

CadWeld Tensile Test for Poland Market

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1. Background

For the Poland market following two tapes of different sizes were received,

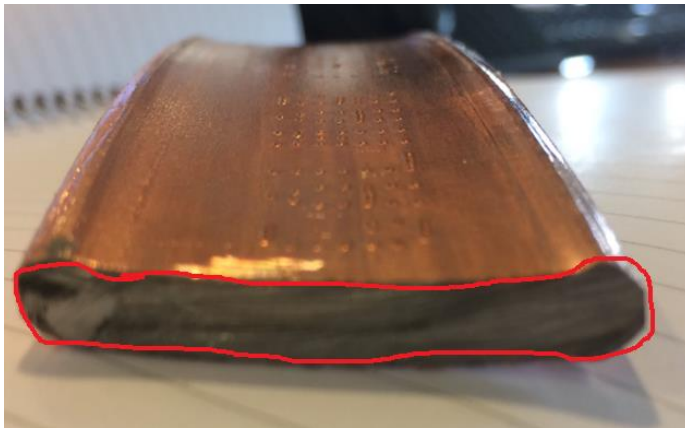
- Copper-bonded
- Galvanized

Following results was obtained after measuring all the tapes,

Tape type	Tape size (mm)	Width (mm)		Thickness (mm)	
		Min	Max	Min	Max
Copper-Bonded	30 x 4	27.71	29.85	4.25	5.28
Copper-Bonded	40 x 5	40.1	40.4	5.43	5.96
Galvanized	25 x 4	24.97	25.11	4.17	4.37
Galvanized	30 x 4	29.98	30.04	4.16	4.49
Galvanized	40 x 5	40.09	40.18	5.47	5.65
Galvanized	50 x 5	50.06	50.19	5.1	5.38

As it can be seen Galvanized tape is constant on its size where copper tape varies special on the edge because of the dog bone effect. Dues to this reason one of the concern from the customer was the copper tape would not fit on the standard molds for its respective size.

See the picture below (highlighted in red) which illustrates the dog bone effect on copper bonded tape,



2. Test objective


Based on the customer requirement, test was conducted to illustrate the following,

- i. Verify tensile strength (19.14 KN) of Cadweld connection per polish market requirement, on following connections for 40 mm x 5 mm copper and galv tape.
 - a. BBC
 - b. BMC
 - c. EBC
- ii. Conduct Cadweld exothermic process on materials for the region, meaning verify standard mold would work for the copper bonded and galv tapes
- iii. Illustrate importance of proper material preparation

3. Test Equipment used

DMR-40 micro meter and MTS Machine test were used to test the conductor resistance and to perform the tensile test respectively. Following you can see the pictures of the equipment used.

3.1. DMR-40 micro meter

 <p>DMR-40 Micro-ohmmeter</p>	Micro ohmmeter specification	
	Precision	0,1% of the reading, +/- 2 counts
	Measurement Range	0,01 $\mu\Omega$ to 200 Ω
	Resolution	4 $\frac{1}{4}$ numbers
	Running Temperatures	-20° C to +50° C (-4° F to 122° F)
	Storage Temperatures	-40° C to +50° C (-40° F to 122° F)
	Humidity	0 to 95% non condensed. Submersible, rain proof
	Measurement Current	5 mA, 250 mA, 5A
	Autonomy	more than 5000 measurements, at 5A more than 10 000 measurements, for the other currents
	Battery	Six (6) 1.2V, 2.1Ah rechargeable "A" NiMh batteries
	Charger	12V 1A adapter with sealed connector, available for 110V or 220V
	Display	Liquid crystal 128 X 64 dots, wide ranging temperatures 2.36 X 1.62 in. (60 X 41 mm) 2 back-lighting intensities (100%, 50%) 8 X 4.5 X 2 in.
	Size & Dimension	(203.3 X 114.3 X 50.8 mm)
	Weight	1.9 lbs (0.86 kg)

