



Incident Report:

Examination and repair of screw threads in flameproof enclosures

Incident:

The Department of Primary Industries (DPI) was notified that numerous thread repairs on a flameproof motor had failed. The failed condition was located by an overhaul workshop that was contracted to overhaul the motor.



Figures 1 and 2: Two separate examples of the numerous failed thread repairs on a flameproof motor

An investigation was undertaken by the DPI to identify how the thread repairs failed and to analyse preventative measures. The overhaul records of the motor enabled the actual workshop that had undertaken the repairs to be located. The DPI and the workshop that conducted the original repairs, each sponsored professional investigations to analyse the failure and to consider the viability of such repair methods.

Discussion:

(i) Determining the health of existing threads in flameproof enclosures

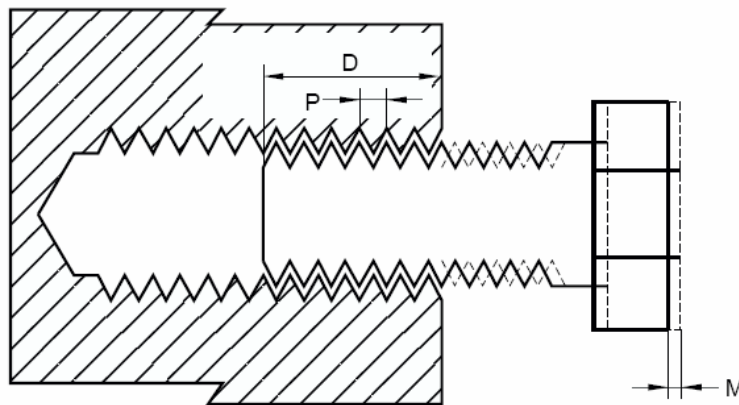
Prior to considering thread repair processes, it would be appropriate to touch upon the hotly disputed subject of testing the condition of existing thread and determining the need for a thread repair. Certainly a thread that has been cracked, sheared and/or cross threaded needs to be repaired. Otherwise, in the case of a visually healthy thread a

definitive test should be applied to worn threads to determine if a thread repair is necessary.

The current maintenance standard (AS/NZS 2290.1:2005) and recently superseded overhaul standard (AS/NZS 3800:1997) for flameproof enclosures require that threads be checked, but both standards fall short of providing practical examples to distinguish an excessively worn thread from a healthy thread. Visual inspection is a useful process to begin the determination of the state of a thread, because damage may be immediately obvious. Tactile tests may only detect obviously defective threads. To determine if a thread is satisfactory, measurements must be taken. There are two methods in use GO-NO-GO gauges and the method specified in AS/NZS 3800.

GO-NO-GO gauges are available in variety of grades. So the desired gauge grade should be clearly specified to the end-user and service workshops by the manufacturer, otherwise the apparatus owner may need to specify this standard (refer to Australian Standards AS 1014, AS 3501 and AS 3635 for the various parallel screw threads forms and associated gauges and gauging practice).

An alternative definitive test of thread condition is nominated in the recently published Australian Standard AS/NZS 3800:2005, which specifies how a new bolt is to be screwed part way into the thread under test and the free lateral travel measured by dial gauge. The free lateral travel can be evaluated as a percentage of the thread pitch diameter.



D must equal diameter of bolt in completed threaded; if $M > 0.1P$, then hole requires attention

LEGEND:

- D = Depth of engagement
- P = Pitch of thread
- M = Movement of bolt thread

FIGURE 2.1 CRITERIA FOR CHECKING THREADED HOLES AND BOLTS FOR THREAD CONDITION

(ii) Determining the viability of a flameproof enclosure requiring a thread repair

The viability of all repairs should be considered against part or whole enclosure replacement. Should repair appear viable in terms of labour content and materials, then the engineering aspects of the repair must be taken into consideration.

Various grades of cast iron and cast steel are not suitable for welding if not specially prepared. Prior to commencing a thread repair, the parent material of the enclosure must be determined from the verification dossier or directly from the manufacturer. When the enclosure is determined suitable for repair, the welding consumable is to be matched with the parent metal of the enclosure. Knowledge of the welding consumable and parent material will be used to determine the welding and preheating operations.

The competency of the person conducting the welding operation and the weld equipment resources available will need to be evaluated to ensure that a sustainable weld repair can be achieved that will remain secure for the life of the enclosure. An integrity level of thread repairs cannot be assigned without applying some type of test to the repaired threads.

(iii) Unsuitable methods of thread repair

History has shown us that thread inserts, such as Heli-coils can dislodge and prevent the flamepath surfaces from correctly mating. More sophisticated keyed thread inserts are now available but have not been considered by the Australian Standards committee.

