## Failed and failing rivets: the correlation to corrosion

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NRC·CNRC

*From Discovery to Innovation...*

# FAILED AND FAILING RIVETS
## the Correlation to Corrosion

**•Large population failed and fractured**

The disassembly of a number of corroded fuselage joints has revealed instances where a large population of the rivets had failed (heads popped off) or fractured. This raised concerns about the integrity of the structure. The wide-spread nature of this deterioration needs to be considered in any analysis of residual strength.

**•Replacement rivets fractured too**

It is known that the rivets are highly stressed and so susceptible to environmentally assisted cracking under sustained stress ($EAC_{ss}$) especially at the base of the countersink.

**•Most fractures at base of countersink**

Where many fractures were initially masked by corrosion products, others were hidden by the faying surface adhesive. In both cases the obscuring substance had to be chemically dissolved to locate and determine the extent of the fracture.

The skins affected were found to be suffering from varying levels of corrosion damage but most were at low levels of thickness loss.

**•No evidence of multi-site fatigue damage**

**•Pillowing cracks have been found**

Ultrasonic NDI techniques have detected failed rivets but this technique is not normally used to inspect fuselage lap joints.

**Conclusions**

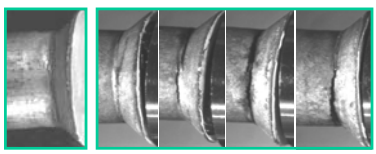
- Individual or combined skin thickness loss, as a result of corrosion, does not correlate to the fracturing of associated rivets. Neither does the pillowing of the skins.

- Modeling of joints should consider rivet failure or degradation of rivet function in the joint at low corrosion levels.

- Rivet failures and fractures are caused by inherent high tensile stress condition and the presence of a corrosive environment.

- The demonstrated susceptibility of rivets to $EAC_{ss}$ requires further study particularly the determination of the residual strength of effected joints.

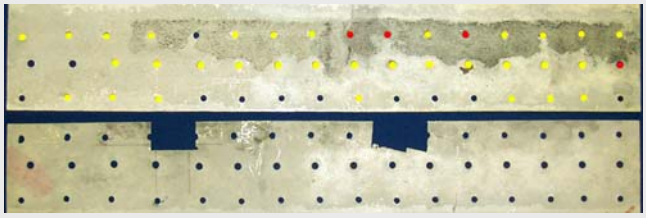
- At present, following the detection of one failed rivet the maintainers are advised to replace an array of the adjacent rivets.



ASL#253. 34M before & after cleaning

**48 Rivets**
4 Failed
32 Fractured
0 Replaced
12 OK
**75%** of fasteners are distressed

B727-295, STR 19R BS440-480. ASL#265



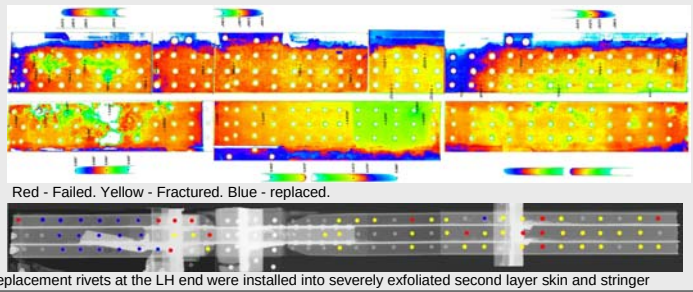

Red - Failed. Yellow - Fractured. Green - OK.

