fluids – From manufacturers of fire-resistant fluids, the Resources Regulator seeks to understand:*

1. **What are the requirements for safely handling fire-resistant fluids?**

   Safety requirements will vary depending on the type of fire-resistant hydraulic fluid in question. The specific product SDS shall always be consulted for safety advice on how to handle any fluid. In direct reference to fire resistant hydraulic fluids (FRHF) type HFDU these products are typically classified as non-hazardous; eye contact should be avoided along with prolonged skin exposure and inhalation of oil mist.

2. **Are there potential health issues arising from handling fire-resistant fluids?**

   Once again, the health issues will depend on the type of FRHFs and the specific product. Generally, no specific health issues handling FRHFs type HFDU are expected relative to standard mineral oil based hydraulic fluids.

3. **What is the cost of HFDU in comparison to mineral oil?**

   Typical cost of FRHFs type HFDU relative to standard mineral oil products is 4:1. Additional operational costs may also be required including increased condition monitoring costs, potential reduction in fluid life due to pressure and/or temperature spikes or contamination and total life cycle costs of equipment if fluid is not managed appropriately.

4. **How is HFDU disposed of?**

   FRHF type HFDU are treated as standard oils when disposed of. Always use a licensed recycler or waste disposal contractor when disposing of the fluid.

5. **What are the environmental considerations for using HFDU?**

   Whilst FRHFs type HFDU are more susceptible to biodegradation relative to mineral oil-based products there is no specific environmental considerations recommended when using these fluids in place of mineral oil products.

NSW Resources Regulator

# Glencore Coal Assets Australia

*Mine operators – From mine operators, the Resources Regulator seeks to understand the current use of HFDU and other fire-resistant fluids in mobile plant.*

1. **Are you currently using HFDU in mining plant?**

   No

2. **Are you currently using fire-resistant coolant?**

   No

3. **Are you using any other fire-resistant fluids?**

   No, refer to response in Question 4.

4. **Why did you make the change or why haven't you made the change to fire-resistant fluids?**

   Glencore's Coal Assets Australia's (Glencore) Lubricant Supplier does not have a HFDU product that is suitable for the application in Surface mining equipment operation at High system pressures and high temperatures. Fuchs Lubricants who is GCAA's contracted lubricant supplier has been engaged in a Global Research and Development Project since 2012 to formulate a HFDU for High Pressure and High Temperature system operating environments. To date a product has not been formulated that meets the laboratory testing criteria. Fuchs have also communicated that current estimate is that it would be 400% more expensive that mineral oil and will be more susceptible to degradation by moisture/water; pressure and high temperatures which causes oil oxidation.

   Fire Resistant Coolants – Glencore has not determined a requirement to move to a fire-resistant coolant based on incident data. Fire incidents with coolants as a source of fuel is have been investigated and the probability and consequence such incidents were very low. Some sites have laboratory tested lower percentage Glycol levels, with negligible improvements. Fire resistant coolants have not been recommended by OEM's and we are not aware of any product trials for validation of performance in surface mining environments i.e.: effect on cooling system components/materials, effect on engine materials; cooling efficiency etc.

   Other Fire-Resistant Fluids – Glencore has not determined a requirement to use other fire–resistant fluids from any fire incident investigation and through risk assessment results being low.

5. **What are the barriers to introducing fire-resistant fluids for mobile plant on mines?**

   GCAA barriers to introduction of are:

   - No validated safety case for change
   - No validated financial case that supports change
   - No HFDU product available on the market for high temp and high-pressure equipment systems
   - No HFDU product tested in mining operational conditions on equipment in NSW operations

- No engineering analysis by OEM's on the effect of HFDU/Fire-resistant Coolants on plant componentry and the resultant financial change in the total cost of ownership of the asset.
- This estimated cost of the the HFDU product as a replacement to mineral oil will be 400% more expensive than current mineral oil used.

6. **If you have switched to HFDU, in some or all mobile plant, what was your experience in switching from mineral oil to HFDU or other substitutions that have been made.**

**6.1. Were there any issues with components, brakes, changes to the operations or safety of the plant?**

No change to HFDU made.

**6.2 Was cost a factor?**

Yes

**6.1.1. Are there additional costs associated with changeover and ongoing maintenance?**

**6.1.2. What is the cost of HFDU in comparison to mineral oil?**

This estimated cost of the the HFDU product as a replacement to engine oil will be 400% more expensive than current mineral oil used. Cost supplied by FUCHS Lubricants Glencore contracted supplier.

7. **Has the use of HFDU in mobile plants resulted in increased or decreased reliability of the plant?**

No change made. Information from Lubricant supplier/manufacturer is able to validate any product until it is developed, laboratory tested, validated through field testing in extreme operating environments.

8. **Were there any unintended consequences or new risks related to the introduction of fire-resistant fuels?**

Unknown until validation results are achieved through operation testing over the life cycle of componentry.

9. **What other fire reduction strategies do you have in place or are you considering implementing?**

Water jacketing:

- Glencore NSW sites operate 397 items of mobile plant over 5 complexes. We have approximately 19 x Trucks that have high horse power engines with water cool exhaust manifolds which the manufacturer provides for the marine industry.

Firewalls:

- Use of Barriers on excavators – between hydraulic pump rooms and engine bays.
- Turbo charger/exhaust manifold lagging – where possible.
- Double skinned exhaust boxes and exhaust pipes where possible/at component replacement.

Segregation Improvements:

- Hydraulic Hose segregation, clamping, rerouting to prevent hose rubbing and failure on equipment: on new equipment; post hose failure; shutdown events hose replacement as part of continuous improvement processes.
- MDG15 – compliance audits and maintenance of equipment to comply to Guideline
- MDG41 – hose testing/ hose tracking/ hose replacement schedules/ hose audits/hoses sheathing

Maintenance Improvements:

- FMECA – Investigation on equipment failure events that lead to fire incident, to determine root Cause and Causal factors contributing incident.  Recommendations and changes to Maintenance strategy to prevent or mitigate and reoccurrence of any fire incident if applicable.
- Implement strategy changes from hydrocarbon hose audits.

GLENCORE

12 September 2018

NSW Resources Regulator
Chief Compliance Officer

**By online submission**

Dear Sir/Madam,

**Re: Preventing Fires on Mobile Plant – Discussion Paper August 2018**

**Feedback Submission**

## Glencore

Glencore Coal Assets Australia Pty Limited (Glencore) is recognised as Australia's largest coal producer with 13 coalmining complexes across New South Wales (NSW) and Queensland. Our managed production in 2017 totalled 101.7Mt of quality thermal and coking coal for export via five key coal chains and ports.

Glencore is the largest coal producer in **NSW** with 8 mining complexes located in the Hunter Valley, Newcastle and the Western coalfields producing around 54Mt in 2017. Glencore is a significant contributor to the NSW economy and community and in 2017:

- employed over 4,784 on site personnel;
- contributed over $1.09 billion in wages, taxes and royalties;
- expended over $3.05 billion on goods and services and investment, and
- achieved strong safety, environmental and community performance.

Glencore prides itself on its commitment to being an industry leader in Health Safety Environment and Community (HSEC) performance. We accept that the mining industry is a heavily regulated industry as a result of its potential HSEC impacts, however changes in regulation and policy should be underpinned by a number of key principles. These key principles include any changes in policy and regulation being evidence based and accurately costed.

## The Risk Based Approach

Extensive assessment is undertaken before any mobile equipment is introduced to operate at any of our sites as the health and safety of our personnel is paramount and a core valve in our business. This assessment includes review against recognised standards and evaluation of the associated risks. The risk of fire forms part of these assessments at both our underground and open cut mines.

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T + 61 2 6570 2416 F + 61 2 6570 2520 www.glencore.com

Glencore Coal Assets Australia Pty Limited ACN 163 821 298

1. **Risks to Personnel** - Through Site Broad Brush Risk Assessment and Equipment Operational and Maintenance Risk Assessments, the risk to personnel is assessed. Risk to personnel resulting from equipment fire are mitigated through:

    a. Engineering controls incorporated in the design of the equipment. (i.e.) assessment against Mining Design Guideline (MDG) 15 and MDG41;

    b. Failure Modes, effects and Criticality Analysis (FMECA) – for each make and model of equipment to target failure modes and causal factors to develop appropriate maintenance and asset management strategies.

    c. Standards - Glencore through its engineering representatives was a major contributor in the development of AS 5062 -2006 - Fire Protection of Mobile and Transportable Equipment. The objective of this standard is to "formalise current good practice in reducing the incidence and severity of fires and to provide a consistent approach to fire risk reduction". Glencore believe that the adoption of this standard has contributed to reduction of fire incidence and severity of fires on mobile equipment.

    d. Fire Systems – Design, installation and maintenance of on-board early fire detection and suppression systems on specific mobile plant; within Glencore these systems are designed and have provided safe and orderly egress from equipment in the event of a fire incident;

    e. Training - all relevant personnel are trained in the operational procedure of mobile equipment fire detection and suppression systems fitted to plant; this forms part of all mobile equipment operator training plans; and,

    f. Retraining and assessment of the competence required in the operation of fire detection and suppression system occurs as part of formal site processes.

2. **Personal Injury** – Glencore Coal Assets Australia have had no recorded incidents where a mobile equipment fire has resulted in the injury of personnel.

3. **Equipment Loss** – Glencore fires incidents, in the 4 year period nominated (2014 to 2018), have not had a significant equipment loss incident relating to mobile equipment fires.

If the above factors are considered as part of a risk-based approach to mobile equipment fires, and the requirements are specified, implemented and monitored correctly, the case for additional mitigation measures should not be required.

## Discussion Paper Data Observations

1. The Data Table used in New South Wales Resource Regulator (NSWRR) Discussion Paper (page 6) is not normalised, (i.e.) incidents per mobile equipment operating hour and comparison from year to year. Without normalisation of this data it is very difficult to draw conclusions regarding the relative split of incident and mine types.

2. The Data Table used in NSWRR Discussion paper does not normalise the number of machines or hydraulic capacity of equipment compared to other sectors. (i.e.) Open Cut mining equipment operates at higher hydraulic pressure and volume when compared to underground equipment

and is operated in much greater numbers Machine type and category would also be relevant to as part of analysis to determine any tending to define equipment to be focused on.

Equipment reliability predictions are one of the most common forms of reliability analysis, and are used to evaluate design and identify failure areas. Reliability predictions are based on failure rates, and are expressed as failures / million hours. We have calculated that at the Glencore NSW sites, mobile equipment has operated for approximately 7.3 million hours, in the period 2014 to 2018. Based on the NSWRR data there have been 315 fire incidents (Sept 2014 to June 2018), of these incidents 18 have occurred a Glencore NSW sites. Using the engineering principle of reliability prediction, the failure rate is therefore 2.47 incidents/million hours (0.00000247 incidents/hour) or **Mean Time Between Failure** (MTBF) of 404,000 hours/ failure. With mobile plant operating at an average of approximately 5000 hours /year, this is an interval of one incident per 80 years. This failure rate is exceptionally low and is at a value of engineering tolerable risk where we would not normally apply any additional engineering controls and it is **As Low as Reasonably Practical** (ALARP).

3. Fires on Mobile Plant Vision – NSWRR have extrapolated the reduction of incidents in the graph (Page 7) on the basis of using temperature control and fire resistant fluid only, using the 2017 non-normalised data. This vision does not consider that there are other initiatives in progress that can address the casual factors of fire incidents and may be at least equivalent or more effective than the proposed mitigation measures or have better velocity to market.
4. Each incident of equipment fire will have a number of causal factors. Without understanding the specific causal factors/protection erosion factors of each incident, which can vary between equipment type and OEM model, a generalised investment for mobile equipment is not favourable.
5. The review of a single year of non-normalised data does not provide sufficient clarity to support the magnitude of mitigation measures proposed.

Glencore recommends a much more comprehensive review and analysis of the NSW incident and equipment data, which has been obtained by the NSWRR, and that this review when conducted is shared with all stakeholders prior to any further consultation on the future direction of fire prevention on mobile equipment.

## Existing Mitigation Measures

MDG15 *Mobile and Transportable Plant for Use on Mines and Petroleum Sites* was developed to improve the safety of surface mining equipment. Guidance in the document includes the requirement to segregate electrical and hydraulic lines, the securing of these lines and electrical circuit protection. These measures greatly minimise the risk of fire whilst also improving equipment reliability. Based on the data available to Glencore from the NSWRR (Quarterly Report April – June 2018 Page 5) there appears to be good performing sites who have had no or a low number of incidents, and other sites with multiple incidents.

However, as explained above this data is not been normalised to a failure rate common measure. From detailed data analysis, the insights gained would be to understand the key mitigations that are occurring at the good performing sites and compare them to the poor performing sites. Both in design and in maintenance.

A common industry approach at this level of comparison would provide identification and focus the application of the fundamental leading practice work that is required (i.e.) Implement well what we know works now and then look at the move to technologies. Without getting the baseline right, the move to technologies will have a less than adequate outcome and possibly provide unintended consequences.

Glencore proposes that engagement with global industry bodies such as the **Earth Moving Equipment Safety Round Table** (EMESRT) could assist in engaging all stakeholders to communicate leading practices and know erosion factors to improve identified poor performers.

The application of this MDG requirement adds significant cost to equipment procurement but clearly provides the benefits of reduction on fire incidents and mitigates any fire consequence. MDG15 compliant equipment in use in NSW is different in specification to that used elsewhere in the world as a result. OEM's are recognising that this is world's best practice, and as a result we are seeing more OEM's adopting MDG15 principles into equipment engineering designs and factory equipment builds.

Similarly MDG41 *Guideline for Fluid Power System Safety at Mines* has been implemented across the NSW mining sector. Implementing the requirements of this guideline has increased the reliability of hydraulic hoses through correct hose selection, Quality Assurance (QA) of hose construction, hose life monitoring and hose sheathing. The application of this MDG is a financial investment that provides a greater level of safety for personnel working near hydraulic hoses and a reduction in hydraulic hose failures. Ultimately, implementing this guideline has resulted in a reduction in fire incidents where release of fluids from hydraulic hoses is a contributing factor.

Initiatives are undertaken, where practical, to reduce the maximum surface temperatures on mobile plant. Specifically, shielding of hot surfaces is undertaken where possible (i.e.) turbo lagging; double skinned exhaust housings etc.

Glencore's mining sites' *licence to operate* conditions require the mobile equipment to be fitted with sound attenuation. One of the unwanted consequences of attenuation is heat accumulation, particularly in the engine bay which places a load on the cooling systems, which may lead to higher rates of hose degradation and higher failure rates. The higher operating temperature and environments has led to ongoing work to improve cooling and operating temperatures, in-house and with OEM's for these unique and specific circumstances.

In summary, significant initiatives have already been implemented to minimise the risk of fire on mobile equipment. These factors need to be recognised when considering any future mitigation measures, especially when compared to other Australian States and internationally.

## Availability of Suitable Fire Resistant Hydraulic Fluids

In 2012 Glencore initiated a Global Research and Development Project with Fuchs Lubricants to develop fire resistant hydraulic (HFDU) oil product for use in mining equipment. Fuchs has developed an HFDU formulation for testing in mining equipment in high operating temperature/high pressure (450 Bar) systems. This product was submitted for testing by Bosch in Germany as recently as 2018.

Fuchs have communicated to Glencore that the formulation did not meet the Bosch testing criteria. If laboratory testing requirements are achieved, the product would then have to undergo extensive field operational testing and validation in the operational environment before release to the market. This would take some years.