3.2. MTS Machine Test



4. Test Preparation

Three molds (table below) were prepared in order to make all the required CadWeld connections,




CadWeld	Mold Details						
	Part#	IP#	Desc1	Desc2	Desc3	Metal/Qty	PLUS
BBC	BBCFAL	IPP/6611	5X40MM LUG/BUS	5X40MM LUG/BUS	3MM GAP	#150 W/M	150PLUSF20
BMC	BMCFALFAL	IPP/6612	5X40MM LUG/BUS	5X40MM LUG/BUS	3MM GAP	#150 W/M	150PLUSF20
EBC	EBCFALFAL	IPP/6777	5X40MM LUG/BUS	5X40MM LUG/BUS	BOTH & WIDER	#250 W/M	250PLUSF20

Before doing the Cadweld connection following preparation were done,


- Tapes were straighten using straightening machine
- Tapes were cut into small pieces, approx. 30 cm
- All three molds were pre-heated using propane torch to approx. 120°C
- Conductors were dried using propane torch
- Conductor were cleaned using metal wire brush
- For galv conductor, galv coating was removed using angle grinder


As a result of the preparation following results (in next page) were obtained for each CadWeld connection.

4.1. BBC



Copper connection	Comment
	<p>As seen in the picture heat transfer around the Cadweld connection is very uniform, which represents very good cadweld connection.</p>
Copper connection without proper preparation	Comment
	<p>In this case there is hardly any heat transfer around the connection, meaning the connection is not well done.</p>
Galv connection	Comment
	<p>Heat transfer is not clear in Galv that is due to the properties of galv. However the colour (similar to copper connection) of the connection shows how good the connection is.</p>

4.2. BMC

Copper connection	Comment
	<p>As seen in the picture heat transfer around the Cadweld connection is very uniform, which represents very good cadweld connection.</p>

Galv connection	Comment
	Heat transfer is not clear in Galv that is due to the properties of galv. However the colour (similar to copper connection) of the connection shows how good the connection is.

4.3. EBC

Copper connection	Comment
	As seen in the picture heat transfer around the Cadweld connection is very uniform, which represents very good cadweld connection. There is some side leakage but the connection itself is still very good.
Galv connection	Comment
	Heat transfer is not clear in Galv that is due to the properties of galv. However the colour (similar to copper connection) of the connection shows how good the connection is.

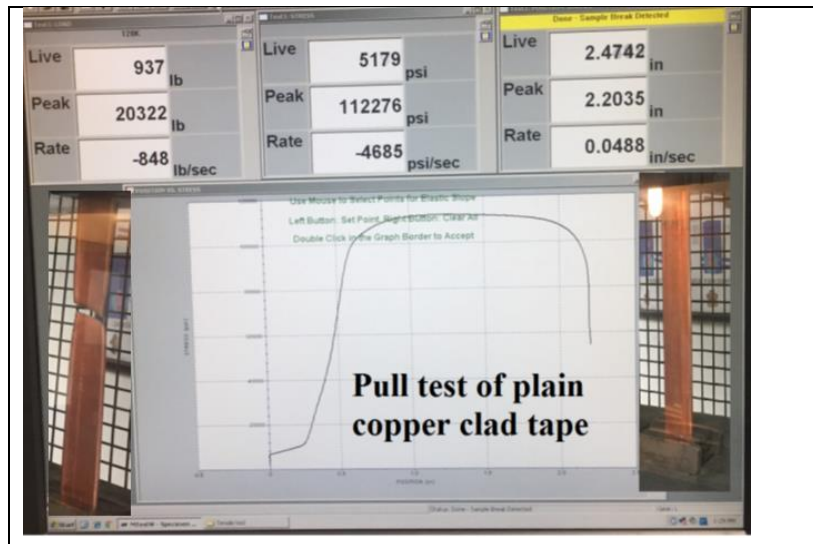
5. Test

5.1. Resistance measurement

Resistance of each Cadweld connection, copper bonded tape and galv tape was measured using DMR-40 micro meter. Measurement reading can be found in chapter 5 test results.

