(1) PLANT INFORMATION:	(2) NOTIFICATION TYPE:	(3) DATE:	
112 BRYAN BLVD SHANNON, MS 38868-8763 Cage Code: 4US81 Plant: 2003	GN-NR	08/18/2020	
(4) SUPPLIER INFORMATION:	(5) RELATED NOTIFICATION:	(6) CSI/CAI:	(7) CFR:
See Plant Information above	7065348	NO	NO
(8) PART NAME:	(9) PART/DWG NO.:		(10) REV:
ZBOM	39532-D-3100		B
(11) CLASSIFICATION: (PRIORITY)	(12) LOCATION:	(13) HWCI NO. AND NAME:	
Major	EMS Tupelo	39532-D-3105-2 - THERMAL BRIDGES, OD, PS2	
(14) CONTRACT NO.:	(15)CONTRACT DELIVERY ITEM NO:	(16) WBS:	(17) PROJECT NO.:
618313	NA	39532-2.1.2.3.3	39532
(18) PROD ORDER-OPERATION NO.:	(19) NETWORK-OPERATION ACC:	(20) LOT SIZE:	(21) QTY. INSP.: (REF.)	(22) QTY. REJ.: (COMP.)
N/A	N/A	N/A	N/A	24
(23) INITIATOR:	(24) EXTERNAL REFERENCE NO.:	(25) NONCONFORMANCE RESPONSIBILITY:	
SHARON DAVENPORT	N/A	GA Responsible	

(26) EFFECT ON CONTRACT COST/PRICE:

NA

(27) EFFECT ON DELIVERY SCHEDULE:

NA

(28) EFFECT ON LOGISTICS SUPPORT, INTERFACE, OR SOFTWARE:

NA

(29) ADDITIONAL INFORMATION:

N/A

(30) SERIAL NUMBER(S):

N/A

(31) REQUIREMENTS: (DESCRIPTION)

Thermal bridges to be continuous (PS2)
08/18/2020 16:16:04 PST SHARON DAVENPORT (DAVESH)
Each thermal bridge to be a single continuous piece per Mu2e-doc-3647 (Reference Design of the Mu2e Production Solenoid.)
10/16/2020 08:25:18 PST (DAVESH)
This text replaces the previous text: Each Outer diameter thermal bridge (39532-D-3105-2) must be produced as a single continuous piece of the length sufficient to make the connection with the cooling tubes per Mu2e-doc-3647 (Reference Design of the Mu2e Production Solenoid.)

(32) NONCONFORMING CONDITION: (TEXT)

Item No: 0001 Found At: EMS Tupelo Defect Code: HDDM INS - Hardware Damaged Damaged outer thermal bridge(s)
10/16/2020 08:26:16 PST (DAVESH)
During lead excavation on the PS2 Coil (39532-D-3122) per Mu2e Manufacturing Work Instruction 39532P00060, operation 320, a technician damaged the aluminum thermal bridges. Twenty-three outer thermal bridges were scratched and dented near their bases during removal of a glass "skirt' (that remained after coil machining) at the parting line between the glass over the thermal bridges and the glass covering the core. One additional thermal bridge was also cracked halfway across at its base. All thermal bridges require sharp bends in order to exit the magnet assembly at the proper location (through slots in the shell). This particular thermal bridge may break completely upon bending, and the others may have some degradation of their heat removal function as well.

(33) DISPOSITION, FINAL CONDITION AND TECHNICAL JUSTIFICATION:

Item No: 0001 - Use As is - Use As Is
10/16/2020 08:30:30 PST (DAVESH)
DISPOSITION: Use As Is per the following instructions:

1. Bend the outer thermal bridges (except the cracked one) into place per Operation 350 of 39532P00060 Rev. A (PS2 Coil and Shell Assembly Work Instructions). If any thermal bridge cracks, stop work and notify Engineering immediately for further direction.
   a. While gripping the free end of the thermal bridge start to bend it over 90°and using a plastic head mallet, gently tap the thermal bridges to its final horizontal position.
2. Remove the cracked thermal bridge (labeled #7) at Operation 350 and gently file down any sharp edges ensuring cleanliness is maintained.