Fuchs have advised Glencore that the fire resistant hydraulic oil product is susceptible to degradation through oxidation, the catalyst being pressure and heat in the operating environment. The oxidisation produces sludge and varnishes which damage equipment, reducing component life and increasing costs.

The development of a fire resistant hydraulic oil, which performs at the high pressure and high operating temperatures mineral oil, is still to be achieved for the surface mobile plant application. Underground equipment operates at lower temperatures, and larger higher pressure equipment is usually electric driven. Fuchs report that a major disadvantage of any current specification fire resistant hydraulic oil is a higher level of susceptibility to degradation via oxidation..

Fuchs have advised Glencore that the cost of a suitable fire resistant hydraulic oil if, and when developed, would be estimated to be 400% more to purchase and have a higher operating costs from increased machine degradation than the presently used mineral oil.

Fuchs Lubricants do manufacture a fire resistant HFDU product that is suitable for low pressure, low temperature applications such as steel mills and equipment with lower temperature and pressure operating specifications and environments.

## Availability of Surface Temperature Limited Options – High Power Engines

The major OEM's Glencore has contacted have all been engaged in some form of work in the area of limiting temperature of surfaces; some of these are the same OEM's for the underground coal mobile equipment. If such a measure were mandated to the levels suggested components would either have to be suitably shielded or double-skinned, or contained in a water jacket. Extensive design, production and testing work would need to be undertaken before any changes to equipment specification of the magnitude proposed are released commercially.

Where available high horsepower marine engines specifically designed to operate at low temperatures have been used in mining application for many years. Glencore, have some in operation however these machines have not been immune to equipment fire incidents. This will add financial expense and therefore could be cost prohibitive. Where engine bay area is limited, the application of different engine configuration may not physically fit and cooling systems to support such engines may require complete redesign. All these factors have an effect on equipment weight, weight distribution, mobile equipment productivities and other unknown consequences. Currently there is a limited appetite from the respective OEM's to undertake this work for specific engine applications for the NSW Australia market mining industry.

The comparison to underground coal equipment in the discussion paper is problematic as it effectively compares equipment of less than 300 HP engine power to surface engines of up to 4000 HP. The challenge in these larger engines is significantly more complex, can contribute to engine failure risks and maintainability issues, and will be more expensive to purchase and operate.

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## Inappropriateness of a Regulated Approach

Glencore are heavily reliant upon the original equipment manufacturers (OEM's), equipment suppliers and fluid suppliers in the development and supply of information regarding the mitigation measures proposed in the discussion paper. Glencore has engaged with a number of companies to gauge the level of information readily available to calculate, estimate and verify any information on the proposed strategies.

Glencore highlights that there is limited options or no product information regarding suitable fire resistant hydraulic oil products and temperature limiting modification for external surfaces of mobile equipment engines.

Glencore recommends that validation for a regulated approach would include an evaluation of commercial competitiveness, equipment suitability, equipment availability, cost-benefit analysis and adverse unintended consequences of control solutions to be undertaken by mine operators to either use of fire resistant hydraulic oil or limit maximum temperature of engine/drivetrain components on mobile equipment used in the NSW mining industry.

**Commercial Competitiveness:** Any mitigation measures proposed need to be assessed for their commercial competitiveness such that costs of such products are not artificially inflated due to limited supply and market circumstances. The NSW mining industry needs to remain globally competitive; the cost of any legislative mandates/requirements need to be fully understood as will their effects on all the NSW stakeholders.

It is unclear which technologies may provide reduction in incidents and the costs associated with their implementation. Analysis of the costs to implement suitable technologies is required to be undertaken to verify the delivery of any positive cost-benefit.

**Equipment Suitability:** Mobile diesel equipment must be fit-for-purpose for each specific operation's needs. Performance specifications, maintenance availability, reliability and maintainability are important considerations when purchasing mobile equipment. Equipment may be available to meet some specific requirements, however in the operational application if the requirements achieved are outweighed by the above mentioned functional and performance requirements, the equipment suitability criteria is not achieved.

**Equipment Availability:** The availability of equipment technology on the global market. As discussed earlier a suitable fire resistant hydraulic oil is not yet available for use in the majority of surface mining equipment. Work is continuing but testing has revealed shortcomings in the products formulated to date.

Only a limited number of OEM's offer a temperature limited option for any of the high powered diesel equipment used in open cut mining.

**Adverse, Unintended Consequences of Control Solutions:** The proposed control measures are hypothetical and have not been tested and verified on the equipment of this capacity and in operating environments. The resulting effects of these measures are not known but may include increased equipment weight impacts, changes to engine emissions, increased cooling package loading, increase in sound attenuation requirements, an increase in maintenance requirements, increased reliability issues and increased or new personnel safety hazards.

This valuation has clearly not been conducted at this time.

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Glencore believe that there is considerable risk in drawing comparisons of technologies from other industry and environments and proposing them without any validation, particularly when these measures would significantly increase costs and could create unacceptable risks.

## Conclusion and Recommendations

Glencore has actively considered, implemented and continues to investigate mitigation strategies to address the fire incidents on mobile plant, such as surface temperature control and the use of fire-resistant fluids. Given the evidence of this work and their findings, Glencore strongly believe a regulated approach is not appropriate.

However, from the data provided in the discussion paper and other NSWRR reports, there are areas of the industry that would benefit from education and guidance around leading practice in the mitigation and elimination of causal factors for fires on mobile plant. One such reference for designers and users is EMESRT Design Philosophy 4.

As detailed in this submission, there has been significant effort put into this area and innovation has been developed and implemented in the industry, specifically directed at mobile equipment fires. Through addressing the key failure modes and causal factors, it is possible the same results will be achieved as technology is developed and validated through mobile equipment operational trials.

Glencore appreciates the opportunity to provide feedback and welcomes future consultation and involvement to improve industry performance. For information regarding our submission, please contact Tim Gray, Engineering Manager - Surface Operations – NSW, on 02 6570 2457 or 0429 701 565 tim.gray@glencore.com.au.

Yours sincerely

Stephen Hubert
General Manager
Glencore Coal Assets Australia

CC: Trevor Wells
Mark Winchester

NSW Resources Regulator

# Liebherr Mining

*Original Equipment Manufacturers – From Original Equipment Manufacturers, the Resources Regulator seeks to understand the specifications for the equipment in relation to the use of HFDUs and other fire-resistant fuels.*

1. **What HFDU/fire-resistant fuel ready plant is currently available for the Australian mining market?**

   The mining excavators and off-highway trucks proposed for sale by Liebherr-Mining in Australia are not currently offered as HFDU / fire-resistant fluid ready.

2. **How compatible is HFDU with currently operating mobile plant?**

   The hydraulic systems of currently operating Liebherr mining excavators and off-highway trucks are not compatible with HFDU / fire resistant fluids. Reasons for this include:

   - Risk of damage to some components e.g. seals as their material properties are not compatible with HFDU / fire-resistant fluids;
   - Incompatibility between the currently admissible pressure and temperature levels of HFDUs and those required for the operation of some hydraulic systems.

   As a consequence, if a machine were to be switched to an HFDU / fire-resistant fluid, then all components of its hydraulic system would need to be reviewed against the specific fluid, and many components would have to be completely redesigned to guarantee reliability and performance. For some of the diesel engines supplied to Liebherr for their mining plants, HFDU (ester fluid lubricant) would be suitable for the engine lubrication and would allow for an extended engine lifetime and an elongated lubricant exchange interval. It is however emphasized that these reported advantages are subject to further review by all of the suppliers of diesel engines, before a final statement can be made on the compatibility of HFDU / fire-resistant lubricants with diesel engines in general.

3. **Can HFDU be directly substituted for mineral oil in currently operating mobile plant?**

   For the reasons stated above (§ 2), Liebherr-Mining does not approve the direct substitution of HFDU in the hydraulic systems of their mining excavators and off-highway trucks. For the diesel engines these machines are fitted with, substitution of HFDU for mineral oil lubrication still requires further review by all of the suppliers of diesel engines.

4. **Is there currently any intention to implement surface temperature control design methods for mobile plant used on underground metalliferous mines and surface mines?**

   Liebherr-Mining have developed their own design guidelines for the surface temperature control of components within the engine compartment, including turbocharger, exhaust piping and other exhaust components. These guidelines include surface temperature performance requirements for the engine components and/or the other design measures used to accomplish thermal insulation of hot surfaces, such as covers and shielding. Thermal insulation of the exhaust system may include externally insulated exhaust piping components from the engine turbocharger or collector to the vehicle muffler.

**4.1 What would be the cost difference of surface temperature-controlled vehicles compared with those currently used?**

Approximately 5 to 10% of the engine price.

**4.2 Is it feasible to retrofit existing vehicles with surface control measures such as water jacketing and what would be the additional cost?**

Engines fitted in Liebherr-Mining plants are not currently available with water jacketing and a retrofit is not feasible. Water jacketing on an existing plant would require repowering with a new engine. Besides the new engine water jacketing would require a new cooling system with increased radiator capacity often not available on existing machines. The costs would be substantial. Water jacketing would also increase fuel consumption and $CO_2$ emission.

**5. What consideration is given to the potential of fires on mobile plant in the design and engineering of mobile plant?**

The engine compartment and the exhaust system are considered the main sources of fire ignition on Liebherr mining plants. Besides the design guidelines and measures mentioned in § 4, Liebherr-Mining have developed their own design guidelines for the design, selection and routing of hoses, pipes and their fittings of hydraulic systems.

Fire risk assessments are conducted for each type of machine. Fire scenarios are investigated and where necessary improvements are defined and implemented.

**5.1 Could more be done in the design of mobile plant to eliminate the risk of fires?**

Further reduction of fire risks can be achieved with electrically-powered mobile plants, as this technology allows for a great reduction of the amount of heat sources and flammable fluids. Liebherr-Mining markets a complete fleet of electrically-driven mining excavators which achieve a very high degree of fire safety.

NSW Resources Regulator

# Mt Owen

*Mine operators – From mine operators, the Resources Regulator seeks to understand the current use of HFDU and other fire-resistant fluids in mobile plant.*

1. **Are you currently using HFDU in mining plant?**

   No

2. **Are you currently using fire-resistant coolant?**

   No

3. **Are you using any other fire-resistant fluids?**

   No

4. **Why did you make the change or why haven't you made the change to fire-resistant fluids?**

   Mt Owen / Glendell Open Cut (MGO) Lubricant Supplier Fuchs does not currently have a HFDU product that is suitable for temperature or duty application in surface mining equipment. Fuchs Lubricants who is MGO's contracted lubricant supplier has been engaged in a Research and Development Project since 2012 to formulate a HFDU for High Pressure and High Temperature system operating environments. To date a product has not been formulated that meets the laboratory testing criteria.

   Fuchs have also communicated that the estimate for the supply of HFDU is 400% more expensive than mineral oil and will be more susceptible to degradation by moisture/water; pressure and high temperatures which causes oil oxidation.

   Fire Resistant Coolants – MGO has not determined a requirement to move to a fire–resistant coolant based on incident data. Fire resistant coolants have not been recommended by equipment manufactures and MGO is not aware of any product trials for validation of performance in surface mining environments.

5. **What are the barriers to introducing fire-resistant fluids for mobile plant on mines?**

   MGO barriers to the introduction of fire-resistant fluids are:

   - No validated safety case for change.
   - No validated financial case that supports change.
   - No HFDU product available on the market for high temp and high-pressure equipment systems.
   - No HFDU product tested in mining operational conditions on equipment in NSW operations.
   - No engineering analysis by OEM's on the effect of HFDU/Fire-resistant Coolants on plant componentry and the resultant financial change in the total cost of ownership of the asset.

- This estimated cost of the HFDU product as a replacement to mineral oil will be 400% more expensive than current mineral oil used.

6. **If you have switched to HFDU, in some or all mobile plant, what was your experience in switching from mineral oil to HFDU or other substitutions that have been made.**

**6.1. Were there any issues with components, brakes, changes to the operations or safety of the plant?**

No change to HFDU made.

**6.2 Was cost a factor?**

Yes

**6.1.1. Are there additional costs associated with changeover and ongoing maintenance?**

**6.1.2. What is the cost of HFDU in comparison to mineral oil?**

This estimated cost of the HFDU product as a replacement to hydraulic oil will be 400% more expensive than current mineral oil used. Cost supplied by FUCHS Lubricants.

7. **Has the use of HFDU in mobile plants resulted in increased or decreased reliability of the plant?**

No change made.

8. **Were there any unintended consequences or new risks related to the introduction of fire-resistant fuels?**

No change made.

9. **What other fire reduction strategies do you have in place or are you considering implementing?**

Water jacketing:

- MGO do not operate mobile plant with engine water jacketing systems

Firewalls:

- Use of Barriers on excavators – between hydraulic pump rooms and engine bays.
- Turbo charger/exhaust manifold lagging.
- Double skinned exhaust boxes and exhaust pipes where possible/at component replacement.

Surface Temperature Control Methods:

- Use of separation barriers on excavators and front-end loaders between hydraulic pump rooms and engine bays.
- Turbo charger/exhaust manifold lagging where necessitated through risk assessment.
- Double skinned exhaust system where necessitated through risk assessment.

Segregation Improvements:

- Hydraulic Hose segregation, clamping, routing to prevent hose failure on equipment: on new equipment; post hose failure; shutdown events hose replacement as part of continuous improvement processes.
- MDG15 – compliance audits during procurement and following major maintenance events.
- MDG41 – hose testing/ hose tracking/ hose replacement schedules/ hose audits/hoses sheathing.

Maintenance Improvements:

- FMECA – Investigation on equipment failure events that lead to fire incident, to determine root Cause and Causal factors contributing incident. Recommendations and changes to Maintenance strategy to prevent or mitigate and reoccurrence of any fire incident if applicable.
- Implement strategy changes from hydrocarbon hose audits.

MGO
MT OWEN / GLENDELL
GLENCORE

13 September 2018

NSW Resources Regulator
Chief Compliance Officer

**By online submission**

Dear Sir/Madam,

**Re: Preventing Fires on Mobile Plant – Discussion Paper August 2018**

**Feedback Submission**

## Risk Based Approach

Extensive assessment is undertaken before any mobile equipment is introduced to operate at Mt Owen Glendell Operations (MGO). This assessment includes review against recognised standards, industry incident records and evaluation of the inherent design risks. The risk of fire forms part of these assessments.

1. **Risks to Personnel** - Through MGO Mechanical Broad Brush Risk Assessment and Individual Equipment Operational and Maintenance Risk Assessments, the risk to personnel is assessed. Risk to personnel resulting from equipment fire are mitigated through:

   a. Engineering controls incorporated in the design of the equipment. (i.e.) assessment against Mining Design Guideline (MDG) 15 and MDG41;

   b. Failure Modes, Effects and Criticality Analysis (FMECA) – for each make and model of equipment to target failure modes and causal factors to develop appropriate maintenance and asset management strategies.

   c. Standards - Glencore through its engineering representatives was a major contributor in the development of AS 5062 -2008 - Fire Protection of Mobile and Transportable Equipment. The objective of this standard is to "formalise current good practice in reducing the incidence and severity of fires and to provide a consistent approach to fire risk reduction". MGO believe that the adoption of this standard has contributed to reduction of fire incidence and severity of fires on mobile equipment.

   d. Fire Systems – Design, installation and maintenance of on-board early fire detection and suppression systems on specific mobile plant;

   e. Training - all relevant personnel are trained in the operational procedure of mobile equipment fire detection and suppression systems fitted to plant; this forms part of all mobile equipment operator training plans; and,

   f. Retraining and assessment of the competence required in the operation of fire detection and suppression system occurs as part of formal site processes.