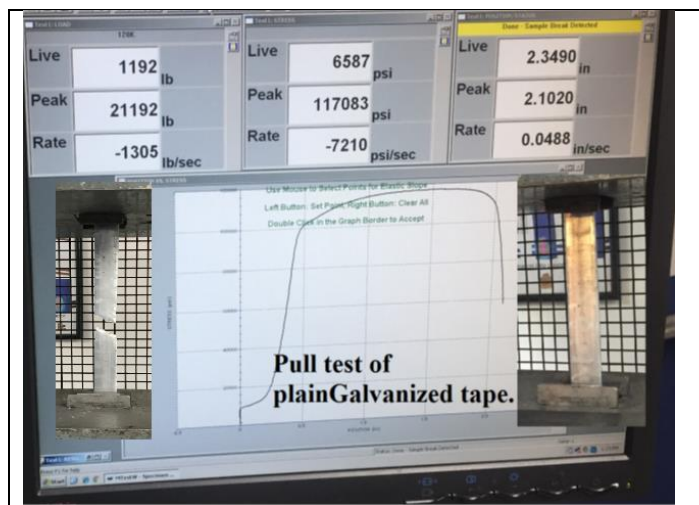
5.2. Copper breaking load test

Plain copper was used for this test to measure its breaking load which would then be compared to breaking load test for different Cadweld connection. Break was detected at peak load of 20322 lb which is equivalent to 90.4KN. See below the test result.



5.3. Galv breaking load test

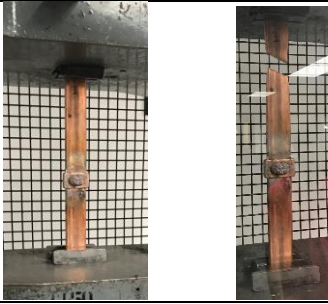
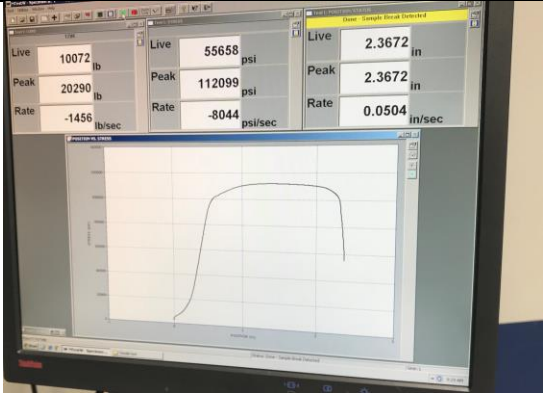
Plain galv tape was used for this test to measure its breaking load which would then be compared to breaking load test for different Cadweld connection. Break was detected at peak load of 21192 lb which is equivalent to 94.2 KN. See below the test result.



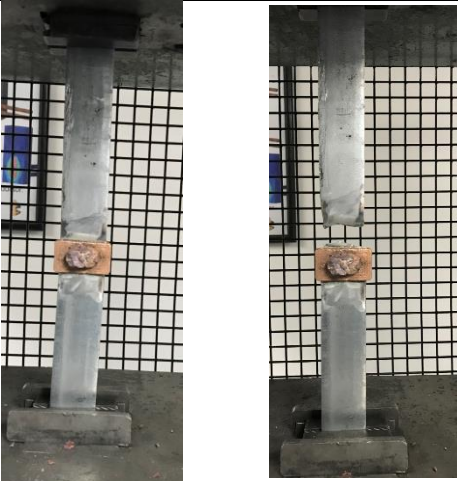
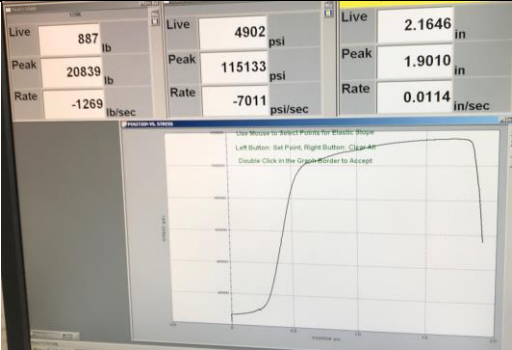
5.4. BBC

