



Test Report

This test report may only be published in full, unless permission for the publication of an approved extract has been obtained in writing from the Managing Director. It does not of itself impute to the subject of test any attributes beyond those shown by the data contained herein.

BINDING STRENGTH OF COPPER CLADDING ON ALUMINIUM BUSBARS USING THE ELCOMETER PULL-OFF TEST

Restricted – In Confidence

By
A. S. Maxwell
NPL Materials Division

Summary

Elcometer pull-off tests were conducted to assess the binding strength of copper cladding on aluminium busbars. Tests were conducted using standard 12.7 mm diameter stubs attached to the copper cladding with FM1000 adhesive from Cytec Engineering. Three sets of copper clad specimens were examined which had been exposed to -40 °C to + 110 °C for 0, 50 and 100 cycles. None of the claddings were found to delaminate in the pull-off tests indicating that their binding strengths were all greater than that of the adhesive used to attach the stubs (>61 MPa).

For: Name Dr Jay Song
Company Applied Composite Material Co., Ltd.
319 N. Harvard Ave., Suite 103
Claremont 91711
United States

Telephone: +1 714 602 5737
Email: jaysong12345@yahoo.com
Order No: 2014070246

Reference: 2014070246

Page 1 of 6

Date of issue: 14/10/14

Signed:  (Authorised Signatory)

Checked by: 

Name: Tamaryn Shean on behalf of NPLML

NPL Management Ltd - In Confidence

NATIONAL PHYSICAL LABORATORY

Continuation Sheet

Table 2 *Pull-off tests results for copper clad aluminium busbars*

Disc Number	NPL Material Code	Exposure cycles	Tensile strength (MPa)
1	AAKJZ232A	0	55.60
1	AAKJZ232A	0	60.90
1	AAKJZ232A	0	59.10
2	AAKJZ232B	50	58.10
2	AAKJZ232B	50	59.20
2	AAKJZ232B	50	61.00
3	AAKJZ232C	100	59.10
3	AAKJZ232C	100	60.10
3	AAKJZ232C	100	58.10

Reference: 2014070246

Checked by: *NPL Gower*

Page 4 of 6

Appendix 1 Interfacial strength test

An additional test was conducted for the customer, which was outside the main measurement service contract. This involved conducting an interfacial strength test on a busbar prepared by the customer. The specimen was rectangular shaped with a width of 20mm and precisely drilled with a 4mm long channel cut from the upper copper layer through the sample leaving just the bottom copper layer. A second channel was then cut parallel to the first through the bottom copper layer leaving a bimetallic connecting area (Figure 2). The bars were tested using an Instron 5500 K8026 tensile machine fitted with a calibrated load cell (load cell no. UK034, E11809111310). The specimens were placed in the grips, taking care to align the longitudinal axis of the test specimen with the axis of the testing machine. Tests were conducted at a rate of 1 mm/min and the tests continued until the specimens fractured. Load-cell force measurements were automatically recorded throughout the experiments. The load-displacement results for this test are shown in Figure 3, with the maximum load at fracture recorded as 2.945 kN.

