



Piston Engine Overhaul - Dangers of
Replating Engine Hardware - Hydrogen
Embrittlement

AWB 85-011 **Issue :** 1
Date : 10 June 2009

1. Applicability

All aircraft powered by piston engines which are overhauled using re-plated hardware manufactured from high strength steels.

2. Purpose

Alert engine overhaul facilities of the dangers associated with re-plating highly stressed hardware, such as engine through bolts and cylinder tie down nuts and provide information to assist with major defect investigation.

3. Background

CASA has received several reports of engine thru-bolts and cylinder tie down nuts which have failed following installation on an engine, typically post overhaul, but in new engines received from the manufacturer as well. The in-flight failure of such items of hardware may well result in engine failure and a serious accident.

In most cases, such failures can be attributed to improper heat treatment at manufacture or following local re-plating processes.

The ATSB investigated a failed cylinder nut (pictured below) and found that:

“...The fracture of the failed nut occurred on several longitudinal planes. Fracture initiated from regions of intergranular cracking in the increased section created by the nut flange. Final fracture occurred in a ductile manner.

These features are typical of hydrogen-induced delayed cracking (hydrogen embrittlement), a condition resulting from the presence of hydrogen in the steel and a sustained tensile stress. The effect of thread shape creates a sustained tensile hoop (circumferential) stress in a tightened nut. A particular hazard of cadmium plating high strength steels is the absorption of hydrogen into the base metal. This hazard is countered by baking the parts after plating.

In order to prevent recurrence it is necessary to establish:

- If the hydrogen-removal baking heat treatment had been applied to the nuts.
- If the baking process was controlled in accordance with process specifications. For example was the temperature distribution throughout the batch uniform, and was the time of exposure to the specified temperature the same for all nuts in the batch.



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- If the engineering work order had taken into consideration that the twelve-point nuts are heat treated to a higher strength than the six-point nuts they replace. Longer baking periods may be required to eliminate the hazard of hydrogen embrittlement in higher strength steels.”

Pictures and extract from ATSB report at:

<http://www.atsb.gov.au/publications/2004/tr200401052.aspx>

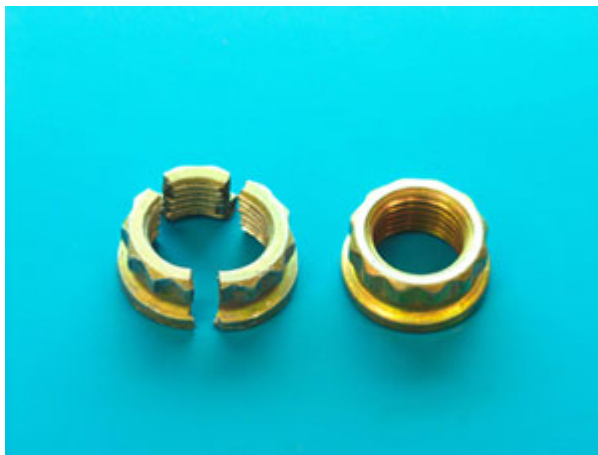


FIGURE 1: Fractured nut as received with an intact nut for comparison.

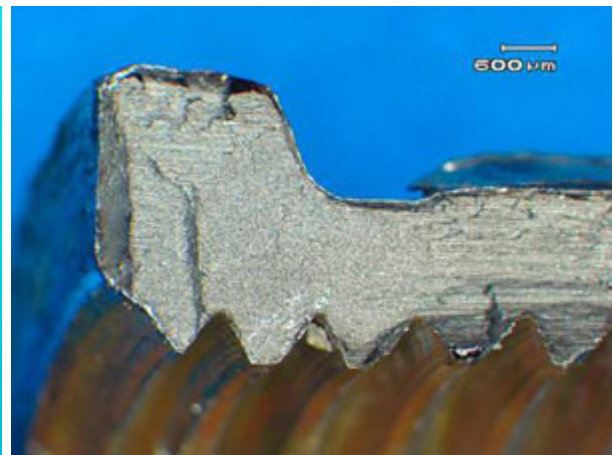


FIGURE 2: Fracture surface showing the brittle cracking region in the centre of the photograph and the surrounding ductile fracture features.