2. **Personal Injury** – MGO have had no recorded incidents where a mobile equipment fire has resulted in the injury of personnel.

3. **Equipment Loss** – MGO fires incidents, in the 4 year period nominated (2014 to 2018), have not had a significant equipment loss incident relating to mobile equipment fires.

If the above factors are considered as part of a risk-based approach to mobile equipment fires, and the requirements are specified, implemented and monitored correctly, the case for additional mitigation measures should not be required.

## Discussion Paper Data Observations

1. The Data Table used in New South Wales Resource Regulator (NSWRR) Discussion Paper (page 6) is not normalised, (i.e.) incidents per mobile equipment operating hour and comparison from year to year. Without normalisation of this data it is very difficult to draw conclusions regarding the relative split of incident and mine types.
2. The Data Table used in NSWRR Discussion paper does not normalise the number of machines or hydraulic capacity of equipment compared to other sectors. (i.e.) Open Cut mining equipment operates at higher hydraulic pressure and volume when compared to underground equipment and is operated in much greater numbers Machine type and category would also be relevant to as part of analysis to determine any tending to define equipment to be focused on.

   Equipment reliability predictions are one of the most common forms of reliability analysis, and are used to evaluate design and identify failure areas. Reliability predictions are based on failure rates, and are expressed as failures / million hours. We have calculated that at the MGO site, mobile equipment has operated for approximately 2 million hours, in the period 2014 to 2018. Based on the NSWRR data there have been 315 fire incidents (Sept 2014 to June 2018), of these incidents four (4) have occurred at MGO sites. Using the engineering principle of reliability prediction, the failure rate is therefore two (2) incidents / million hours (0.000002 incidents / hour) or **Mean Time Between Failure** (MTBF) of 500,000 hours / failure. With mobile plant operating at an average of approximately 5000 hours /year, this is an interval of one incident per 100 years.

   This failure rate is exceptionally low and is at a value of engineering tolerable risk where we would not normally apply any additional engineering controls and it is **As Low as Reasonably Practical** (ALARP).

3. Fires on Mobile Plant Vision – NSWRR have extrapolated the reduction of incidents in the graph (Page 7) on the basis of using temperature control and fire resistant fluid only, using the 2017 non-normalised data. This estimation does not consider that there are other initiatives in progress that can address the casual factors of fire incidents and may be at least equivalent or more effective than the proposed mitigation measures.
4. Each incident of equipment fire will have a number of causal factors. Without understanding the specific causal factors/protection erosion factors of each incident, which can vary between equipment type and OEM model, a generalised investment for mobile equipment is not favourable.
5. The review of a single year of non-normalised data does not provide sufficient clarity to support the magnitude of mitigation measures proposed.

MGO recommends a much more comprehensive review and analysis of the NSW incident and equipment data, which has been obtained by the NSWRR, and that this review when conducted is shared with all stakeholders prior to any further consultation on the future direction of fire prevention on mobile equipment.

GLENCORE

## Existing Mitigation Measures

MDG15 *Mobile and Transportable Plant for Use on Mines and Petroleum Sites* was developed to improve the safety of surface mining equipment. Guidance in the document includes the requirement to segregate electrical and hydraulic lines, the securing of these lines and electrical circuit protection. These measures greatly minimise the risk of fire whilst also improving equipment reliability. Based on the data available to Glencore from the NSWRR (Quarterly Report April – June 2018 Page 5) there appears to be good performing sites who have had no or a low number of incidents, and other sites with multiple incidents.

However, as explained above this data is not been normalised to a failure rate common measure. From detailed data analysis, the insights gained would be to understand the key mitigations that are occurring at the good performing sites and compare them to the poor performing sites.

The application of this MDG requirement adds significant cost to equipment procurement but clearly provides the benefits of reduction on fire incidents and mitigates any fire consequence. MDG15 compliant equipment in use in NSW is different in specification to that used elsewhere in the world as a result. OEM's are recognising that this is world's best practice, and as a result we are seeing more OEM's adopting MDG15 principles into equipment engineering designs and factory equipment builds.

Similarly MDG41 *Guideline for Fluid Power System Safety at Mines* has been implemented across the NSW mining sector. Implementing the requirements of this guideline has increased the reliability of hydraulic hoses through correct hose selection, Quality Assurance (QA) of hose construction, hose life monitoring and hose sheathing. The application of this MDG is a financial investment that provides a greater level of safety for personnel working near hydraulic hoses and a reduction in hydraulic hose failures. Ultimately, implementing this guideline has resulted in a reduction in fire incidents where release of fluids from hydraulic hoses is a contributing factor.

Initiatives are undertaken, where practical, to reduce the maximum surface temperatures on mobile plant. Specifically, shielding of hot surfaces is undertaken where possible (i.e.) turbo lagging; double skinned exhaust housings etc.

MGO environmental development consent conditions require the mobile equipment to be fitted with sound attenuation. One of the unwanted consequences of attenuation is heat accumulation, particularly in the engine bay, which places additional load on the cooling systems and can contribute to higher rates of hydraulic hose degradation.

In summary, significant initiatives have already been implemented to minimise the risk of fire on mobile equipment. These factors need to be recognised when considering any future mitigation measures, especially when compared to other Australian States and internationally.

## Availability of Suitable Fire Resistant Hydraulic Fluids

In 2012 Glencore initiated a Global Research and Development Project with Fuchs Lubricants to develop fire resistant hydraulic (HFDU) oil product for use in mining equipment. Fuchs has developed an HFDU formulation for testing in mining equipment in high operating temperature / high-pressure (450 Bar) systems. This product was submitted for testing by Bosch in Germany as recently as 2018.

Fuchs have communicated to Glencore that the formulation did not meet the Bosch testing criteria. If laboratory-testing requirements were achieved, the product would then have to undergo extensive field operational testing and validation in the operational environment before release to the market. This would take some years.

Fuchs have advised Glencore that the fire resistant hydraulic oil product is susceptible to degradation through oxidation, the catalyst being pressure and heat in the operating environment. The oxidisation produces sludge and varnishes that damage equipment, reducing component life and increasing costs.

The development of a fire resistant hydraulic oil, which performs at the high pressure and high operating temperatures mineral oil, is still to be achieved for the surface mobile plant application. Underground equipment operates at lower temperatures, and larger higher pressure equipment is usually electric driven. Fuchs report that a major disadvantage of any current specification fire resistant hydraulic oil is a higher level of susceptibility to degradation via oxidation.

Fuchs have advised Glencore that the cost of a suitable fire resistant hydraulic oil if, and when developed, would be estimated to be 400% more to purchase and have a higher operating costs from increased machine degradation than the presently used mineral oil.

Fuchs Lubricants do manufacture a fire resistant HFDU product that is suitable for low pressure, low temperature applications such as steel mills and equipment with lower temperature and pressure operating specifications and environments.

## Availability of Surface Temperature Limited Options – High Power Engines

The major OEM's Glencore has contacted have all been engaged in some form of work in the area of limiting surface temperatures; some of these are the same OEM's for the underground coal mobile equipment. If such a measure were mandated to the levels, suggested components would either have to be suitably shielded or double-skinned, or contained in a water jacket. Extensive design, production and testing work would need to be undertaken before any changes to equipment specification of the magnitude proposed are released commercially.

Where available high horsepower marine engines specifically designed to operate at low temperatures have been used in mining application for many years. Glencore, have some in operation however these machines have not been immune to equipment fire incidents. This will add financial expense and therefore could be cost prohibitive. Where engine bay area is limited, the application of different engine configuration may not physically fit and cooling systems to support such engines may require complete redesign. All these factors have an effect on equipment weight, weight distribution, mobile equipment productivities and other unknown consequences. Currently there is a limited appetite from the respective OEM's to undertake this work for specific engine applications for the NSW Australia market mining industry.

The comparison to underground coal equipment in the discussion paper is problematic as it effectively compares equipment of less than 300 HP engine power to surface engines of up to 4000 HP. The challenge in these larger engines is significantly more complex, can contribute to engine failure risks and maintainability issues, and will be more expensive to purchase and operate.

## Inappropriateness of a Regulated Approach

Glencore are heavily reliant upon the original equipment manufacturers (OEM's), equipment suppliers and fluid suppliers in the development and supply of information regarding the mitigation measures proposed in the discussion paper. Glencore has engaged with a number of companies to gauge the level of information readily available to calculate, estimate and verify any information on the proposed strategies.

Glencore highlights that there is limited options or no product information regarding suitable fire resistant hydraulic oil products and temperature limiting modification for external surfaces of mobile equipment engines.

Glencore recommends that validation for a regulated approach would include an evaluation of commercial competitiveness, equipment suitability, equipment availability, cost-benefit analysis and adverse unintended consequences of control solutions to be undertaken by mine operators to either use of fire resistant hydraulic oil or limit maximum temperature of engine/drivetrain components on mobile equipment used in the NSW mining industry.

**Commercial Competitiveness:** Any mitigation measures proposed need to be assessed for their commercial competitiveness such that costs of such products are not artificially inflated due to limited supply and market circumstances. The NSW mining industry needs to remain globally competitive; the cost of any legislative mandates/requirements need to be fully understood as will their effects on all the NSW stakeholders.

It is unclear which technologies may provide reduction in incidents and the costs associated with their implementation. Analysis of the costs to implement suitable technologies is required to be undertaken to verify the delivery of any positive cost-benefit.

**Equipment Suitability:** Mobile diesel equipment must be fit-for-purpose for each specific operation's needs. Performance specifications, maintenance availability, reliability and maintainability are important considerations when purchasing mobile equipment. Equipment may be available to meet some specific requirements, however in the operational application if the requirements achieved are outweighed by the above mentioned functional and performance requirements, the equipment suitability criteria is not achieved.

**Equipment Availability:** The availability of equipment technology on the global market. As discussed earlier a suitable fire resistant hydraulic oil is not yet available for use in the majority of surface mining equipment. Work is continuing but testing has revealed shortcomings in the products formulated to date.

Only a limited number of OEM's offer a temperature limited option for any of the high powered diesel equipment used in open cut mining.

**Adverse, Unintended Consequences of Control Solutions:** The proposed control measures are hypothetical and have not been tested and verified on the equipment of this capacity and in operating environments. The resulting effects of these measures are not known but may include increased equipment weight impacts, changes to engine emissions, increased cooling package loading, increase in sound attenuation requirements, an increase in maintenance requirements, increased reliability issues and increased or new personnel safety hazards.

This valuation has clearly not been conducted at this time.

Glencore believe that there is considerable risk in drawing comparisons of technologies from other industry and environments and proposing them without any validation, particularly when these measures would significantly increase costs and could create unacceptable risks.

## Conclusion and Recommendations

Mt Owen Glendell has actively considered, implemented and continues to investigate mitigation strategies to address the fire incidents on mobile plant, such as surface temperature control and the use of fire-resistant fluids. Given the evidence of this work and their findings, MGO strongly believe a regulated approach is not appropriate.

However, from the data provided in the discussion paper and other NSWRR reports, there are areas of the industry that would benefit from education and guidance around leading practice in the mitigation and elimination of causal factors for fires on mobile plant. One such reference for designers and users is EMESRT Design Philosophy 4.

As detailed in this submission, there has been significant effort put into this area and innovation has been developed and implemented in the industry, specifically directed at mobile equipment fires. Through addressing the key failure modes and causal factors, it is possible the same results will be achieved as technology is developed and validated through mobile equipment operational trials.

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# Discussion Paper: Preventing Fires on Mobile Plant

# NSW Minerals Council Submission

## Executive Summary

The Resources Regulator (the Regulator) has identified fires on mobile plant as a significant hazard in the New South Wales mining industry. In particular the higher rates of such fires in surface mines and underground metaliferous mines is the focus of the Regulator's proposals for change outlined in the Discussion Paper.

Safety is the minerals industry's highest priority. NSW Minerals Council's (NSWMC) members recognise that industry and the Regulator need to closely consider what can be done to address fires on mobile plant. Industry has already commenced a proactive approach to address this issue including working closely with Original Equipment Manufacturers (OEMs), engineering design experts and maintenance personnel to identify solutions to prevent the occurrence of fire on mobile plant.

The Discussion Paper contemplates the introduction of controls utilised in the underground coal mining environment, into underground metaliferous mines and surface mines, which have a significantly higher rate of fires on mobile plant than underground coal mines. The industry is concerned that introduction of these solutions could have a significant impacts on industry, without commensurate health and safety benefits. While this appears to be a shift away from outcomes-based regulation, there may be merit in exploring the application of these controls, and others, in the underground metalliferous and surface mining environments.

The controls suggested by the Regulator, fire resistant fluids and surface temperature control, present a series of health and safety, technical and financial challenges and limitations. Alternative methods of reducing fires on mobile plant are not considered.

The Discussion Paper provides a desktop analysis of the data on mobile plant fires and the proposed solutions of use of fire-resistant fluids and surface temperature control. However, given the complex nature and potential unintended consequences of making such changes, the Regulator should undertake an extensive research and consultation program in collaboration with industry before deciding on the appropriate approach to reducing mobile plant fires.

This should include conducting detailed analysis of data to provide a better understanding of the increase in fires on mobile plant, and detailed analysis of all potential solutions. This may necessitate conducting research through bodies such as the Australian Coal Association Research Program (ACARP) and obtaining technical engineering input. Collaboration with OEMs through forums such as the Earth Moving Equipment Safety Round Table (EMESRT) will be pivotal to developing solutions to preventing fires on mobile plant.

It is important that any proposed control is feasible, technically and financially, and will result in a demonstrated improvement to health and safety outcomes. In considering what is feasible, it is important to consider the nature of the environment in which the mobile plant is operating. Risks to workers from fires underground are higher than risks of fire on surface vehicles as more people are potentially exposed to the products of fire and there is a risk of explosion from volatile gases and coal dust. It is recognised that underground coal mining takes place in a high hazard environment and corresponding controls are utilised. The surface mining and metalliferous environments do not present the same hazards, and as such, may not warrant the same controls.

Industry members are engaged in a global research project that has been undertaken with a leading worldwide supplier of lubricants to develop a fire resistant HFDU fluid that would be suitable for use in equipment in surface mines. Current knowledge from reputable lubricant suppliers is that there is no HFDU product available that can be substituted for hydraulic mineral oil for high pressure and high temperature operating environments.

Considering the technologically unfeasible state of the controls proposed by the Regulator, industry strongly recommends that neither fire-resistant fluids nor surface temperature control be mandated. Rather than increasing safety, such mandates could create additional safety risks. However, industry recognises the importance of this issue and encourages the Regulator to continue striving for outcomes-based improvements in health and safety and looks forward to working collaboratively to investigate options to reduce the risk of fires on mobile plant.

## NSWMC Comments on the Discussion Paper

The Discussion Paper focuses on surface temperature control and the use of fire-resistant fluids as strategies to mitigate fire on mobile plant. NSWMC has sought technical input from member companies to identify the key challenges associated with the adoption of surface temperature controls and fire-resistant fluids. The key issues are set out below. Appendix A contains responses to the questions asked of mine operators in the Discussion Paper.

However the controls proposed by the Discussion paper are not the only strategies or initiatives available to prevent fire on mobile plant and as discussed in this submission there are significant practical and technical hurdles to implementing these controls outside of the underground coal mine setting.