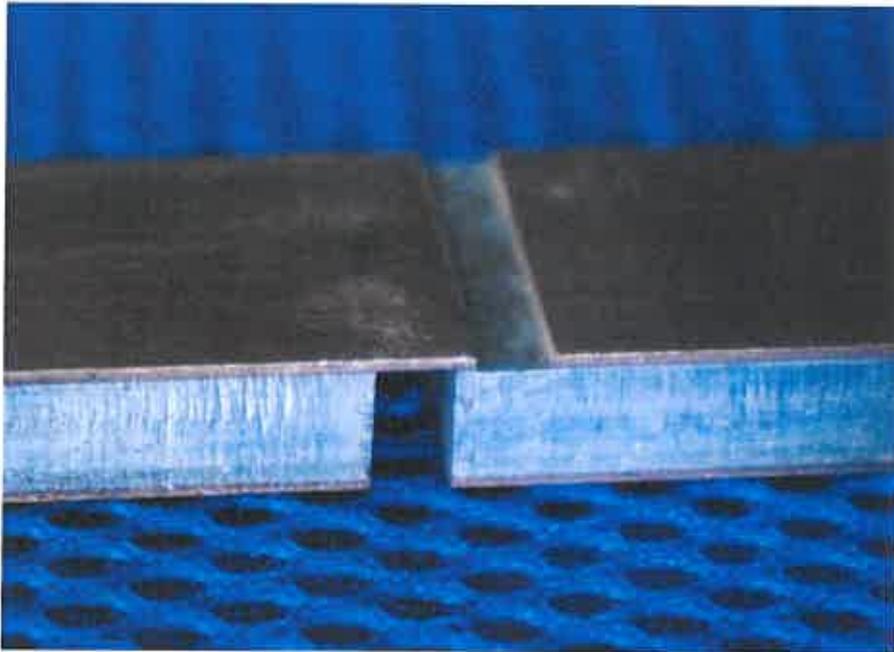


Figure 2 *Typical busbar specimen used for the interfacial strength test*

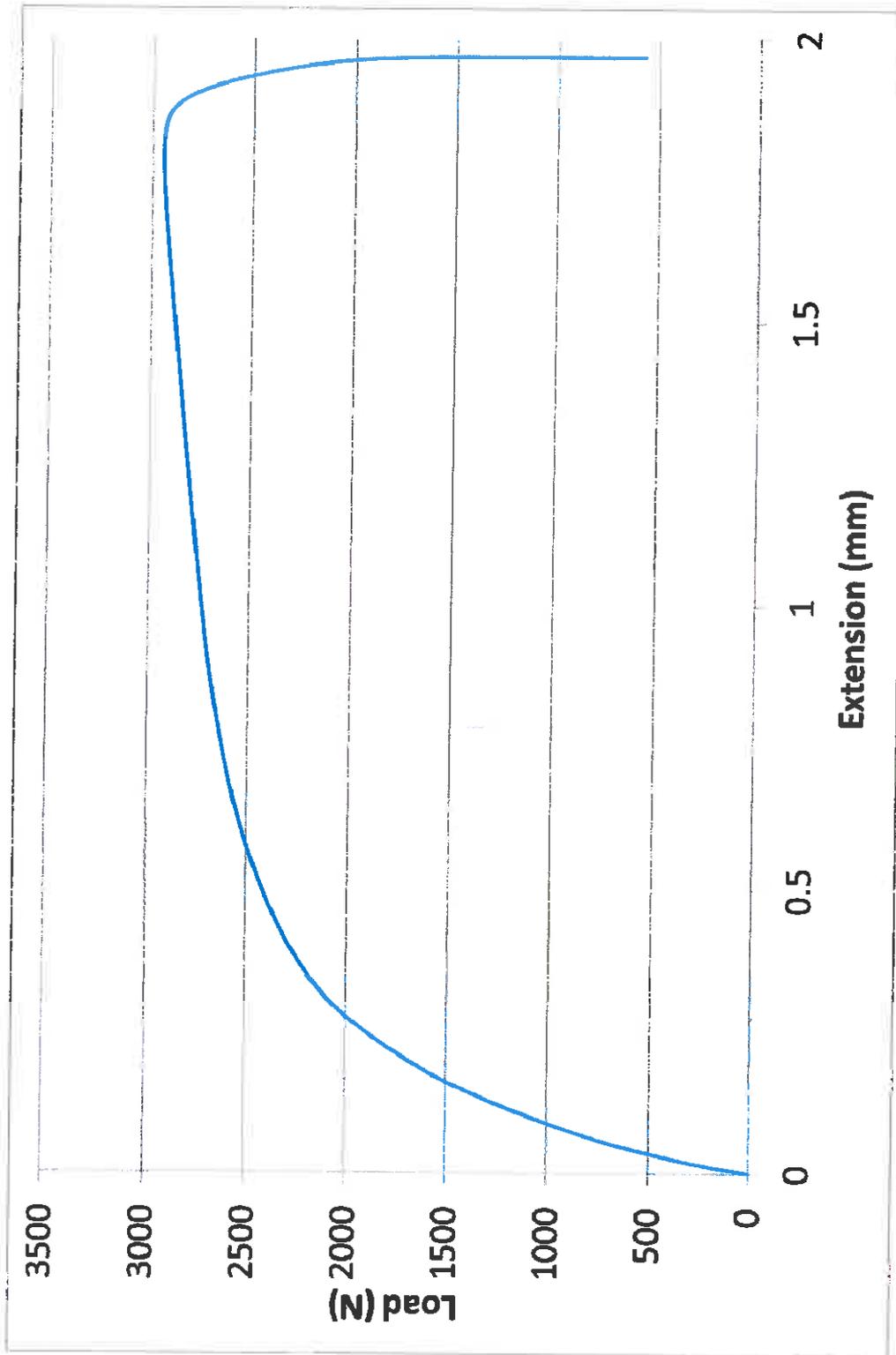


Figure 3 Load-displacement results obtained from interfacial strength test.

Reference: 2014070246

Checked by: *M.L. Gower*