BBC connection was tested for its breaking load, following are the details of the test.

5.4.1. Copper-bonded Tape

Configuration	Comment
	<p>Picture showing,</p> <ul style="list-style-type: none"> - Test setup - Breaking point on conductor
Test result	Comment
	<p>Break was detected on peak load 20290 lb which is equivalent to 90.2 KN</p>


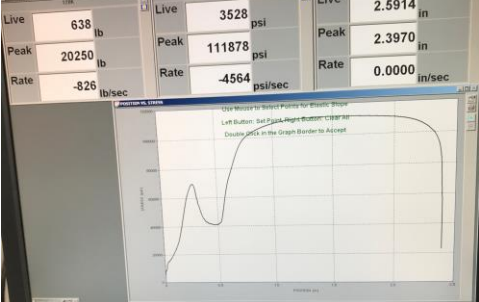
5.4.2. Galvanized Tape

Configuration		Comment
		Picture showing, <ul style="list-style-type: none"> - Test setup - Breaking point on conductor
Test result		Comment
		Break was detected on peak load 20839 lb which is equivalent to 92.6 KN


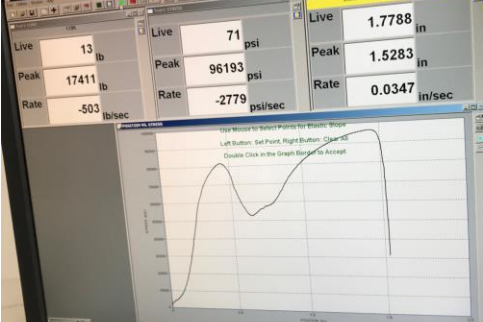
5.5. BMC

BMC connection was tested for its breaking load, following are the details of the test.

5.5.1. Copper-bonded Tape


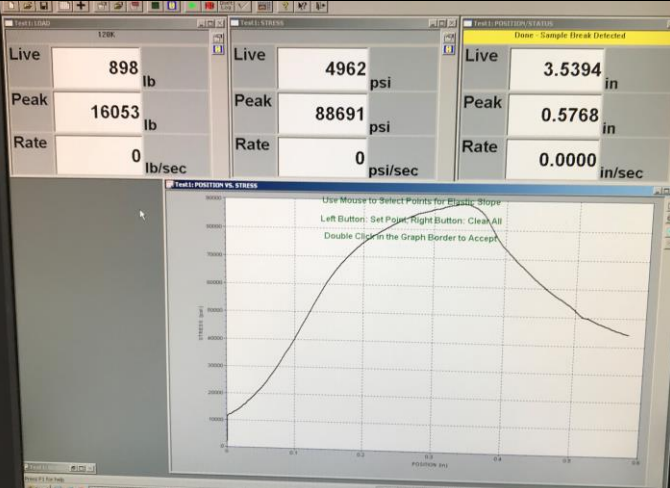
Configuration	Comment
	Picture showing, <ul style="list-style-type: none"> - Test setup - Breaking point on conductor
Test result	Comment
	Break was detected on peak load 20250 lb which is equivalent to 90 KN

5.5.2. Galvanized Tape

Configuration	Comment
	Picture showing, <ul style="list-style-type: none"> - Test setup - Breaking point on conductor
Test result	Comment
	Break was detected on peak load 17411 lb which is equivalent to 77.4 KN

5.6. EBC

EBC connection pull testing was not completed due the fixturing damaging the MTS machine. The test sample reached 16053 lbs (71.4 KN) before shunting off. The machine failed due to the limit switch.