Further consideration of other methods to limit the incidents of fire on mobile equipment should be considered by the Regulator in collaboration with the industry, particularly in the light of the different circumstances of underground coal and other mining operations.

### Frequency, causes, scale, hazard level and outcomes of fires on mobile plant

The figures in the Discussion Paper note that there was an average of 3.1 fires reported per month between 2001-2008, while reporting for 2018 shows an average rate of 8.4 fires per month. The Discussion Paper does not provide any analysis of the reasons for the increase. This should be the first step to understanding the problem that faces the regulator and the industry.

As a first step in a more detailed program of analysis and research, the Regulator should undertake a detailed breakdown of the incidents including an analysis of the frequencies (normalised by fleet numbers and equipment hours), causes, scale, hazard level (indicated by measures such as hydraulic oil capacity) and outcomes of incidents split across all sectors.

This will assist in understanding the hazard presented by the incidents. For example, if the fires reported are primarily small, short lived flames or embers where there is a low potential hazard and no injury, then the hazard is significantly reduced compared with a large, oil fuelled fire with a high potential hazard resulting in an injury.

This information is fundamental in conducting a detailed analysis of failure modes and causal factors that have initiated incidents.

The Regulator should consider any patterns that emerge through the analysis, including operations where fires are less frequent and interrogate how practices in those operations differ and what can be learnt from those operations about fire prevention that could be transferrable to other operations.

### Alternatives strategies for preventing and mitigating fire incidents on mobile plant

The industry's highest priority is the safety of personnel. Mine operators undertake detailed risk assessment to prevent and mitigate the risks of fires on mobile plant. A range of different focus areas are considered beyond surface temperature controls and fire-resistant fluids. Examples of initiatives undertaken include implementation of engineering controls such as those contained in *MDG 15 Guideline for mobile and transportable plant for use at mines (other than underground coal mines) 2017* and *MDG41 Fluid power system safety*.

*MDG 15 Guideline for mobile and transportable plant for use at mines (other than underground coal mines) 2017* was developed to improve the segregation and securing of electrical and hydraulic lines, as well as electrical circuit protection to prevent the incidence of fire whilst also improving equipment reliability. The application of this MDG regulation adds significant cost to equipment procurement and provides the benefits of reduction of fire incidents and mitigation of any fire consequences.

*MDG41 Fluid power system safety* has been implemented across the mining sector to increase reliability of pressure hoses through hose selection, quality assurance of hose construction and hose life monitoring and hose sheathing. The application of this MDG provides:

- Improved safety for personnel working near hoses
- Reduction in hose failures which leads to reduction in fire incidents where release of fluids is a contributing factor.

Monitoring hoses and hydraulic systems can be complex and in operational settings it can be nearly impossible to predict the failure point of a hose. Even close inspection does not always uncover potential failures. It is important that over reliance is not placed on inspection, but there is more of a focus on the manufacturer and qualitative aspects. A potential area of research for preventing fires on mobile plant is determining the predictive point at which a hose may indicate an imminent failure.

Collaborating with OEMs also provides a way in which to develop practical solutions. Mine operators have been working closely with OEMs, engineering design experts and maintenance personnel to identify solutions to prevent the occurrence of fire on mobile plant. The development of fire prevention strategies and trialling of various initiatives to fire ignition points on mobile plant (e.g installing barriers, dual skinned exhaust systems, engine turbo charger guarding/heat shields) are aimed at delivering fit for purpose solutions. Trials undertaken by mine operators of dual skinning have shown positive results to date. Such initiatives have already and will continue to result in a reduction in mobile plant fires without the need for prescriptive controls. In fact, a prescriptive approach may stifle innovative, better outcomes and cost-effective solutions.

The specific reasons and causal factors behind mobile plant fires will vary for each incident. Variations will arise between different equipment types and OEM models and operating environments. In light of this, a generalised requirement for mobile equipment as proposed in the Discussion Paper is not appropriate and mine operators support tailored solutions for the specific equipment being used, which should be considered by the Regulator.

### Important differences between underground coal mines and metalliferous and surface mines not fully considered by the Regulator

The Discussion Paper does not fully consider the important differences between underground and coal mines, surface and metalliferous mines. These differences need to be investigated when considering if it is feasible or beneficial to adopt controls that are successful in underground coal mines, or whether there may be better solutions for non-underground coal mines.

The drivers for higher levels of control are different in an underground coal mine. As noted in the Discussion Paper, fires on mobile plant in underground mines can be particularly dangerous. Risks to workers from fires underground are higher than risks of fire on surface vehicles as more people are potentially exposed to the products of fire. A fire in an underground coal environment has a significant difference to other underground or surface environments due to the potential risk of explosion from ignition of volatile gas mixtures and coal dust ignition. The maintenance of surface temperature controls in underground coal applications of less than 150 degrees Celsius targets the minimum ignition temperature of some specific coal types.

By contrast, in the surface mine context, mobile equipment has on board early detection and fire suppression systems. These improvements, installed on all mobile plant, allow safe and orderly egress from equipment and reduce fire incident risk to operators and other workers.

The mobile plant used underground compared to that used on the surface is different in scale. Underground equipment typically has less than 300 HP capacity compared to surface engines of up to over 4,000 HP capacity. The scale of surface equipment results in significantly different financial implications for the implementation of the proposed controls and adds complexity, engine risks and maintainability issues.

In addition, surface mining applications have some unique features not encountered in other hydraulic systems. Due to weight and space constraints lubricant storage capacity on mining equipment is limited. Pressures and duty cycles are also often quite high. As a result fluid turnover rates and operating temperatures are also higher than in many other applications. This makes surface mining equipment a more arduous application for lubricants and caution needs to be exercised when translating experience in other industries to mining applications.

In light of the different risks and mobile plant involved in underground coal mines compared to metalliferous mines and surface mines, it is not appropriate to simply adopt the underground coal mine requirements across the board without further analysis of feasibility, effectiveness and proportionality.

The different environments have different hazards and hence different consequences are applicable to each, requiring a different level of controls. Applying the underground coal requirements across the board would have significant impact on the viability of projects and result in some projects no longer being feasible. It is important that the Regulator work with the industry to understand the costs and benefits of proposed solutions.

## Impact on safety and performance of the Regulator's proposed controls

A number of major OEMs have limited lubricant approvals and in most cases the use of fire resistant-fluids would not be supported by these OEMs for use in current large mining equipment. Breaching OEM recommendations has impacts on warranties and potential safety and financial impacts.

Mining OEMs have not tested componentry while substituting HFDU for mineral oil, and component life will need to be validated if equipment is to operate with changed fluid specification. The use of fire-resistant fluids not approved by OEMs also poses performance and safety concerns, including braking, steering and hydraulic hoist systems under performance or failure.

Water/emulsion aqueous type fluids such as HFAS, HFAE, HFB and HFC should not operate above 65 degrees Celsius due to high vapour pressures and potential evaporative loss. This alone limits their applicability as many mobile hydraulic systems currently run well in excess of this temperature. At temperatures above 100 degrees Celsius water/emulsion aqueous type fluids HFAS, HFAE, HFB and HFC exhibit rapid increases in acidity and varnish potential. These varnish deposits are extremely detrimental to the control systems, valves and actuators and rapidly diminish machine performance. Aqueous based fluids require de-rating of the system making them less practical for use in mobile equipment.

Of the remaining fire-resistant fluids, HFDR fluids are the most fire resistant, however they are incompatible with nitrile seals/hoses meaning that they are not suitable for use in most existing mobile fleet systems. In addition there is also ongoing discussion on the toxicity of fumes from phosphate esters that would need to be considered.

As highlighted in the Discussion Paper, HFDU is 400% to 500% times more expensive than mineral oil. As an example of the potential cost implications, one mine operator estimated that the usage across their NSW operations is 1.5 million litres of hydraulic oil each year. Whilst there are claims that extended life may be achieved, that can only occur where the fluid is not contaminated or lost due to hose or other failures. As a result, the offset of any extended life to the increased cost incurred will not be a direct relationship.

In addition to increased running costs, there would be a significant financial impost in transitioning to fire-resistant fluids as mineral oil and HFDU fluids are not compatible. The transition would require equipment to be hydraulically disassembled to flush out the mineral oil. Premature failures are a likely outcome of any transition to HFDU oils. The consequences of using HFDU that is not suitable are failures that could cost in the range of hundreds of thousands of dollars for a single machine, and cumulatively millions of dollars over fleets of equipment.

Industry members are engaged in a global research project that has been undertaken with a leading worldwide supplier of lubricants to develop a fire resistant HFDU fluid that would be suitable for use in equipment on surface mines. Current knowledge from reputable lubricant suppliers is that there is no HFDU product available that can be substituted for hydraulic mineral oil for high pressure and high temperature operating environments.

Furthermore, as noted in the Discussion Paper there was only one fire incident in the underground coal sector in 2017. Mineral oil is used in equipment for the underground coal sector hence this highlights that the use of mineral oil is not causative of fires occurring on mobile plant. Any changes requiring the use of fire-resistant fluids would not have a tangible effect on safety.

Considering the above circumstances, mandating the use of HFDU is not technologically viable and NSWMC strongly recommends against it. There are no suitable products available, development time is unknown and it is not a commercially viable alternative.

### Unintended consequences of the Regulator's proposed approach

There is presently limited or no available information on the effects of a proposed regulated approach on surface temperature controls and fire-resistant fluids. It is important that an evaluation of commercial competitiveness, equipment suitability, equipment availability, cost-benefit analysis and adverse, unintended consequences of control solutions be undertaken.

Adverse, unintended consequences of control solutions as proposed control measures are hypothetical and have not been tested and verified on equipment of this capacity and in operating environments. The resulting effects of these measures are not known but may include increased equipment weight impacts, changes to engine emissions, increased cooling package loading, increase in sound attenuation requirements, increase in maintenance requirements, increased reliability issues and increased or new personnel safety hazards.

There is considerable risk in drawing comparisons of technologies from other industry and environments and proposing them without any validation. This would significantly increase costs and could create unacceptable risks.

## Conclusion and Recommendations

In light of the complexities in the ability to adopt surface temperature controls and the use of fire-resistant fluids a blanket regulatory approach to preventing fires on mobile plant is strongly not recommended. Rather than increase safety, implementing such requirement could create additional safety risks.

It is recommended that further analysis and work is undertaken with OEMs and mine operators to understand the causes of mobile plant fires and explore effective and practical solutions.

Detailed engineering input should be gathered through research bodies such as Australian Coal Association Research Program (ACARP). Forums such as the Earth Moving Equipment Safety Round Table (EMESRT) would be useful in progressing the prevention of fires on mobile plant. EMESRT involves member companies engaging with key mining industry OEMs to advance the design of equipment to improve safe operability and maintainability beyond Standards.

NSWMC appreciates the opportunity to provide feedback on the Discussion Paper and welcomes future involvement in any further development of this initiative. For information regarding our submission, please contact James Barben, Director Policy, on 02 9274 1431 or jbarben@nswmining.com.au.

## Appendix A

**Are you currently using HFDU in mining plant?**

Mine operators are not currently using HFDU in mining plant.

**Are you currently using fire-resistant coolant?**

Mine operators are not currently using fire-resistant coolant.

Whilst coolant is flammable is certain circumstances, the risk to people and assets is minimal and managed by the on-board fire suppression systems or hand-held fire extinguishers.

**Are you using any other fire-resistant fluids?**

Other fire-resistant fluids used include using:

- HFD-U oil
- Tap water with Donaldson coolant tablets instead of coolant in some heavy vehicles.

**Why did you make the change or why haven't you made the change to fire-resistant fluids?**

Reasons the change to fire-resistant fluids has not been made include:

- The cost of HFDU is up to 5 times greater than mineral based oils. Whilst there are claims that extended life may be achieved that can only occur where the fluid is not contaminated or lost due to hose or other failures. As a result the offset of any extended life to the increased cost incurred will not be a direct relationship.
- The equipment used in open cut mining has far more complex hydraulic circuits with larger volumes, greater flows and duty cycles. The impact HFDU oil has on component life in hydraulic excavators is currently unknown.
- OEM recommendations and warranty concerns. Failure to follow OEM recommendations can void warranties for equipment of significant value. A number of major OEMs have limited lubricant approvals and in most cases the use of fire-resistant fluids would not be supported by these OEMs for use in current large mining equipment.
- Performance concerns, with using lesser product. This is a safety and asset concern, which can create other performance-based risks including braking, steering and hydraulic hoist systems under performance.
- Inadequate real time study and evidence basis to utilise in change and risk assessment process.
- Focusing on other fire prevention areas. Fire is better controlled eliminating sources, from suppression and maintenance practices. Significant time and resources has been invested on fire prevention, including robust hose replacement and monitoring regimes.
- Water/emulsion aqueous type fluids such as HFAS, HFAE, HFB and HFC should not operate above 65 degrees Celsius due to high vapour pressures and potential evaporative loss. Of the remaining fire-resistant fluids, HFDR fluids are the most fire resistant, however they are incompatible with nitrile seals/hoses meaning that they are not suitable for use in most existing mobile fleet systems.

**What are the barriers to introducing fire-resistant fluids for mobile plant on mines?**

Barriers to introducing fire-resistant fluids for mobile plant on mines include:

- Potential detrimental health and safety impacts such as equipment failure and fumes
- Cost
- Equipment requirements and compatibility. Equipment is not designed to utilise fire-resistant fluids and would need to undergo major engineering design changes and component changes by the OEM to achieve this.
- Lack of supply available
- Lack of vendor options

**If you have switched to HFDU, in some or all mobile plant, what was your experience in switching from mineral oil to HFDU or other substitutions that have been made.**

- **Were there any issues with components, brakes, changes to the operations or safety of the plant?**
  - Component failures occur due to the incompatibility of additive packs in the oils. This causes the additives to drop out of the oil reducing the lubrication effect of the oil.
- **Was cost a factor?**
  - Are there additional costs associated with changeover and ongoing maintenance?

    Failure, flushing of fluids and disposal of hydrocarbon based oils. There are also concerns around supply continuity during the transition period if HFDU oils were to be mandated in open cut operations.
  - What is the cost of HFDU in comparison to mineral oil?

    4 to 5 times the cost with no history available on oil life comparison.
- **Has the use of HFDU in mobile plants resulted in increased or decreased reliability of the plant?**

  Not applicable
- **Were there any unintended consequences or new risks related to the introduction of fire-resistant fuels?**

  Not applicable

**What other fire reduction strategies do you have in place or are you considering implementing such as:**

- **Water jacketing**
  - Adoption of strategies would require a cost benefit analysis to be undertaken. Currently water jacketing is not available with engineering and manufacture being far too expensive for no benefit. The water jacket exhaust would potentially create a failure point for the engine, with the risk of failure of a 300T haul truck engine being $750,000.
  - The volume of water required for cooling to circulate through additional radiators would be extremely large and the radiators would be a size that would make them difficult to mount on most equipment.

The addition of further weight to equipment also reduces payload and adds significant cost to the operation and productivity of fleet.

- **Other surface temperature control methods**
  - Installing dual skin exhausts on engine with greater than 1000 hp and (where space allows) on equipment such as excavators and haul trucks. Recommend aligning the installation at the engine change out, based on current engine life this would be 3 years on excavators and up to 6 years on haul trucks.
  - Blankets to cover manifolds.
  - Turbo lagging.
  - Ceramic exhaust coatings, textile lagging or OEM heat shielding.