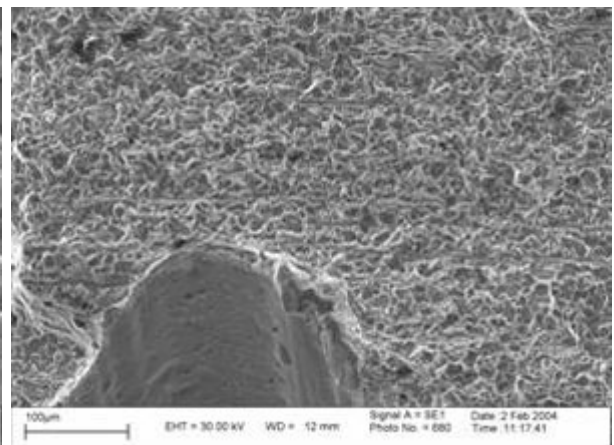
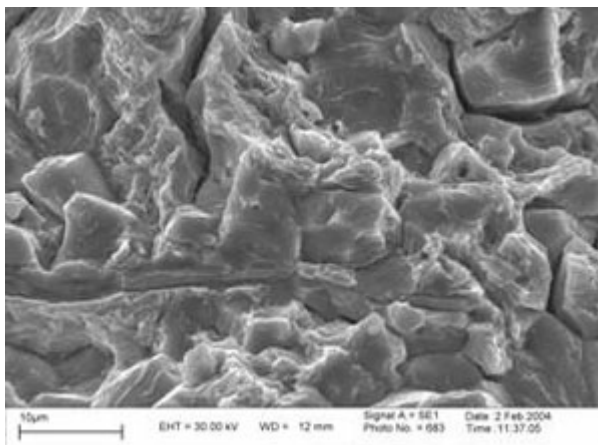


FIGURE 3,4: Scanning electron micrographs of the brittle cracking region.



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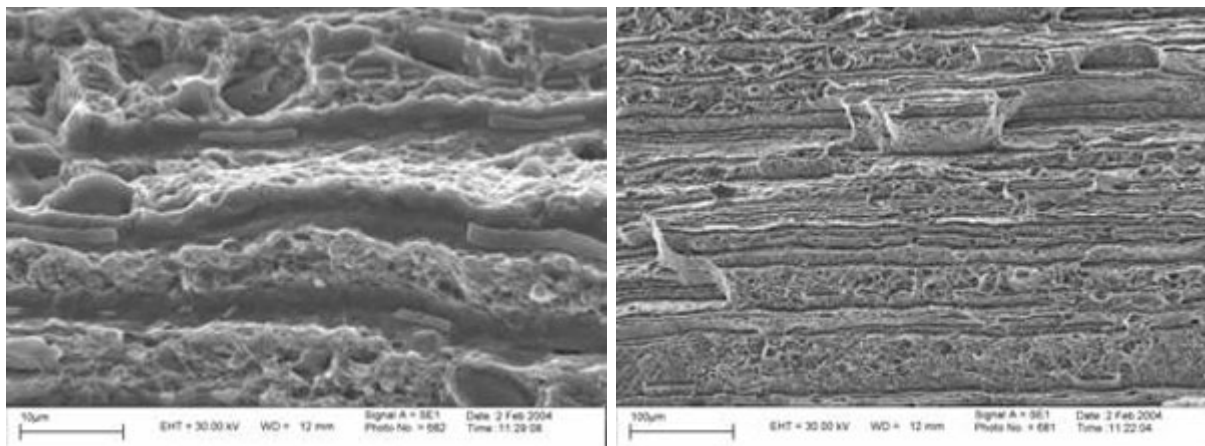


FIGURE 5,6: Scanning electron micrographs showing the features of the ductile fracture region.

4. Recommendation

CASA recommends that engine manufacturing and overhaul facilities review current plating practices, to determine if the cadmium plating and baking process and process controls employed by the plating facility prevent the occurrence of hydrogen-induced delayed cracking in high-strength steel engine hardware, including through-bolts and nuts.

Should the fasteners installed on a new engine at manufacture fail, in the manner described in this AWB, contact the appropriate NAA authority. If the engine was manufactured in the USA, contact the FAA Suspected Unapproved Parts (SUP) office directly.

5. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

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Or in writing, to:
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