

SAFETY BULLETIN

Failures of Explosion Protected Diesel Engine Systems

BACKGROUND

Clause 56(1)(m) of the *Coal Mine Health and Safety Regulation 2006* (CMHSR) requires notification by the Coal Operator to the Chief Inspector of any incident or matter involving –

‘the in-service failure of the explosion-protection characteristics of explosion-protected plant’.

Safety Bulletin SB08-05 provides guidance in assessing clause 56(1)(m) reporting requirements.

Between December 2006 and December 2009 there were over 465 reported failures of explosion protected diesel engine systems (DES) by mine operators. On average there is a failure of an explosion protected DES every 56 hours.

Safety Alerts SA08-04 and SA07-06 identify some of these failures. (See **References**)

Industry & Investment NSW (I&I NSW) has approximately 1,080 explosion protected DES items registered for use in NSW. Given the 465 reported failures, this means approximately 15% of explosion protected DES in use in NSW mines would fail to be in an explosion protected condition at some stage during the year. Alternatively, in a seven year period, the explosion protection properties on every DES in use would fail.

It is envisaged that there are more failures than these figures suggest, as:

- These figures do not include failures that may have been detected off the mine-site, i.e. in OEM workshops.
- Not all failures are reported by mines as the analysis shows inconsistencies in reporting between mines.
- Some DES while registered in NSW may be in use in QLD, subsequently increasing the mean failure rate.

This is an unacceptable failure rate in view of contemporary engineering standards and the consequence of failure may be an explosive catastrophic event.

SIGNIFICANCE OF FAILURES

An explosion protected DES is designed and tested to AS/NZS 3584.2. This provides time limited safe operation in atmospheres containing up to 1% methane. The explosion protected properties provide short term protection to shut down the DES in the event of an explosive atmosphere being present during use of the DES.

Within all underground Coal Mines there is a potential for explosive atmospheres. The consequence of an explosion is unacceptable, with multiple fatalities, significant damage to the mine, consequent loss of production, employment and public confidence. While mine ventilation is the primary risk control to prevent an explosive atmosphere being present, history indicates that ventilation failures do occur and DES have been in methane enriched atmospheres significantly greater than 1%. Refer to safety alerts SA05-08 and SA09-02.

There have been several mine explosions in history where a DES may have been the source of ignition. Because of the potential consequences, a high degree of integrity in the explosion protected properties of the DES must be maintained.

Clauses 13(1)(f)(v) and (vi) of the *CMHSR* impose an obligation to prevent uncontrolled fires being initiated or fuelled by mechanical plant or installations and to prevent initiation of gas or coal dust explosions by mechanical energy.