- **Segregation improvements**
  - Consideration is being given to sheaving of fuel and hydraulic hoses in the engine bay of smaller units such as dozers and small loaders.
  - Segregation of electrical harnesses and metal fuel/oil hoses.
  - Improved support and separation of known high risk hoses.

- **Maintenance improvements**
  - In conjunction with dual skin exhaust, consideration should be given to time-based thermography inspections to identify and manage potential flash points on the equipment.
  - Guidance on fire suppression system requirements would be useful. e.g. loss of pressure activation AFFF systems verses rise of pressure activation or fog maker systems.

- **Other**
  - Lagging of hot exhaust parts in engine bays (including turbos).
  - Detailed equipment maintenance strategies (inclusive of daily inspections).
  - Industry best practice on site oil analysis to predict component failures, subsequently reducing the risk of oil contacting hot surfaces.
  - Time based preventative hydraulic and fuel line change outs for hoses at risk of spraying oil/fuel on the hot side of the engine in the event the hose bursts.
  - Burst protection/flame retardant sheathing of specific high-risk hoses.
  - Improved support and separation of known high risk hoses.
  - Upgraded fuel system hardware including double braided fuel lines, fire resistant housings and hardware (steel or glass).
  - Relocation of header tanks on Volvo ITs to remove the risk of coolant contacting exhaust lagging.

NSW Resources Regulator

# PENSKE

*Original Equipment Manufacturers – From Original Equipment Manufacturers, the Resources Regulator seeks to understand the specifications for the equipment in relation to the use of HFDUs and other fire-resistant fuels.*

1. **What HFDU/fire-resistant fuel ready plant is currently available for the Australian mining market?**
2. **How compatible is HFDU with currently operating mobile plant?**
3. **Can HFDU be directly substituted for mineral oil in currently operating mobile plant?**
4. **Is there currently any intention to implement surface temperature control design methods for mobile plant used on underground metalliferous mines and surface mines?**

   Large engines (>750kW) are available with coolant cooled manifolds and turbochargers. These are limited. Other engines are available from the marine sector but are a significantly greater cost and would pose issues with cooling in such an environment.

   **4.1 What would be the cost difference of surface temperature-controlled vehicles compared with those currently used?**

   The engine cost is not the only factor as the cooling system must be increased to accommodate the additional cooling load. Est +50% increase in cost.

   **4.2 Is it feasible to retrofit existing vehicles with surface control measures such as water jacketing and what would be the additional cost?**

   Coolant jacketing is not feasible for retrofit. Our experience indicates that other controls would be a better option including correct maintenance of existing fluid couplings, hoses and pipes, installation and commissioning of fire suppression systems that are relevant to the engine installation, firesleeves on vulnerable equipment and specialist coatings on items such as exhaust manifolds.

   It must be noted that coolant jacketed systems place additional load into the cooling system and that retrofitted systems must make an allowance for this. Either additional coolers or a larger radiator or fan may be required.

5. **What consideration is given to the potential of fires on mobile plant in the design and engineering of mobile plant?**

   **5.1 Could more be done in the design of mobile plant to eliminate the risk of fires?**

# FIRES ON MOBILE PLANT

As a supplier of power systems for mobile plant both as standalone and repower modules our experience indicates that the best approach is to apply controls to the installation in the first instance and then to ensure maintenance of the plant longer term.

In many instances, hoses or piping are not maintained correctly with the correct specification or these components reach the end of life and are not replaced before a failure occurs.

Additionally, fire suppression equipment must be installed and commissioned correctly to suit the engine installation. This ensures that spray jets are directed at potential sources such as manifolds and turbochargers.

All of this must be checked and maintained regularly with scheduled inspections and tests of this type of equipment.

Depending on the installation and the engine involved, some additional protection can be included in the build of the engine such as fire sleeves on vulnerable components or specialist coatings on items such as exhaust manifolds.

As the paper suggests, exhaust lagging can absorb contaminants that may allow the spread of fire but our experience indicates that lagging can also reduce the life of exhaust components that may lead to leaks.

Noise suppression is also applied to equipment in many mines thereby increasing the risk of lagging coming into contact with such contaminants.

Whilst coolant jacketed manifolds and turbo chargers are available it is not something that is readily retrofitted and would be prohibitively expensive in this guise. Engines from our suppliers are available with this already fitted, however, the additional cooling capacity required combined with noise suppression and high ambient temperature conditions, potentially restrict the application of this to a small population of mines. The high cost of these engines above the standard engine is also a factor to be considered.

Whilst the paper acknowledges that substituting engine lubricating oils, diesel fuel and grease is not possible at this time it does mention that fire resistant coolant is available. At this stage there are no approved non-flammable coolants available for the engines we supply.

The use of coolants that are not approved may lead to engine failure.

NSW Resources Regulator

# PrixMax

*Manufacturers of fire-resistant fluids – From manufacturers of fire-resistant fluids, the Resources Regulator seeks to understand:*

1. **What are the requirements for safely handling fire-resistant fluids?**

   This will depend on the nature of the fluid, in particular, paying close regard to the Safety Data Sheet prepared by the manufacturer. PrixMax manufactures non-flammable, glycol-free engine coolants that are currently used by certain mine sites in Australia. There are no special requirements for handling our glycol-free engine coolants compared with other fluids.

2. **Are there potential health issues arising from handling fire-resistant fluids?**

   Again, this will depend on the nature of the fluid. For PrixMax's non-flammable engine coolants, there are no potential health issues arising from handling when used at the recommended treat rate.

3. **What is the cost of HFDU in comparison to mineral oil?**

   HFDU N/A for PrixMax.

   PrixMax's non-flammable engine coolants are significantly more cost effective (cheaper) than the traditional glycol-based engine coolants.

4. **How is HFDU disposed of?**

   HDFU N/A for PrixMax. PrixMax's non-flammable engine coolants offer greater scope for safe disposal given they do not contain ethylene glycol or other non-environmentally inhibitors or heavy metals.

5. **What are the environmental considerations for using HFDU?**

   N/A for PrixMax

13 September 2018

NSW Resources Regulator
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**BY EMAIL**

To the NSW Resources Regulator

**Re: Preventing Fires on Mobile Plant – Discussion Paper August 2018**

PrixMax Australia Pty Ltd (**PrixMax**) welcomes the recent discussion paper “Preventing Fires on Mobile Plant” published by the NSW Resources Regulator in August 2018 (**Discussion Paper**). It is a timely report, and one that addresses important considerations regarding the use of fire-resistant fluids in particular.

## 1. About PrixMax

PrixMax is a leading transport chemicals and engine coolants specialist group which manufactures and markets a range of products for all engine types including petrol, diesel, LPG and natural gas powered. The company operates from an ISO 9001 and ISO 14001 accredited manufacturing plant and state of the art laboratories in Dandenong South, Australia. PrixMax has a wide distribution network throughout Australia, New Zealand and Southeast Asia.

PrixMax specialises in global coolant solutions and is a recognised leader in the supply of engine coolants to the Australian mining industry. In 1996, PrixMax was the first 100% Australian owned coolant company to introduce Organic Additive Technology (OAT) coolants meeting key OEM specifications into the automotive, transport, oil & gas and mining industries in Australasia and Southeast Asia.

Through a focus on environmental sustainability and extended service performance in heavy duty engines in particular, PrixMax has distinguished itself as a leading supplier of glycol-free OAT coolant technology in the mining, oil & gas, power generation and heavy transport industries in temperate climates. PrixMax was also responsible for introducing the world’s first certified carbon neutral engine coolants in 2015. Relevantly for the present discussion, one of the key points of distinction with this technology is the fact that PrixMax’s glycol-free engine coolants are completely non-flammable.

## 2. Non-Flammable Coolants

PrixMax’s “RCP” glycol-free engine coolants are completely non-flammable, eliminating the fire hazard associated with glycol-containing antifreeze coolants. A recent PrixMax video on the advantages of the PrixMax water-based extended service coolant technology in heavy duty service where coolant related fires have been or could be an issue has been well received in the market. Pre-mixed antifreeze coolant (whether based on ethylene glycol or propylene glycol) represents a potential fire hazard in offshore oil & gas and mining operations in particular.

PrixMax laboratory testing has shown that under test conditions where the water is boiled off, the auto-ignition point of a pre-mixed glycol-based engine coolant is that of the relevant glycol base material (the auto-ignition temperature of ethylene glycol is 412°C, and propylene glycol is 371°C). In comparison, testing showed that PrixMax’s RCP coolants lack an auto-ignition point. Hot surfaces such as an exhaust manifold or turbocharger may reach temperatures well in excess of 412°C when under load, which can auto-ignite even the heaviest hydrocarbons found in the engine compartment.

We note the following extract from the Discussion Paper:

*While the surface temperature control to 150° Celsius targets ignition temperatures specific to underground coal mines, reduction of surface temperature to less than 150° Celsius may not be necessary to eliminate fires in underground metalliferous and surface mining applications. The vehicles involved in fire events reported to the Resources Regulator have typically involved dry exhaust systems that <u>operate up to or above 500° Celsius</u>.* (Emphasis added)

PrixMax testing showed that under these temperatures, glycol-based engine coolants will auto-ignite after the water has boiled off, whereas PrixMax's glycol-free engine coolants will not.

### 3. Relevant Experience

Since 1996, the PrixMax's glycol-free engine coolant technology has been successfully used in some of the largest mining sites in the Southern Hemisphere, including sites in the Pilbara, open-cut and underground sites in Queensland, coal mines in Indonesia, and gold mines in PNG. PrixMax's glycol-free coolants are also currently used in some of Australia's largest bus fleets,[1] as well as in applications on off-shore oil and gas rigs.

Where the requirement to protect against freezing temperatures is not a relevant concern (as is the case for most parts of Australia), the use of PrixMax's glycol-free engine coolants not only offers certain performance benefits (such as better heat transfer capacity), but also eliminates coolant-related fire hazards and has significant cost, environmental and safety benefits.

### 4. Conclusion

The Discussion Paper is a timely one, and raises some important issues regarding mine safety and the potential for eliminating certain fluid-related fire hazards on mine sites.

For many years now, PrixMax has taken a lead in promoting the benefits of non-flammable engine coolants in the Australian mining, oil and gas, and transport industries in particular. The fact is that there are non-flammable coolant alternatives available from PrixMax in the Australian market that have demonstrated significant success for many years when replacing the traditional glycol-based technologies.

PrixMax is encouraged by the fact that these alternatives are now increasingly being considered by mining operators in the industry. Although the stance of particular OEMs may represent a barrier to introducing non-flammable engine coolants for plant on mines, many OEMs do in fact recognise that there are performance, safety and environmental benefits to using glycol-free or "treated water" engine coolants where freeze protection is not required. It is simply not a standard recommendation given that most of the OEMs are based in the Northern Hemisphere where freeze protection is required.

From PrixMax's perspective, all of our customers that have introduced our non-flammable engine coolants into their operations have not only found improvements in performance, longevity and safety, but – and this is undoubtedly one of the key reasons for mining operators switching to this coolant technology – the cost benefits of doing so are very significant given the expense of ethylene glycol and propylene glycol as raw materials. Compatibility with other coolant technologies is also not an issue, and has been regularly demonstrated by PrixMax via laboratory testing according to standard compatibility test methods.

We believe it is simply a matter of increasing education on this matter for coolants in particular. Glycol-free engine coolants such as those manufactured by PrixMax not only eliminate coolant-related fire hazards, but are also (1) safer from an environmental, disposal and handling perspective, (2) better from a heat transfer perspective, and (3) significantly more cost effective than glycol-based alternatives.

PrixMax will follow the discussion around preventing mobile plant fires on mines with great interest, and hope that regulators in other Australian States and Territories consider joining the discussion. For more information, or should you wish to discuss further, please do not hesitate to contact me on [redacted]

Yours sincerely,

[redacted]

[1] Investigations into various bus fires have shown that ethylene glycol-based engine coolants can ignite in circumstances where the glycol impregnates other materials such as lagging or shielding and is then exposed to the combination of a heat source and air (see, for example, this report from the Office of Transport Safety Investigations (OTSI)).

NSW Resources Regulator

# Quaker Houghton

*Mine operators – From mine operators, the Resources Regulator seeks to understand the current use of HFDU and other fire-resistant fluids in mobile plant.*

1. **Are you currently using HFDU in mining plant?**

   No

2. **Are you currently using fire-resistant coolant?**

   No

3. **Are you using any other fire-resistant fluids?**

   No. Quaker chemical is the leading supplier of HFDU fluids globally. We have over 50,000 hydraulic units operating on our Quintolubric HFDU fire resistant fluids globally in both stationary and mobile plant. Mobile plant around hot areas of primary metal processing plants were the first mobile plant to use HFDU fluids over 40yrs ago.

4. **Why did you make the change or why haven't you made the change to fire-resistant fluids?**

   The main drivers of change have been fatalities, near miss incidents and operational security risk.

5. **What are the barriers to introducing fire-resistant fluids for mobile plant on mines?**

   Equipment OEM approval/support and Cost are often key considerations.

6. **If you have switched to HFDU, in some or all mobile plant, what was your experience in switching from mineral oil to HFDU or other substitutions that have been made.**

   **6.1. Were there any issues with components, brakes, changes to the operations or safety of the plant?**

   **6.2 Was cost a factor?**

   Yes

   **6.1.1. Are there additional costs associated with changeover and ongoing maintenance?**

   **6.1.2. What is the cost of HFDU in comparison to mineral oil?**

   The cost is typically 3-5x depending on pack size, order volumes, and location/logistics costs.

7. **Has the use of HFDU in mobile plants resulted in increased or decreased reliability of the plant?**

   Reliability experience in the primary metal industry is very good.

8. **Were there any unintended consequences or new risks related to the introduction of fire-resistant fuels?**

   Drain intervals may need to be shortened for very small volume hydraulic systems or ones that operate at high temperatures.

9. **What other fire reduction strategies do you have in place or are you considering implementing?**

   It is important to note that removing the risk of ignition is key to improving safety. Strategies that involve mitigating the effect of ignition (e.g. fire suppression systems) pose higher risk than rendering the system inherently fire resistant with the use of fire-resistant fluids or the removal of the ignition source as a fire once ignited can behave in unpredictable manner. For example, if grease residues are present a fire could be difficult to extinguish.

*Original Equipment Manufacturers – From Original Equipment Manufacturers, the Resources Regulator seeks to understand the specifications for the equipment in relation to the use of HFDUs and other fire-resistant fuels.*

1. **What HFDU/fire-resistant fuel ready plant is currently available for the Australian mining market?**

   Most systems operating on mineral oil based hydraulic fluids can operate on HFDU

2. **How compatible is HFDU with currently operating mobile plant?**

   Highly

3. **Can HFDU be directly substituted for mineral oil in currently operating mobile plant?**

   Yes, in most cases. Note however that some HFDU fluids are not chemically compatible with mineral oil. Also, mineral oil residues need to be limited to <5% for the system to be rendered fire resistant so flushing may be required for some systems.

4. **Is there currently any intention to implement surface temperature control design methods for mobile plant used on underground metalliferous mines and surface mines?**

   **4.1 What would be the cost difference of surface temperature-controlled vehicles compared with those currently used?**

   **4.2 Is it feasible to retrofit existing vehicles with surface control measures such as water jacketing and what would be the additional cost?**

5. **What consideration is given to the potential of fires on mobile plant in the design and engineering of mobile plant?**

   **5.1 Could more be done in the design of mobile plant to eliminate the risk of fires?**

   It is important to note that removing the risk of ignition is key to improving safety. Strategies that involve mitigating the effect of ignition (e.g. fire suppression systems) pose higher risk than rendering the system inherently fire resistant with the use of fire-resistant fluids or the removal of the ignition source as a fire once ignited can behave in unpredictable manner. For example, if grease residues are present a fire could be difficult to extinguish.