Configuration	Comment
	Picture showing, - Test setup
Test result	Comment
 <p>The screenshot displays the MTS software interface. On the left, a 'Test Load' panel shows: Live 898 lb, Peak 16053 lb, Rate 0 lb/sec. In the center, a 'Test 3: 32893' panel shows: Live 4962 psi, Peak 88691 psi, Rate 0 psi/sec. On the right, a 'Test 1: POSITION STATUS' panel shows: Live 3.5394 in, Peak 0.5768 in, Rate 0.0000 in/sec. Below these panels is a 'Test 1: POSITION VS. STRESS' graph showing a stress-strain curve. The y-axis is 'STRESS (psi)' ranging from 0 to 80,000. The x-axis is 'POSITION (in)' ranging from 0 to 0.6. The curve rises to a peak and then begins to drop. A message box on the graph says: 'Use Mouse to select Points for Plastic Slope. Left Button: Set Point, Right Button: Clear All. Double Click on the Graph Border to Accept.'</p>	Break was detected on peak load 16053 lb which is equivalent to 71.4 KN



6. Test Result

Below table give all the test results (resistance & tensile) obtained from different connections.

Test No	Material	Size (mm)	Connection type	Weld Metal	Comment	Bar Inspection	RESISTANCE TEST ($\mu\Omega$)	PULL TEST (lb)	PULL TEST (KN)
1	PULL TEST OF Galvanized tape	5X40MM LUG/BUS	N/A	N/A	Bar break no weld	Galvanized Surface	N/A	21192	94.2
	PULL TEST OF Galvanized tape	5X40MM LUG/BUS	N/A	N/A	Bar break no weld	Galvanized Surface	N/A	20886	92.9
	PULL TEST Copper bonded tape	5X40MM LUG/BUS	N/A	N/A	Bar break no weld	oil/grease on surface	N/A	20322	90.3
	PULL TEST Copper bonded tape	5X40MM LUG/BUS	N/A	N/A	Bar break no weld	oil/grease on surface	N/A	20308	90.3
2	RESISTANCE IN MICRO OHMS Galvanized tape	5X40MM LUG/BUS	N/A	N/A	resistance .75 inches (19mm)	oil/grease on surface	15.6	N/A	N/A
	RESISTANCE IN MICRO OHMS Copper bonded tape	5X40MM LUG/BUS	N/A	N/A	resistance .75 inches (19mm)	oil/grease on surface	14.3	N/A	N/A
3	Copper bonded tape	5X40MM LUG/BUS	BBCFAL	150PLUSF20	Standard preparation	surface degreased	9.31	20571	91.5
	Galvanized tape Removed	5X40MM LUG/BUS			Standard preparation	Galvanized Removed	8.65	20839	92.6

Tensile test for copper bonded and Galvanize tape



4	Copper bonded tape	5X40MM LUG/BUS	BMCFALFAL	150PLUSF18	Standard preparation	surface degreased	9.7	20250	90
	Galvanized tape	5X40MM LUG/BUS			Standard preparation	Galvanized Removed	10.26	16053	71.4
5	Copper bonded tape	5X40MM LUG/BUS	EBCFALFAL	250PLUSF20	Standard preparation	surface degreased	5.52	N/A	N/A
	Galvanized tape Removed	5X40MM LUG/BUS			Standard preparation	Galvanized Removed	7.84	N/A	N/A

7. Conclusion

With the above test following can be concluded.

1. Cadweld connection meets the customer's tensile requirements of 19.14 KN
2. With proper material preparation,
 - a. Good Cadweld connection can be achieved (section 4.1)
 - b. Copper bonded/Galv tape size will not have issues fitting into the mold or leaking weld metal.