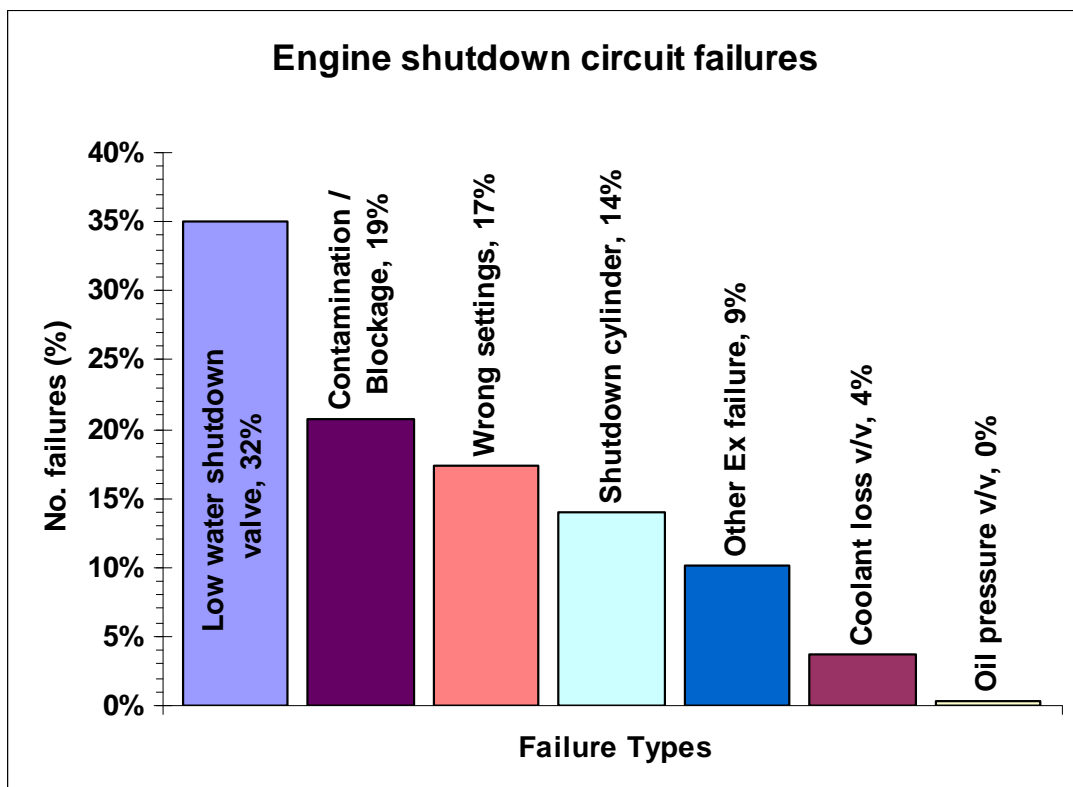
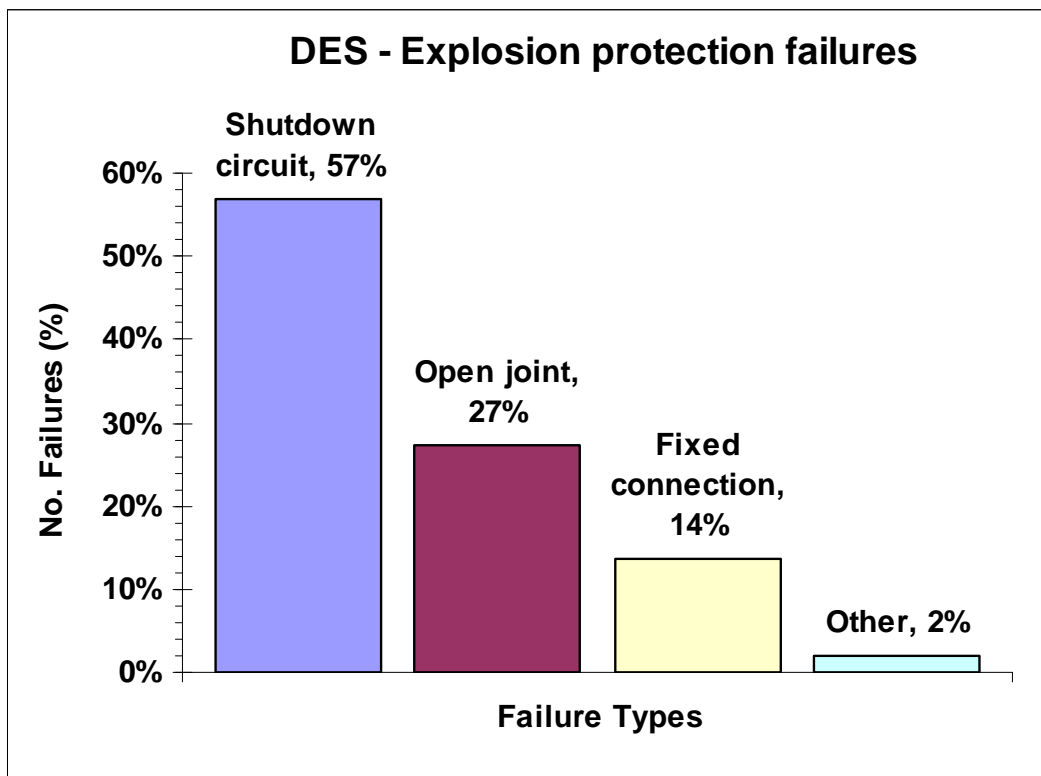
Clause 13(1)(f)(viii) also requires the mechanical engineering management plan to provide safeguards for mechanical plant and installations, with a probability of failure appropriate to the degree of risk posed by any mechanical plant or installation.