NSW Resources Regulator

*Manufacturers of fire-resistant fluids – From manufacturers of fire-resistant fluids, the Resources Regulator seeks to understand:*

1. **What are the requirements for safely handling fire-resistant fluids?**

   This depends on the type of Fire-Resistant Hydraulic Fluids that is being used:

   - HFC (water glycol) Fire Resistant Hydraulic Fluids: most HFC fluids carry a "Health Hazard" label (GHS08). This directly implies this fluid should be handled with great to avoid any contact with any human tissue. Spills to the environment should be avoided.
   - HFDU: polyol ester based. These Fire-Resistant Hydraulic Fluids are typically harmless and good biodegradable. These fluids generally do not need hygiene measures above the standard measures for any chemical material => just standard goggles and gloves.
   - HFDR (phosphate ester based): these type of Fire-Resistant Hydraulic Fluids are typically classified as CRM (Carcinogenic, Reproductive, Mutagenic). Upon combustion Noxic fumes can be formed. Fluids are generally labelled with GHS 08, but at least GHS09. This directly implies this fluid should be handled with great to avoid any contact with any human tissue. Spills to the environment should be avoided.

2. **Are there potential health issues arising from handling fire-resistant fluids?**

   See the answer at Question 1.

3. **What is the cost of HFDU in comparison to mineral oil?**

   Typically, 3-5x depending on pack size, order volumes, and location/logistics costs.

4. **How is HFDU disposed of?**

   It is recommended to follow disposal treatments as usd for any Mineral Oil based lube. It can be destructed at an incinerator plant.

5. **What are the environmental considerations for using HFDU?**

   In general, the HFDU type of Fire-Resistant Hydraulic Fluids are based on renewable resources. Some suppliers have hazard label free product (but not all!). They can be more biodegradable and pose lower water toxicity in comparison to mineral hydraulic oils. Also, one Fire Resistant Hydraulic Fluid with an ECO label is available (QUINTOLUBRIC® ECO 46 and QUINTOLUBRIC® ECO 68). These fluids are guaranteed free of any cumulative environmental unfriendly component.


# FIRE-RESISTANT TEST PARAMETERS EXPLAINED

## OVERVIEW

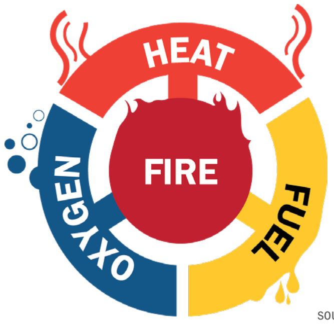
The resistance to ignition and burning, termed fire-resistance in the hydraulic fluids field, is measured using a variety of methods. The techniques developed include laboratory testing methods, as well as simulations for possible industrial crisis situations. When it comes to the testing methods it is not always clear what the parameters used actually mean or how to interpret the results of the tests.

The following will explain the parameters used, and how to interpret the results of six tests used to measure fire resistance in hydraulic fluids, and most frequently included on product Technical Data Sheets. The tests to be discussed are:

» Fire triangle
» Lower/higher flammability limits
» Flash-and fire point
» Auto Ignition point
» Heat capacity
» Heat of combustion

## FIRE TRIANGLE AND FLAMMABILITY LIMITS

The **fire triangles** or **combustion triangles** or "fire diamond" are simple models for understanding the necessary ingredients for most fires. The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen).




source : Quaker

If any one of the parameters stated - Oxygen, Fuel or Heat - is missing, a fire will not occur. Additionally, if any one of these parameters is removed the fire will extinguish.

Upper and lower flammability limits or explosive levels are the well-defined boundaries between which mixtures of dispersed combustible materials (gaseous or vaporized fuels and some dusts) and oxygen will combust. Combustion can range in violence from deflagration through detonation depending on the ratio vapors to air.

The level of these parameters can also determine if a fire takes place. Not only is sufficient energy in the form of heat or a spark needed before a fire can start, but also the ratio of fuel (as vapor!) to oxygen has to be within the upper and lower flammability limits to be able to get an ignition. Too little fuel vapor or too much fuel vapor is the difference between no fire at all or an explosion.

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# FIRE-RESISTANT TEST PARAMETERS EXPLAINED

## FLASH AND FIRE POINT

The **flash point** of a fuel is the lowest temperature at which a particular organic compound gives off sufficient vapor to ignite in air, when exposed to an open flame.

The **fire point** of a fuel is the lowest temperature at which a particular organic compound gives off sufficient vapor to burn for at least 5 seconds after ignition by an open flame.

When hydraulic fluids are tested for fire resistance by Factory Mutual, the fire point is particularly important, since it is a key parameter in the equation used to calculate the Spray Flammability Parameter (SFP) [1].

The results of the flash point test has no impact on the fire-resistant classification made by Factory Mutual. However, to explain the flash point further, consider a practice situation where two polyol ester based fluids with flash points of 250°C/ 482°F and 310°C/ 590°F respectively come into contact with a hot surface around open sparks or fire. If the hot surface has a temperature between 250°C/ 482°F and 310°C/ 590°F, the fluid with the lower flash point might give a flash, but will not continue to burn.

If the hot surface is outside of the 250°C/ 482°F and 310°C/ 590°F range the fire-resistant behavior will be comparable for both fluids.

## AUTO IGNITION TEMPERATURE, HEAT CAPACITY AND HEAT OF COMBUSTION

The **auto ignition temperature** (AIT) of a substance is the lowest temperature at which it spontaneously ignites in normal atmosphere without an external source of ignition, such as a flame or spark.

The **specific heat (heat capacity)** is the amount of heat/energy needed to raise the temperature of one gram of mass by 1 kelvin.

The **heat of combustion** is the amount of heat released during the combustion of a specified amount of a substance.

How are these parameters useful when comparing a Mineral Oil with QUINTOLUBRIC® 888?

| PROPERTY | MINERAL OIL | QUINTOLUBRIC® 888 HFDU |
|---|---|---|
| Auto Ignition Temperature | 300°C 572°F | 460°C 860°F |
| Specific Heat | 1.7-1.8 J/g.K | 2.06 J/g.K |
| Heat of Combustion | 43 KJ/g | 38 KJ/g |

1) The SFP is calculated using the formula :

$$SFP_{normalized} = 11.02 \times 10^6 \times \frac{Q_{ch}}{\rho_f q_{cr} m_f}$$ Of which $q_{cr} = \alpha \times \sigma \times T_f^4$, where $T_f$ is the Fire point.

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## FIRE-RESISTANT TEST PARAMETERS EXPLAINED

The driving force is the relative low auto ignition temperature of mineral oil in combination with a relative low specific heat and high heat of combustion.

1. The auto ignition point of mineral oil is much lower than that of QUINTOLUBRIC® 888.
2. The specific heat shows that you need 10-15% less energy to heat mineral oil based lubricants.
3. The heat of combustion of a mineral oil based hydraulic fluid is typically about 43-44 kJ/g, whereas an HFDu, polyol ester fire-resistant hydraulic fluid has a heat of combustion of about 38 kJ/g. So chemically an HFDu fluid generates 10-15% less heat during combustion.

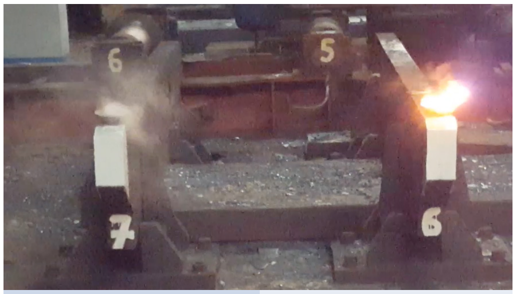
Purely on physical facts it can be stated

» Less energy is needed to heat mineral oil based lubricants to reach the temperature needed to auto ignite (which is already relatively low)
» The relative high heat of combustion of mineral oil based lubricants acts as a catalyst to the process and causes the mineral oil to keep itself burning

This effect is very well demonstrated in a pool fire comparing a mineral oil based hydraulic fluid and a HFDu polyol ester based hydraulic fluid.


| QUINTOLUBRIC® | mineral oil based hydraulic fluid |
|---|---|

A red hot piece of iron is placed into a pool of QUINTOLUBRIC® fire-resistant hydraulic fluid, and a pool of mineral oil based hydraulic fluid.




| QUINTOLUBRIC® | mineral oil based hydraulic fluid |
|---|---|

After **53 seconds QUINTOLUBRIC® self-extinguishes** and **stops burning.** The mineral oil based hydraulic fluid continues to burn.

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# SKILL BUILDER

## FIRE-RESISTANT TEST PARAMETERS EXPLAINED

| QUINTOLUBRIC® | mineral oil based hydraulic fluid |
|---|---|

The **mineral oil continues to burn for over 1 hour** until all the mineral oil is gone, and **only black tar and stained iron remain.**

In general for TMP (Trimethylolpropane) -trioleate (polyol ester) based HFDu's the **auto ignition temperature (AIT)** will be in the range of 420-460°C/ 788-860°F. A high or low flash point or fire point does not have an impact on the AIT thus its performance in the pool test. The same principle is valid for burning fluid falling from for instance a red hot blank and falling on the ground. The more base fluid there is, the more likely to continue burning and igniting the greasy surrounding, where the polyol ester based fluid will self-extinguish and stop the event.

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TIM MATTERN, RONALD KNECHT [1]

# RISK ASSESSMENT FOR LUBRICANTS IN USE IN STEEL PLANTS. HOW FIRE RESISTANT LUBRICANTS IMPROVE WORK SAFETY AND REDUCE FIRE HAZARD IN STEEL PLANTS.

## Abstract

Fire hazards in the steel industry is not a new topic, and the steel industry is taking all possible efforts to lower the fire hazard in its production plants. Fire hazards are present in several different forms, but fires induced and intensified by mineral oil based lubricants are notorious and feared.
For hydraulic fluids several alternatives are available, but for lubricating greases fire resistance is a greenfield area. This paper explains the Risk Assessment process a company can go through to make a proper estimation of the risk involved and how the evaluation of the several alternatives can be made. Finally the paper describes what change can be made to the choice of lubricants to get to a situation with significant reduced risk, enhanced work safety and a secured productivity in Continuous Casters, Hot- and Cold Rolling Mills.

**Keywords**

Risk assessment, fire resistant, hydraulic fluid, grease

## 1. Summary

The Steel producing industry is an industry where situations occur every day that can be classified as dangerous. Dangerous not only due to the plant's heavy machinery, or the operations involving liquid or red hot steel, but also because of the escalated fire risk based on the Lubricants & Greases being used.

In this paper we will focus on the potential risks associated with the use of mineral oil based hydraulic fluids and greases in steel plants, and what alternatives can be used without jeopardizing the performance or productivity of the production line.

## 2. The Fire Risks of mineral oil based lubricants

A fire is one of the events that, once experienced, leaves a huge impression on the people involved. In addition to the risk of personnel injuries, there is a likelihood of loss in both capital and production.  These losses not only include damage to the building and equipment, but also encompass interruptions in production that can idle lines for days or even months.

One cause of fire in a steel production plant is the ignition of mineral oil based hydraulic fluids or greases.

[1] QUAKER CHEMICALS B.V.

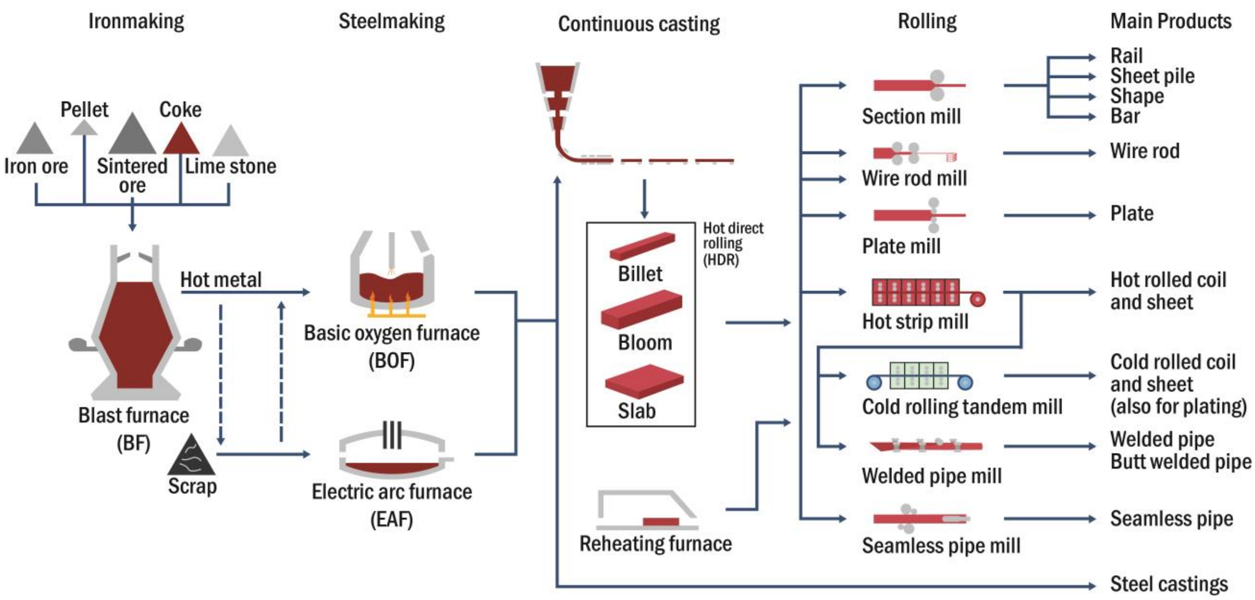


Fig 1. Rough schematic of the steel making process

In the graphic above, all the areas in red represent an operation where the processed materials reach temperatures ± 900°C up to > 1500°C (± 1652°F up to > 2732°F). In most of these processes hydraulic units are used to operate the equipment, and in many cases a mineral oil based hydraulic fluid is chosen to fuel the hydraulic unit. While mineral oil has the definite advantage of a good cost-performance ratio, it is a distillate from crude oil, and not always the safest choice, due to its tendency to catch fire easily.

Fire resulting from the ignition of a mineral oil based lubricant can happen in many different ways. Two that occur most often are when mineral oil based lubricants leak onto a very hot surface; or when sparks or hot (liquid) metal land in a pool of mineral oil based lubricants.

The first instance becomes a larger issue when it happens with a liquid mineral oil based lubricants like a hydraulic fluid because the risk of larger spills or oil spray has a much wider reach. The second example is likely to happen with both liquid as well as greases like mineral oil based lubricants.

Fortunately, there are alternatives available to manage these risks and reduce the chance of an ignition.