Thickness Loss

| 7sti-3 COMBINED | | OK | Cracked | Failed | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inter-Rivet Locn | 1 | 1 to 2 | 2 | 2 to 3 | 3 | 3 to 4 | 4 | 4 to 5 | 5 | 5 to 6 | 6 | 6 to 7 | 7 | 7 to 8 | 8 | 8 to 9 | 9 | 9 to 10 | 10 | 10 to 11 | 11 | 11 to 12 | 12 | 12 to 13 | 13 | 13 to 14 | 14 | 14 to 15 | 15 | 15 to 16 | Average |
| Skins | | 0.1174 | | 0.1182 | | 0.1171 | | 0.1156 | | 0.1160 | | 0.1152 | | 0.1162 | | 0.1164 | | 0.1167 | | 0.1154 | | 0.1158 | | 0.1163 | | 0.1163 | | 0.1166 | | 0.1167 | 0.1164 |
| Top % loss | | -3.6% | | -3.3% | | -13.4% | | -21.8% | | -23.9% | | -42.2% | | -33.2% | | -14.7% | | -10.9% | | -13.0% | | -26.9% | | -14.7% | | -11.4% | | -10.0% | | -9.1% | -15.4% |
| T-M % loss | | -4.7% | | -7.8% | | -10.2% | | -9.0% | | -16.9% | | -19.1% | | -8.3% | | -10.3% | | -8.2% | | -12.1% | | -16.9% | | -8.4% | | -7.8% | | -6.5% | | -7.6% | -10.1% |
| Middle % loss | | -8.4% | | -7.2% | | -8.2% | | -8.4% | | -7.5% | | -7.1% | | -5.4% | | -7.8% | | -4.2% | | -5.2% | | -7.8% | | -8.4% | | -8.4% | | -7.0% | | -7.5% | -7.0% |
| M-B % loss | | -8.6% | | -7.2% | | -6.9% | | -8.8% | | -5.8% | | -4.3% | | -4.5% | | -4.2% | | -3.2% | | -3.1% | | -5.5% | | -8.9% | | -6.5% | | -6.0% | | -5.2% | -5.6% |
| Bottom % loss | | -10.2% | | -8.1% | | -6.9% | | -6.2% | | -6.7% | | -4.9% | | -4.8% | | -4.6% | | -3.7% | | -4.1% | | -5.9% | | -6.9% | | -5.5% | | -6.0% | | -5.5% | -6.0% |
| MEAN TK LOSS | | -6.7% | | -7.7% | | -9.1% | | -9.7% | | -12.0% | | -15.5% | | -7.2% | | -8.3% | | -5.6% | | -7.5% | | -12.3% | | -9.1% | | -7.9% | | -7.1% | | -7.2% | -8.8% |

**108 Rivets**
13 Failed
31 Fractured
18 Replaced *
46 OK
**57%** of fasteners are distressed

B727-35C, STR 19R, BS660-680. ASL#224




Red - Failed. Yellow - Fractured. Blue - replaced.

Rivet Condition



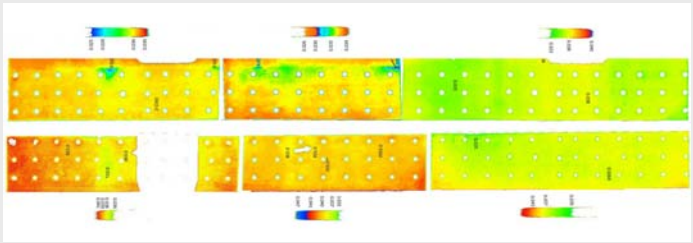
* The 17 replacement rivets at the LH end were installed into severely exfoliated second layer skin and stringer

M23

T10

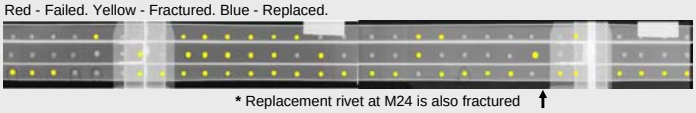
**93 Rivets**
0 Failed
43 Fractured
1 Replaced *
49 OK
**47%** of fasteners are distressed

B727-235, STR 4R, BS 1070-1050. ASL#65B




Red - Failed. Yellow - Fractured. Blue - Replaced.

Rivet Condition



* Replacement rivet at M24 is also fractured

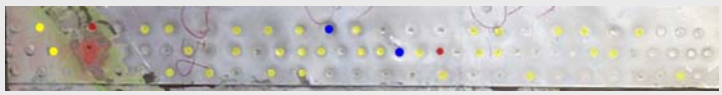
Before Cleaning

After cleaning

ASL#253 32M

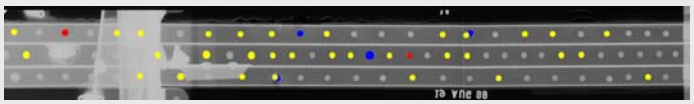
**85 Rivets**
2 Failed
32 Fractured
5 Replaced *
49 OK
**43%** of fasteners are distressed

B707-3J6C, STR20R BS 600G-600H+10. ASL Mil

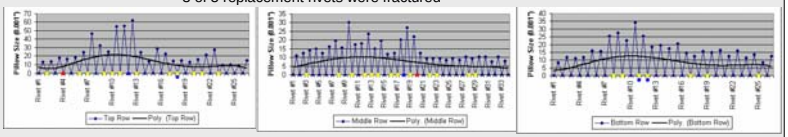



Red - Failed. Yellow - Fractured. Blue - Replaced.

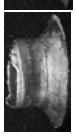
Rivet Condition



* 3 of 5 replacement rivets were fractured



Pillowing measurements of joint prior to disassembly plus rivet conditions after disassembly



ASL#20 T2,T3,T4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CPR-SMPL-2001-0183, R.W. Gould. Rivet and Skin preparation - J. Overton. M. Harrison.
SEM - N. Bellinger. X-ray Thickness Loss - C.E. Chapman, M. Brothers, D. Forsyth

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