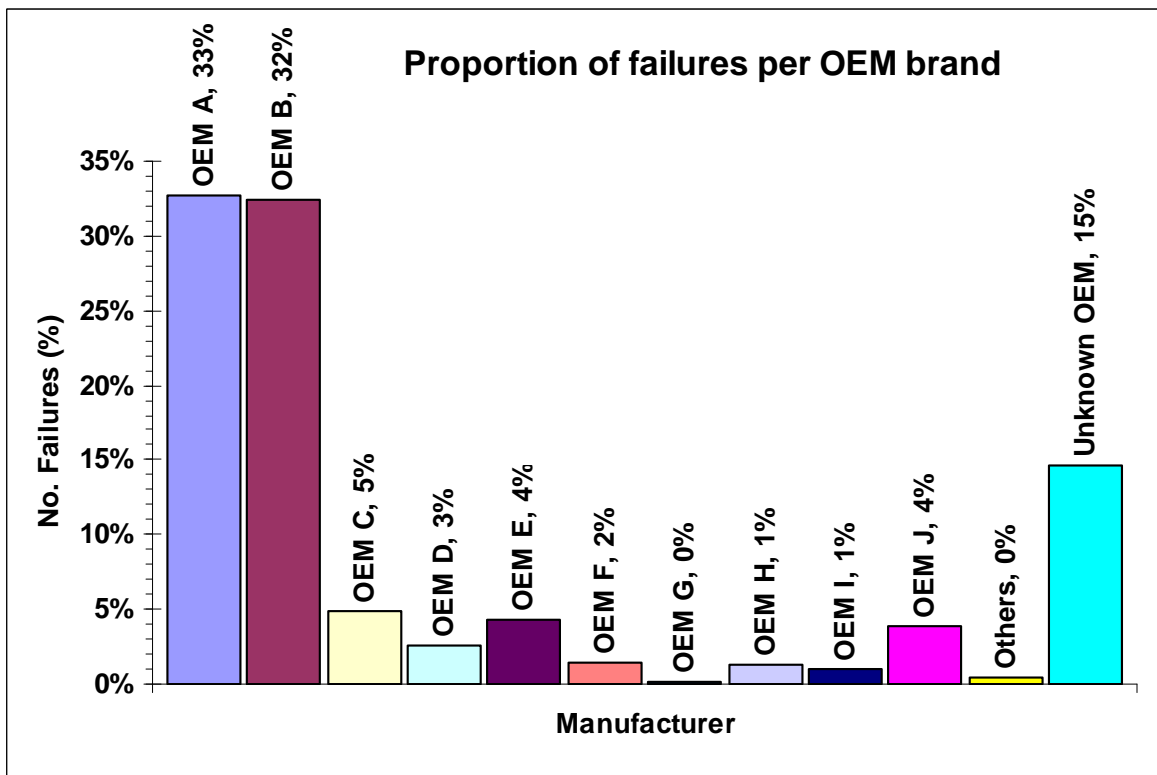
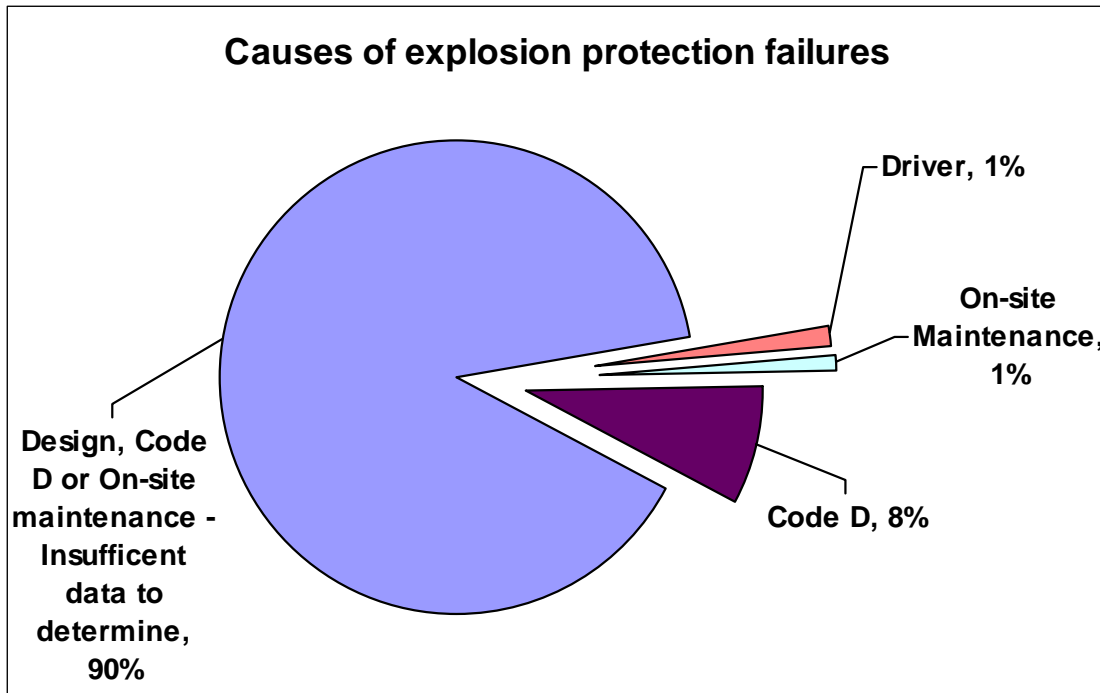
Explosion protected properties of a DES must have a very low probability of failure. See also Legislation Update LU07-05.