## 3 Fire Resistant Hydraulic Fluid.

### 3.1 Types of Fire Resistant Hydraulic Fluids

The standard hydraulic fluids used in steel production are mineral oil based. But an alternative to mineral oil hydraulic fluids are fire resistant hydraulic fluids, as described below using the ISO 6743/4 classification.

| **Water-based Fluids** | **Water-free Fluids** |
|---|---|

| | |
|---|---|
| **HFA-E:** Oil in water emulsions<br>water content > 80%<br>common use 1 to 5%<br><br>**HFA-S:** Synthetic aqueous solutions<br>water content > 90%<br>common use 1 to 5%<br><br>**HFC:** Water glycol solutions<br>water content >35% | **HFD-R:** Phosphate ester based. These products are less used because of CMR reputation<br><br>**HFD-U:** Based on other compounds, but mainly synthetic polyol ester and natural esters (renewable resources) |

Fig. 1 ISO 6743/4 classification

For each fluid type there are both pros and cons. Figure 2 shows a comparison of the performance properties for several hydraulic fluid types. The properties shown are considered important by both Maintenance Managers as well as Purchasers.

| Property | Mineral Oil | Phosphate Ester (HFDR) | Water Glycol (HFC) | Synthetic Polyol Ester (HFDU) |
|---|---|---|---|---|
| Fire resistance | – – | + + | + + + | + |
| Environmental performance | – | + and – | + and – | + + |
| Thermal stability | + + | + + | – | + |
| Fluid maintenance | + | – – | – – | + |
| Component life/ System reliability | + | + and – | – – | + |
| Price | + + | – – | + + | + – |
| Total Cost of Operation | – | – | – – | + |

Fig. 2 Hydraulic fluid comparison when used in fire hazardous situation.

The comparison table shows that mineral oil has good hydraulic fluid performance attributes, at a reasonable price. However, because mineral oil is not biodegradable, it is not environmentally friendly, and the rating for Total Cost of Operation (TCO) is due to the aftermath experienced once a fire takes place.

Phosphate ester (HFDr) fluids are an older fluid technology, and are fire resistant by chemistry, but have a negative reputation. They are reported to be formulated with CMR (Carcinogenic, Mutagenic, Reprotoxic) materials, and the combustion fumes they produce are reported to be neurotoxic. HFDr fluids can be 10 to 15 times more expensive than mineral oil and need to be carefully maintained as these products become aggressive acids as they age. These fluids are mainly used nowadays in Power generation, although they are sometimes found in a steel plants as well.

HFC fluids, better known as water glycols, are widely used in steel plants as well as other industries, and represent about 50% of the total fire resistant hydraulic fluids market. Their high water content makes them very good for fire resistance, and while they have a comparable price to mineral oil, they do not measure up in performance attributes. Additionally, compared to water free hydraulic fluids, the hydraulic units for HFC are more expensive to purchase, the service components have a shorter lifetime, more fluid management is needed, and energy consumption is 10 to 20% higher compared to mineral oil or polyol ester based fire resistant hydraulic fluids.

Polyol ester based fluids (HFDu) are the best solution and alternative to mineral oil. Typically, no changes need to be made to the hydraulic unit when converting from a mineral oil or water glycol hydraulic fluid to a polyol ester fluid. They are more expensive than mineral oil (around 2 to 3 times more), but with the reduction in the risk of fire from the hydraulic fluid, the result is a lower Total Cost of Operation and a much safer work environment. Additionally, nothing is sacrificed in terms of the fluid's performance, and the polyol ester based (HFDu) fluids have reduced environmental impact.

When the user knows the types of Fire Resistant Hydraulic Fluid available, a comparison between possible solutions can be made.

| **FINANCIAL AND TECHNICAL EVALUATIONS OF POSSIBLE SOLUTIONS TO ENHANCE SAFETY** | | |
|---|---|---|
| **Solution** | **Positive** | **Negative** |
| **Change design of the Unit to avoid mineral oil leakages close to the hot surface** | » Company can keep the same oil technology | » Does not avoid using a straight hydraulic oil (HLP) coming close to the hot surface. Does not avoid formation of pools. |
| **Installation of a fire extinguisher system** | » Company can keep the same oil technology | » Very expensive and it does not catch the explosive ignition and fire balls |
| **Change hydraulic fluid to a Water Glycol HFC type** | » Offers a safe solution | » Reduction in lubrication performance<br>» Expensive |
| **Change hydraulic fluid with HFD-U type** | » Hydraulic performance closest to Mineral oil based lubricants and general no investments needed on hydraulic systems | » Low risk of spreading fire (under control) but still possible on a 900°C (1,650°F) surface |

Fig. 3 Possible solutions to enhance safety

## 3.2 How is Fire Resistance perceived?

The term *fire resistant* is often mistakenly understood to be the same as *fire retardant*. It is not necessarily the same. Almost all fire resistant hydraulic fluids will burn under certain conditions.

- » HFC fluids will ignite if a certain amount of water evaporates
- » Most HFDu fluids will burn, but will not give the vaporized kind of explosion mineral oil generates

The ignition-like explosion caused by the mineral oil is what leads to an uncontrollable situation. The only hydraulic fluids that can truly be considered fire retardant are the high water content (HFA) fluids.

Fluids can be tested to determine their fire resistance. The most common and generally accepted tests are those used by Factory Mutual (FM Global), the testing and approval arm of a major industrial insurance underwriter (www.fmglobal.com). Using an FM global approved hydraulic fluid can reduce the premium a company needs to pay.

Additionally, beyond FM Global, many other organizations and companies have developed fire resistance tests, usually to simulate a certain type of real-world accident.

The following video frame shots show the comparison between ignition of mineral oils and HFDu fluids.

### 3.3 Comparison of Mineral Oil and HFDu Polyol Ester when poured on a 900°C Surface.

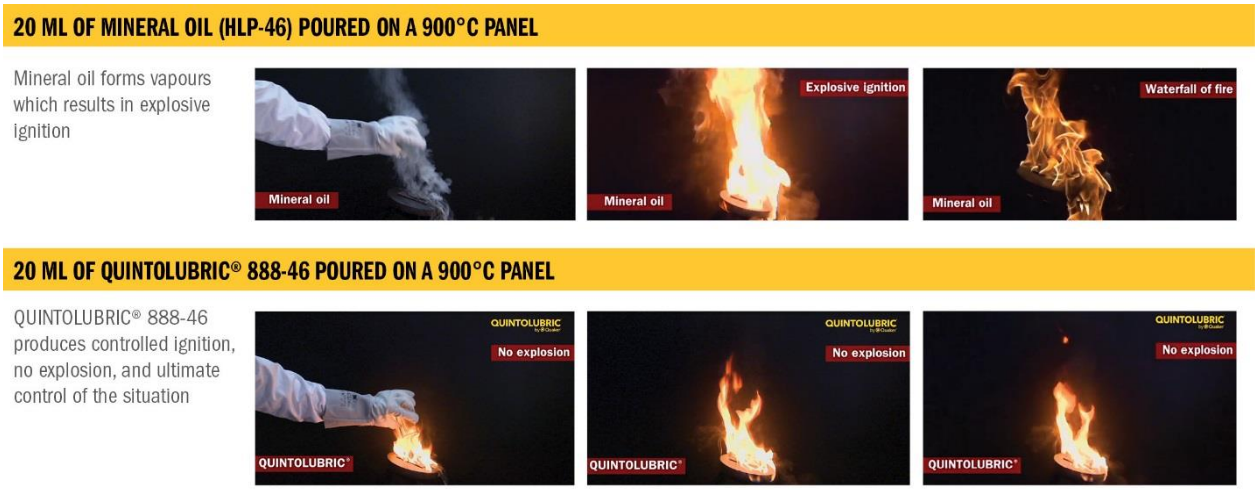


Fig. 4 Comparison of Mineral Oil and HFDu Polyol Ester

The complete movie can be found on Youtube under
http://www.youtube.com/watch?v=bEtlikCMRWM

The still frames demonstrate the problem that typically occurs when a mineral oil based lubricant comes into contact with a hot surface. The mineral oil evaporates easily, and therefore, tends to build a vapour of oil droplets. Once ignition takes place, the oil droplets can catch fire and result in an explosion and/or fire ball. These two effects make the fire with a mineral oil dangerous and hard to control as the fire ball can go to the roof or to cables and can ignite that area. With the polyol ester based HFDu fluids this evaporation does not take place and thus no explosion or fire ball will be generated. The HFDu fluid might burn as well, but there is no vapour or explosion and it is limited to the place it comes in contact with, so the situation remains under control.

**3.4 Comparison of a pool of Mineral Oil and HFDu Polyol Ester a hot subject drops into it.**

To explain this phenomenon some physical parameters should be understood.

| Property | Mineral oil | QUINTOLUBRIC® 888 HFDU |
|---|---|---|
| Auto Ignition Point | 300°C<br>572°F | 460°C<br>860°F |
| Specific Heat | 1.7-1.8 J/g.K | 2.06 J/g.K |
| Heat of Combustion | 43 KJ/g | 38 KJ/g |

Fig. 5 Physical Parameters

A driving force in this process is the relative low auto ignition temperature of mineral oil in combination with a relative low specific heat and high heat of combustion.

1. The auto ignition point of MO is much lower than that of QUINTOLUBRIC® 888
2. The Specific heat expresses the energy needed to heat 1 g MO 1°K => 10-15 % less energy to heat Mineral oil based lubricants .
3. The heat of combustion of a mineral oil based hydraulic fluid is typically about 43-44 kJ/g, whereas an HFDu, polyol ester fire-resistant hydraulic fluid has a heat of combustion of about 38 kJ/g. So chemically an HFDu fluid generates 10-15% less heat during combustion.

So purely on physical facts it can be stated that less energy is needed to heat Mineral oil based lubricants to reach the temperature needed to auto ignite ( which is already relatively low ). The relative high heat of combustion of Mineral oil based lubricants acts as a catalysis in the process and creates the situation of the explosive ignition and propagation of the flames.

**4 Examples how Fire Resistant Grease improved work safety and reduced fire hazards in high risk areas**

Because of the nature of steel production, steel plants have hazards in every operation. This requires a “safety first” approach from everyone, including visitors, to minimize the risks of negative outcomes. Within the large context of safety, fire hazards are substantial areas of risks within steel plants.

Fire hazards exist in many places within steel plants. This includes, but is not limited to areas such as the coke oven, blast furnace, melt shop, hot rolling mills, etc.

To extinguish the fire, the National Fire Protection Agency [1] describes the four main approaches. These are cooling the burning material, eliminating the oxygen, removing the fuel and breaking the chemical reaction. Typically, steel plants cool the burning material. This is usually done with water either from a system or from a steel worker manually extinguishing the fire.

**Example #1 – Hot Rolling Mill Walking Beam Furnace Exit – Roller Table**

In the hot rolling mill of a major North American steel producer, hot scale was falling off the 1,260°C temperature steel bars as they exited the walking beam furnaces, causing excess grease on the bearings to catch on fire. The steel producer thereupon instructed Quaker Chemical to develop a fire-resistant grease that could be used on the roller bearings to reduce the amount of fire hazards. Quaker Chemical proposed QUINTOPLEX ™ LXS 1002-EP grease for use on the hot rolling mill. Before introducing QUINTOPLEX™ into operation, the steel producer challenged the fire-resistant properties of the grease with tests that exposed it to open flames and extremely hot metals. QUINTOPLEX™ passed all the tests performed, resulting in its introduction into the hot rolling mill lubrication system. Running their system with the fire resistant grease, the mill realized 90 percent less fire hazards. Furthermore, the continuous water supply the mill was using to control the fire hazards could be removed, which led to a reduction in corrosion on the roller bearings. Keeping operations running smoothly Mill operators should work with a grease supplier who has the expertise to offer technical advice to help evaluate situations, and who can offer realistic solutions to solve problems ranging from production efficiency to worker safety. At a minimum, grease manufacturers need to provide sustainable product solutions that require less volume and reduce energy during use, in order to bring real value to the customer

**Benefits of Fire-Resistant Greases in Hot Mills**

In steel plants, the common approach to putting out the fire is done with variations of cooling the burning material. With a fire resistant grease, the approach is removal of the fuel. This is because a typical mineral oil based lubricating grease is a fuel source. A fire resistant grease is not a fuel source because the base oil and additive chemistry are selected based on their ability to resist combustion. Ultimately, the combustible hydrocarbons are removed from the formulation. This results in materials with lower volatility, which minimizes the generation of combustible vapors that are able to ignite and propogate the flame after ignition. Furthermore, some base oils, such as esters require substantially more energy to ignite and sustain fires.

**Example #2 – Continuous Casting – Ladle Turret Bearing**

Challenges: A major steel producer in China with an integrated steel plant for flat steel production faced 3-4 fire hazards annually at the ladle turret area The ladle turret main bearing is been centralized lubricated and used a common Mineral Oil based EP2 Multi Purpose Grease. Although the area of the ladle turret is usually not seen as a high risk area as usually there are not a lot of media installations like Oxygen, Nitrogen, Natural Gas or Argon Pipes and the amount of electrical cables and other installations is usually low. Due to the high amount of grease applied to the main bearing of this ladle turret the grease piles up at the floor. Both inside and outside the ladle turret. Combined with all kinds of dirt and dust from the casting process it creates a significant fire hazard. While starting casting liquid steel rinse from the Ladle though a shroud into the tundish. In this case it usually happens that hot steel particles and sparks flying on the casting platform and can reach the hazardous waste grease on the casting floor. In this case the grease will catch fire and set the whole grease that is in that area under fire and creates a lot of smoke. It will burn as long as mineral oil is present. Fires are a potential risk and needs to be distinguished asap. This required trained people and necessary equipment. To be on the safe side the production should be stopped controlled to allow operators and staff working in that area to get out of the risk area to a safe assembly point outside and away from any building.

## Conclusions

Safety hazards are inherent within the steel industry. In particular, fire hazards present a sizeable risk for steel workers as the nature of steel production requires significant heat to produce the desired finished products. Minimizing and controlling the hazards is very challenging and this paper explains how fire resistant fluids and greases can reduce some of those risks.

According to Schrama [2], about 50% of all steel tonnage is processed at the hot strip mill. Within the hot strip mill, the furnace exceeds 1,260°C. As the furnace moves hot bars of steel to the rolling table, the process creates excess slag that falls on to the ground. Simultaneously, the bearings on the rolling table expel excess quantities of grease on to the floor.

Because fluids and greases are typically mineral oil based, this becomes the fuel for a fire event. The authors propose that using a synthetic ester oil based fluid and grease would reduce the likelihood of lubricants catching on fire. This ester technology is used in fire resistant hydraulic fluids for many years. This is further supported in that the ester technology requires a higher energy level to cause and sustain combustion. Additionally, the physical characteristics of this type of synthetic ester oil has a tendency to char and reduce the oxygen needed for fire.

## References

[1]. National Fire Protection Agency, $20^{th}$ Edition (2008). Fire Protection Handbook. Quincy, Massachusetts.

[2]. Schrama, R. (2006). Chapter 18. Steel Industry. Handbook of Lubrication and Tribology: Volume 1 Application and Maintenance, Edited by Totten, G. pp. 18-3 – 18-59.

NSW Resources Regulator

# Viva Energy Australia

*Email submission from Darren Berwick, National Technical Manager, Viva Energy Australia*

As a distributor of Shell manufactured fire-resistant Hydraulic fluids, I would like to make the following comments re the discussion paper on Fires on mobile plant:

- Limiting response to discussion on FR Fluid properties, not cost or on any other components of the discussion paper
- The paper focus's heavily on HFDU fluids which it notes is only less flammable, not fire resistant.
- HFDU fluids are primarily designed to resist ignition under atomisation conditions, however support combustion in many other instances – hence considered less flammable, not fire resistant.
- Any water/emulsion aqueous type fluids such as HFAS, HFAE, HFB and HFC should not operate above 65 deg C due to high vapour pressures and potential evaporative loss. This limits their applicability alone as many mobile hydraulic systems currently run well in excess of this temperature.
- Aqueous based fluids require de-rating of the system making them less practical for use in mobile equipment.
- Of the remaining fire-resistant fluids, HFDR fluids are the most fire resistant, however they are incompatible with nitrile seals/hoses meaning an almost impossible replacing program for mobile fleet systems. There is also ongoing discussion on the toxicity of fumes from Phosphate esters which needs to be considered.
- Many mobile fleets have common components with the hydraulic systems, such as brake, steering and transmission systems. FR fluids will not be compatible with these systems. E.g. unlikely to have the frictional characteristics for wet brake systems.
- There is no perfect fire-resistant product and given the limitations discussed will have limited application in mobile fleet.