TECHNICAL JUSTIFICATION:
The 23 thermal bridges cannot be repaired or replaced at this point. Though deformed with dents at the base, as long as the metal in the thermal bridges is still intact (with no cracks) they can still function in place (although coil cooling may be reduced during operation). [This is not true for any cracked thermal bridge(s), so any cracks occurring at this final bend must be reported to Engineering for evaluation & disposition].

10/16/2020 13:05:01 PST (SPIEKE)
A thermal bridge bending test was conducted with spare thermal bridges to assess how denting may affect bending the bridges in to their designed slots. The results showed that the work hardening from the flexing (multiple times) appreared more damaging than the dents themselves, and that any bending of thermal bridges during assembly should be minimized. Thermal Bridge Bending Test presentation is attached to the QN.

(34) CAUSE OF DISCREPANCY:

Item No: 0001 Cause: EP03 - Handling/Packaging Error (Process) Cause Text: Glass "skirt" req'd removal
10/16/2020 08:27:22 PST (DAVESH)
During machining of the coil, a conservative undercut was used to avoid the thermal bridges. This left a thin ridge of glass/resin material beyond the coil pack that had to be removed after insertion so that the thermal bridges can be bent down properly. [The only thing between thermal bridges and outer glass is a thin sheet of Teflon.] One chisel type process used to remove some of this glass "shell" damaged the 24 thermal bridges.

Item No: 0001 Cause: EP01 - Workmanship (Process) Cause Text: Reliance on Operators skill
10/16/2020 12:14:29 PST (SPIEKE)
Technician was overly aggressive with glass removal technique causing damage to the thermal bridges.

Item No: 0001 Cause: EP02 - Training Inadequate (Process) Cause Text: Tech not properly trained or Supervised
10/26/2020 15:36:27 PST (SPIEKE)

The technicians were not trained nor properly supervised when starting the work. The damage went unnoticed until 24 thermal bridges were damaged.

Item No: 0001 Cause: EP04 - Work Inst/Proc/Plng/ProgError (Process) Cause Text: Out of scope work not identified
10/26/2020 15:48:23 PST (SPIEKE)

Removal of the glass skirt was not identified or called out in the Work Instruction Operation being performed, and an approved procedure / technique was not documented to effectively remove it.

(35) CORRECTIVE ACTION: (EXECUTION)

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Obtain Cause &CA

Item No: 0001 Task Code: NOTF Task Code Text: Notify Responsible Organization Task Text : Notify Customer
10/16/2020 10:20:53 PST (DAVESH)
A Powerpoint presentation showing the cause of the thermal bridge damage was presented to the customer on 9/9/20.
10/26/2020 15:53:25 PST (SPIEKE)

Received FNAL feedback on cause and corrective actions on 10/26/20 and have incorporated their comments.

12/15/2020 08:34:47 PST (SPIEKE)

FNAL review and concurrence of QN (via e-mail) attached in SAP.

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Immediate Action:Execute Dispo
10/16/2020 09:50:35 PST (DAVESH)
Execute Disposition, pending FNAL review and approval of corrective actions described in this QN report and attachments (to be provided via separate correspondence and attached to this QN).

12/15/2020 09:24:38 PST (SPIEKE)

Per the disposition of the QN, the thermal bridges were "used as-is" per the instructions provided in the QN and attachments. Initial bends were completed on the Lead end outer thermal bridges on 11/4/20. It is noted that there was some slight cracking discovered on the outside surface of TB#5 that had not previously been observed (and recorded). FNAL was informed via e-mail on 11/3/20. Wet lay-up of the washer plates and leads was completed per Operation 340 of 39532P00060, and then secondary bends on the outer thermal bridges was completed on 11/10/20. The first bend of the inner thermal bridges was completed and the coil was flipped on 12/2/20. A Splice end thermal bridge inspection was completed and the initial bend to the Splice end outer thermal bridges was completed on 12/3/20. There was no damage observed on the Splice end thermal bridges.