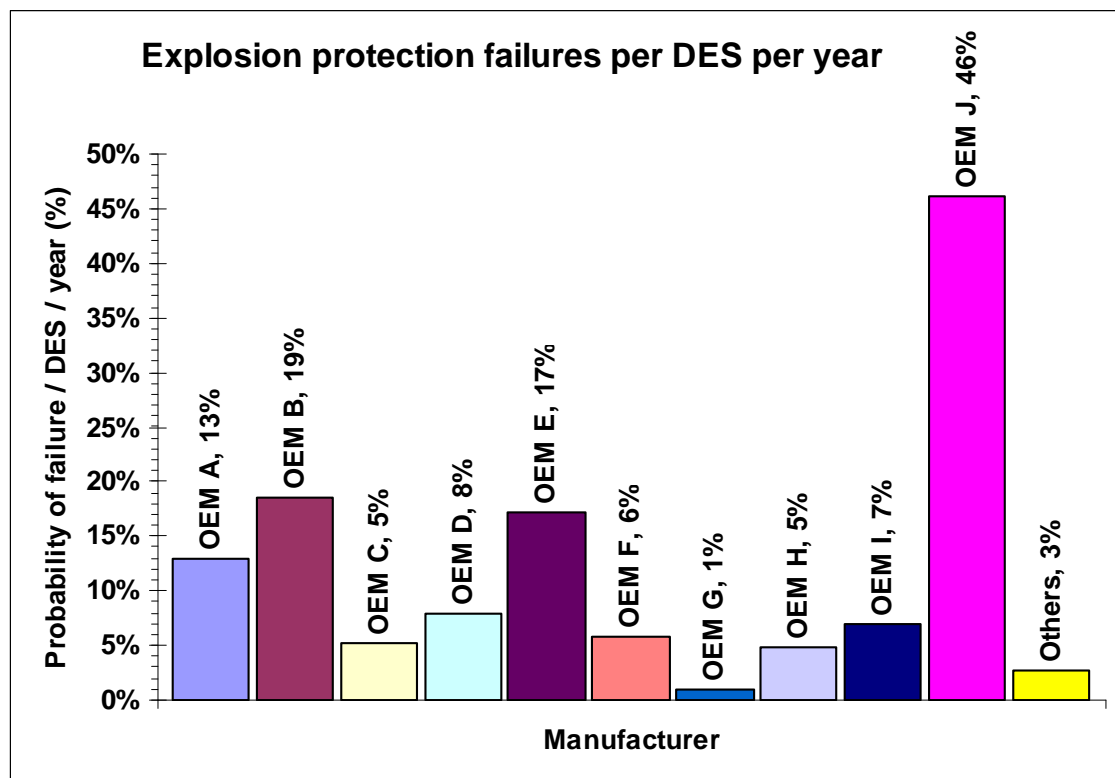
ANALYSIS OF FAILURES

The analysis of the 465 failures indicates:

- Failures of the engine safety shutdown circuit contributed to 57% of all failures. Of these:
 - Low water shutdown contributed to 32%.
 - Contamination or blockage of the shutdown circuit contributed to 18%.
 - Wrong settings, e.g. too high air pressure/flow rate contributed to 17%.
 - Shutdown cylinder failures contributed to 14%.
- Open joint and fixed connection failures contributed 27% and 14% respectively.
- The issues are spread across all explosion protected DES manufacturers.
- Poor design, code D maintenance and on-site maintenance are all contributing factors.