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MANAGEMENT RESOURCE SOLUTIONS

HYDRAULIC ISOLATOR

# Achieving Complete Isolation

# HOW DO WE ACHIEVE COMPLETE ISOLATION?

| Risk Assessment / Take 5 | |
|---|---|
| **Energy Source/Hazard** | **Control** |
| Electrical | Battery Isolator |
| Fire/ Explosion | Fire  System |
| Gravity | Harness Fall Arrest |
| Noise | PPE/ hearing protection |
| **Stored Pressure - Hydraulic** | **???** |

# HOW DO WE ACHIEVE COMPLETE ISOLATION?

- **MDG 41 Guidelines**

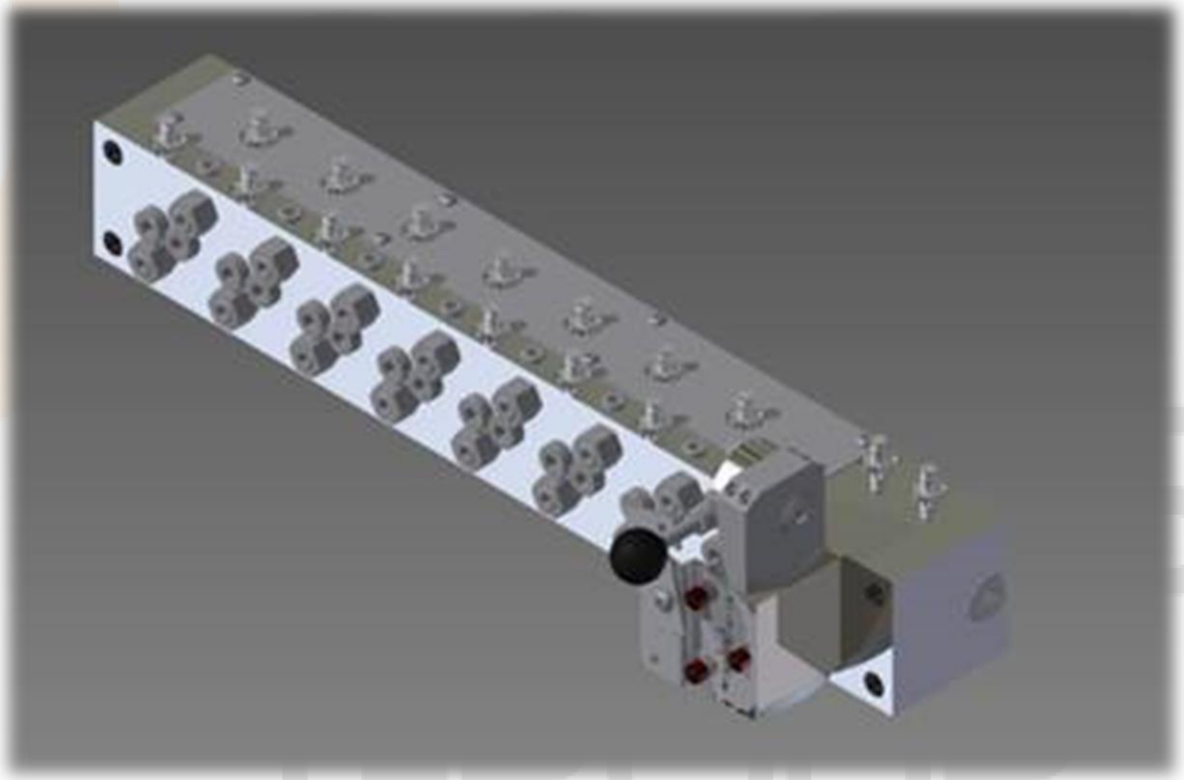
  "A person shall not carry out repairs to fluid systems unless the energy source is isolated and dissipated and cannot be reenergised inadvertently. The system of energy isolation and dissipation adopted shall incorporate a locking system, a tagging system or permit system and in any case should also include a method for ensuring that energy isolation and dissipation is effectively established." (Industry & Investment NSW – Mine Safety, MDG41 Section 3.6 Isolation & Energy Dissipation, Issued: December 2010)

# CURRENT ISOLATION METHODS

- Don’t completely isolate residual pressures
- No way to test ‘effectiveness of isolation’
- Does not incorporate ‘locking system, tagging system or a permit system’
- Can ‘re-energise inadvertently’
- Potential risk involved

# SOLUTION: HYDRAULIC ISOLATOR

The **Hydraulic Isolator** is a safety device used to relieve stored pressure in hydraulic systems and maintain the systems deenergised state.



# SOLUTION: HYDRAULIC ISOLATOR




- Complete & safe release of hydraulic pressure
- Single point of hydraulic isolation
- Single ‘test for dead’ point
- No cross contamination of hydraulic circuits

# SOLUTION: HYDRAULIC ISOLATOR

Eliminates Oil Injection Injuries

# SOLUTION: HYDRAULIC ISOLATOR

## Secondary Fire Control

# SOLUTION: HYDRAULIC ISOLATOR

- Common hydraulic diagnostic test points
- Eliminates oil injection injuries
- Secondary fire control
- Reduced environmental impact

# RESEARCH & DEVELOPMENT

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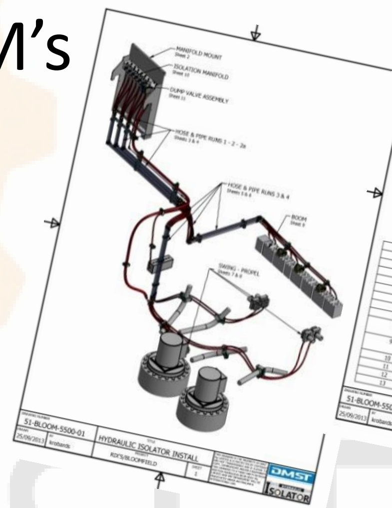
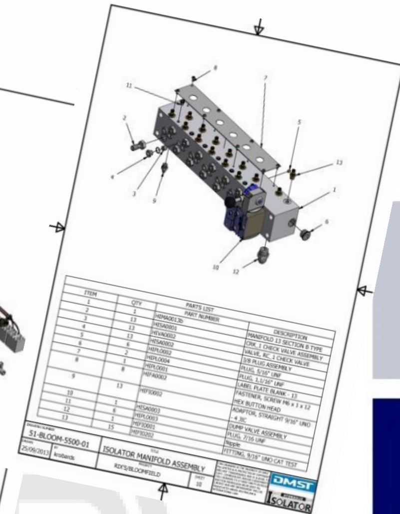
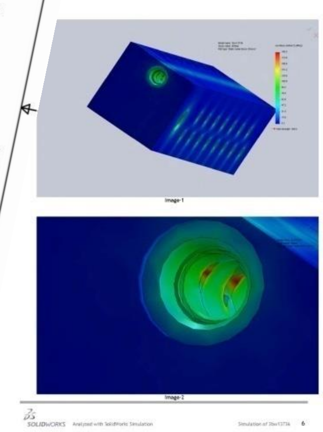
- Consultation with OEM's
- MDG41
- Engineer Certified
- Patent Protected
- Industry Awards







- Minerals Council of Australia,
  National Innovation Award for Health and Safety
- NSW Minerals Council, Supplier of the Year Award for Construction and Engineering

# OPERATION

HYDRAULIC ISOLATOR

(Patent Protected)

WARNING

ONLY TRAINED AND COMPETENT PERSONNEL ARE TO USE THIS DEVICE

## OPERATIONAL INSTRUCTIONS

1. Hook up 0-6000psi pressure gauge to TP1.
2. Move Dump Handle to dump position, and hold until pressure reads zero.
3. Lockout Dump Handle and apply lock.

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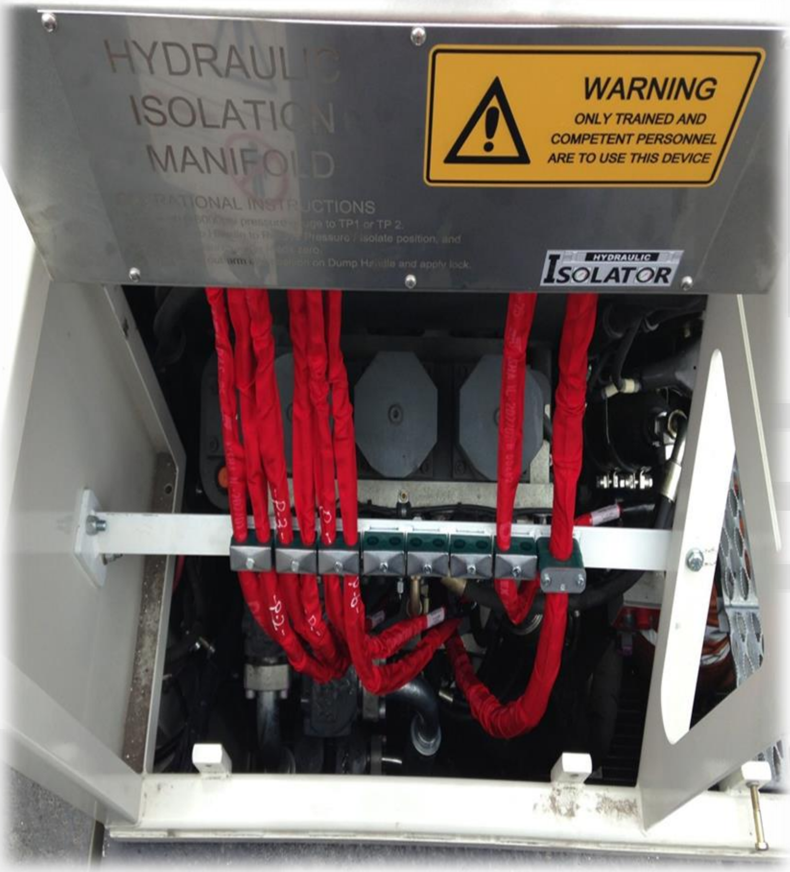
# After Installation Photos


# After Installation Photos






# After Installation Photos


# After Installation Photos

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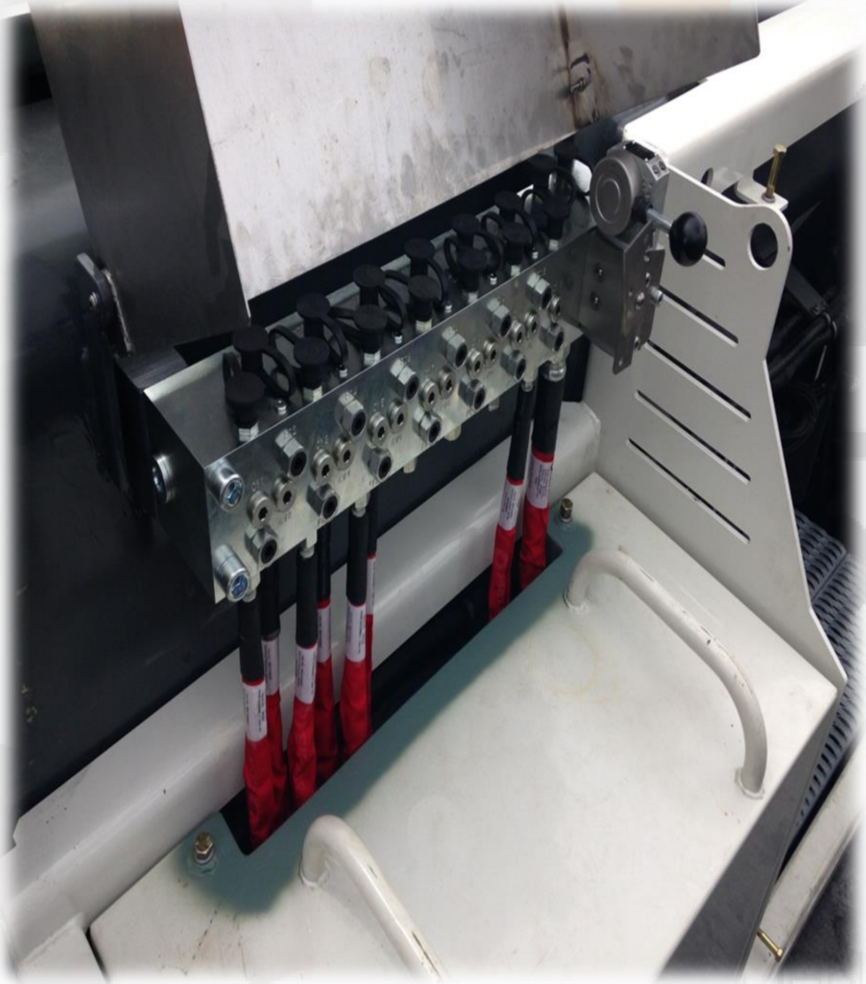
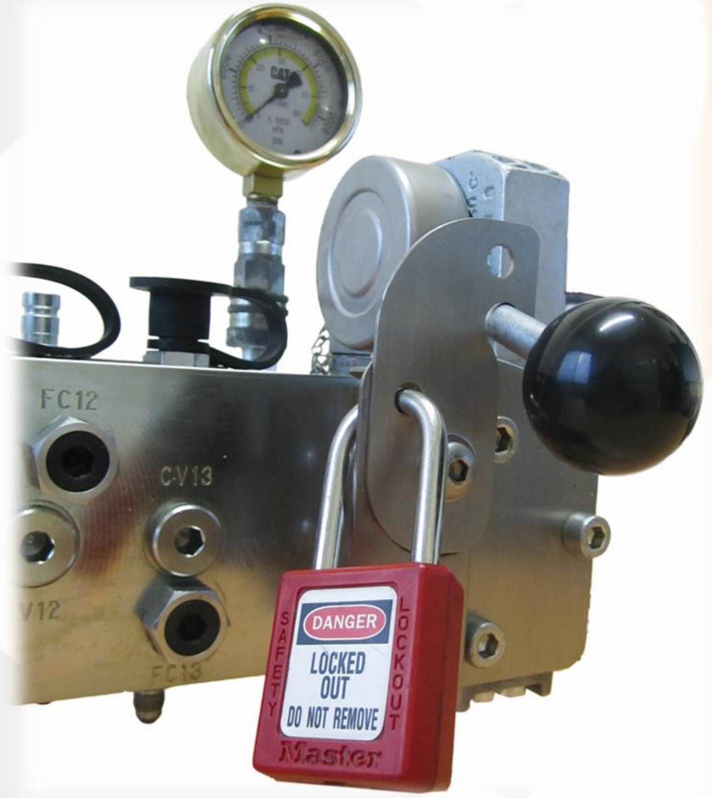
MANAGEMENT RESOURCE SOLUTIONS






# HYDRAULIC ISOLATOR

## COMPLETE ISOLATION SAVES LIVES

**1. Identify 2. Isolate**

**3. Test 4. Lock**