Other inappropriate methods include:

- plugging, where the previous thread is drilled clean and a piece of round bar is simply inserted into the hole to be re-drill and re-tapped;
- Manual metal-arc (stick) welding, where welding flux contaminates the repair.
- Gas metal-arc (GMAW or MIG) welding where lack of fusion will be produced in deep narrow holes

(iv) Possible suitable methods of thread repair

A temporary repair method for threaded plug insert is nominated in Appendix C, Australian Standard AS/NZS 2290.1:2005 *Electrical equipment for coal mines - Introduction and maintenance, Part 1: For hazardous areas*. This temporary repair method can be quickly converted to a permanent repair method by counter sinking the external surface of the enclosure prior to insertion of the plug and finishing the repair by welding the insert into place. This method is suggested to apply the minimum amount of heat and distortion to the enclosure. A further enhancement may including a threaded plug insert but with the new hole drilled elsewhere, such as rotating the end cover on a motor.

Welded thread repairs have also been used extensively in overhaul workshops for many years with mostly good results. This entails either drilling out existing damaged thread

and plug welding, or cutting away the side of the enclosure near the damaged thread to permit better access for welding nominally used with flameproof motor cases. Both weld repair methods apply significant heat to the enclosure and may cause distortion, so machining of flamepaths will be warranted and perhaps stress relieving.

The Welding Technology Institute of Australia (WTIA) report into the failure of thread repairs on flameproof enclosures, commissioned by the DPI, highlights limitations in the plug welding method which are derived from the Structural Steel Welding Code (Australian Standard AS/NZS 1554.1:2004 *Structural steel welding Part 1: Welding of steel structures*). WTIA's report provides additional advice and precautions about welding repairs and proposes alternative thread repair methods for consideration and trial.

(v) Integrity testing options for thread repairs

Australian Standard AS/NZS 3800 Electrical equipment for explosive atmospheres- Repair and overhaul distinguishes the difference between flameproof enclosure repair and no repair. Structural work on an enclosure to repair a thread by threaded insert or welding would be classified as a repair in terms of AS/NZS 3800:2005 clauses 1.4.27 and 2.3.3 and warrant over-pressure testing of the enclosure in accordance with Appendix G, AS/NZS 3800:2005.

In addition, WTIA recommends that critically important welding and verification activities such as welded thread repairs on flameproof apparatus should be conducted under the guidance of a welding quality management system in accordance with Australian Standard AS/NZS ISO 3834. A welding quality management system approach would identify the minimum competencies of the welder, qualification of a welding procedure specification and a method for qualifying the whole process. Qualifying a critical welding process could take the form of metallographic or other metallurgical examination. The WTIA report can be located at <http://www.minerals.nsw.gov.au> > Safety > Technical Services > Electrical Engineering Safety > Guidance Material > Technical Papers.

(vi) Identifying repairs in the verification dossier

All explosion protected apparatus should be accompanied with a verification dossier. Part of the role of the verification dossier is to identify the history of the apparatus. In this instance it would have been useful to identify specifically each of the threads repaired so that corrective action could result. It would also be appropriate to nominate the repair method and any deviations from standard or qualified procedures.

To date very few instances of failed thread repairs have been identified to the DPI, however the onus is on the workshop conducting the overhaul to verify the integrity of the explosion protected apparatus. The Department's review revealed that it is likely that past overhaul reports nominate that thread repairs have been conducted, but in no instance were the specific threads identified. Therefore it would be appropriate to apply an integrity test to verify the condition of past thread repairs. The selected method of

verification should be appropriate to test the whole repair condition. Magnetic particle and dye penetration tests will not report a condition of thread repair integrity as they only reveal the surface condition of material. The WTIA report considers a number of weld repair integrity test methods.

Recommendations:

As a result of the thread repair failures with this particular motor, it would be appropriate to review current thread inspection and repair methods used within your workshop, or by your preferred service provider. In the course of the Department's investigation a further example of a failed plug weld repair in a flameproof motor was brought to our attention. The Department considers flameproof apparatus as a critical safety feature in an underground coal mine. Overhauls and repairs must be conducted to the highest possible standards. The integrity of repairs needs to be verified by testing and the complete process reported clearly and specifically to the end user of the apparatus.

The WTIA report is recommended reading and is freely available from the DPI website. Identified in the WTIA report, Australian Standard AS/NZS 1554:2004 *Structural steel welding Part 1: Welding of steel structures* sets limits on plug welding applications. These limits need to be considered when repairing flameproof enclosures. Welding processes which have critical safety outcomes must be implemented with an appropriate verification process and qualified by an industry specific body.

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Mine Safety

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Referenced Standards:

AS 1014:1986 *Gauging of metric screw threads*

AS 3501: *Parallel screw threads of Whitworth form (BSW and BSF) and associated gauges and gauging practice*

AS 3635: *Unified (ISO inch) screw threads, associated gauges, and gauging practice*

AS/NZS 1554.1:2004 *Structural steel welding Part 1: Welding of steel structures*

AS/NZS 2290.1:2005 *Electrical equipment for coal mines - Introduction and maintenance, Part 1: For hazardous areas*

AS/NZS 3800:2005 *Electrical equipment for explosive atmospheres – Repair and overhaul*

AS/NZS ISO 3834:1999 *Quality requirements for welding – Fusion welding of metallic materials – Guidelines for selection and use*

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