ISSUES

Analysis of the information provided by mines highlights the following issues:

- The reason for the failure was not always reported.
- Information on the cause of the failure is difficult to obtain due to the quality of reporting by some mines.
- The person filling out the incident form may not have had the competence to know what the root cause(s) of the failure was or may not have been senior enough to know the necessary details.
- The following information was not always provided:
 - Design registration number (or exemption number)
 - Item registration number
 - The machine type (OEM), model
 - Last code D and workshop
- It is difficult to determine whether the failure was due to reliability of the system design, competency of the Code D examiner, mine site maintenance, the operator, or a combination of these issues.
- The OEM may not be aware of the quantum of failures on their DES.

As a result of this, the analysis is indicative rather than absolute.

RECOMMENDATIONS

1. **Designers, manufacturers and suppliers** should:

- Refer immediately to clause 88 *Occupational Health and Safety Regulation 2001* (OHS Regulation) as designers have a duty to review risk assessments whenever information is provided about a design fault.

Note: Design faults include designs which do not cater for foreseeable misuse such as shut down systems which can be readily bypassed, contaminated or incorrectly adjusted. I&I NSW will distribute relevant incidents to each OEM

- Provide information to relevant stakeholder on improvements resulting from risk assessment reviews.
- Review the safety integrity level (or category level) on safety shutdown circuits. A *Failure Modes and Effects Analysis* (FMEA) or other similar risk assessment method should be carried out to confirm the integrity of all safety critical systems.
- Comply with AS/NZS 3584.2 and provide fail-to-safety engine-shutdown systems which are verified by risk assessment.
- Provide realistic lifecycle maintenance information compliant with clause 96 OHS Regulation and AS/NZS 3584.3 that if followed will ensure explosion protection properties of the DES are maintained for life. A finite life for each component of the DES should be provided.

2. **Mine Operators (and other owners of explosion protected DES)** should:

- Ensure people undertaking safety inspections, examinations or maintenance activities on DES are competent (and periodically assessed as being competent) for the particular DES in use at the mine.
- Provide a maintenance management system compliant to AS/NZS 3584.3.
- Inspect, test and maintain the DES having regard to the procedures recommended by the designer/manufacturer or as otherwise recommended by a competent person.
- Have competent people investigate and document all failures of explosion protected DES and report the relevant information to the Manager of Mechanical Engineering and I&I NSW.
- Notify the OEM of any design faults identified or areas where failure occurs regularly.
- Have an inspection/maintenance system that:
 - i. ensures all safety features and warning devices on the DES are maintained and tested at appropriate intervals by appropriate methods (refer to clause 137 of the OHS Regulation)
 - ii. at appropriate intervals checks dual sensors individually such that a fault with one sensor will be detected prior to the failure of the second sensor. The probability of an undetected failure should be minimised. For example, dual floats on exhaust conditioners, dual temperature sensors, etc., should be checked individually.

- Have code D examinations carried out by an organisation with appropriate quality systems, equipment, procedures, and competent people for such work.
3. **Organisations carrying out overhauls, alterations and code D examinations** should:
- Carry out explosion protected overhauls, Code D examinations, or explosion protection repairs (being work that may alter the explosion protected properties of the DES) in accordance with AS 3584.3 and the information provided by the designer/manufacture.
 - Develop a program to implement systems in accordance with LU10-01.
 - Only work on DES where all relevant documentation as set out by the design registration documents or approval documents and Section 5 of AS 3584.2 is readily available to the persons carrying out the works.
 - Ensure that only people competent with the particular DES undertake work.
 - Record results of all work carried out.

References

- SB08-05 [In-service failures of explosion-protected diesel engine systems](#)
- SA08-04 [Failure of explosion-protected characteristics of a diesel engine system](#)
- SA09-02 [Diesel engines run on methane-enriched atmosphere](#)
- SA07-06 [In-service failure of Explosion-protected equipment](#)
- SA05-08 [Danger of Explosion - Methane](#)
- LU10- 01 Guidelines for the Renewal of Item Registration for Diesel engine systems used in underground mines at a coal workplace
- LU07-05 [Electrical and mechanical safeguards with appropriate safety integrity](#)
- AS/NZS 3584.2:2008 : Diesel engine systems for underground coal mines - Explosion protected
- AS/NZS 3584.3:2005 : Diesel engine systems for underground coal mines - Maintenance

NOTE: Please ensure all relevant people in your organisation receive a copy of this Safety Bulletin, and are informed of its content and recommendations. This Safety Bulletin should be processed in a systematic manner through the mine's information and communication process. It should also be placed on the mine's notice board.

Signed



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MINE SAFETY OPERATIONS BRANCH
NSW DEPARTMENT OF PRIMARY INDUSTRIES

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