Item No: 0001 Task Code: RPOS Task Code Text: Revise Process Task Text : Future Action(s)
10/16/2020 09:46:21 PST (DAVESH)
1. Train all technicians on the incident to help prevent reoccurrence (provide training OQE).
2. Supervisor to conduct a pre-job brief prior to non-routine (error prone) evolutions (see the GA-EMS Human Performance Tool Pre-Job brief checklist as an example).
3. For PS1:
a. Add a thicker and wider layer of Teflon to the parting lines so that at OD machining the lathe tool can gouge the first sign of Teflon while safely avoiding damage to the thermal bridges.
b. Cut a wider (wider than 1 inch) machined groove for the parting lines.
c. If the glass skirt on PS1 is not completely removed during OD machining then the remaining "skirt" shall be completely removed/cleaned away prior to coil insertion into the shell.
d. A method shall be devised and tested to remove the remaining skirt without gouging into the thermal bridges.
e. Inspection shall verify that the metallic surface of the TB's is exposed at the parting lines prior to coil insertion.

10/26/2020 16:02:42 PST (SPIEKE)

Amplifying actions for 3c. above: If glass skirt on PS1 is not removed, provide more explicit guidance on how to remove it to insure no damage to thermal bridges.

Amplifying actions for 3d. above: Revise future work instructions to prevent the use of chisels on thermal bridges and show how to use the putty knife technique instead.

12/15/2020 10:56:18 PST (SPIEKE)

Training was completed on 11/3/20 - Training OQE attached.

PS1 Coil and Shell Assembly and Coil Machining Manufacturing Work Instructions (MWIs) 39532P00055 and 39532P00053, respectively, are being revised at this time to include lessons learned from this QN.

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Discrepant Material to Block Status
10/21/2020 05:35:25 PST (HOLLIJ) Phone 662566 3044
This is WIP material. WIP material does not exist in SAP. There is nothing to process systematically.

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Remove From Blocked Status
10/21/2020 05:36:32 PST (HOLLIJ) Phone 662566 3044
This is WIP material. WIP material does not exist in SAP. There is nothing to process systematically.

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Update Prod Order with QN Info
11/18/2020 12:40:49 PST (HARMAS)
no order to update

(36) ECR Number:	(37) ECN Number:	(38) CAR:
NA	NA	NA

APPROVALS:

TASK	COMMENTS	APPROVER	APPROVED DATE/TIME
Provide Pre-Disposition	Create QN	SHARON DAVENPORT	10/16/2020 08:32:44
MRB Approval - Manufacturing Engineering	ME Approval	JONATHAN MILLER	10/19/2020 07:18:56
MRB Approval - Engineering	ENG Approval	Robert Mackintosh	10/16/2020 10:49:07
MRB Approval - Quality Engineering	QE Approval	KEVIN SPIELDENNER	10/16/2020 12:20:42
MRB Approval - Manufacturing Engineering	Manager Approval	Mark J. Myers	10/27/2020 13:02:34

TASK	COMMENTS	APPROVER	APPROVED DATE/TIME
MRB Approval - Internal MRB (EMS)	IMRB Approval	KEVIN SPIELDENNER	10/27/2020 13:19:59
Coordinator Distribute QN	Distribution for Action	KEVIN HICKEY	10/29/2020 15:07:40
Execute Disposition Tasks for Closure	Execution of Disposition	JONATHAN MILLER	11/12/2020 09:19:55
Close Quality Notification	QE review and close	KEVIN SPIELDENNER	12/15/2020 11:47:13

From:	Thomas M. Page
To:	Spieldenner, Kevin; Mackintosh, Robert F.; Sandor Feher; Karie E. Badgley; Clark, Paul; Miller, Jonathan; James A Hocker; Vadim Kashikhin; Michael J Lamm; Ronald E Ray; Juliana Whitmore; Chitwood, Neil; Davenport, Sharon; Hearsum, Andrew; Myers, Mark; Hickey, Kevin; Selby, James
Cc:	Thomas M. Page
Subject:	-EXT-RE: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.
Date:	Monday, November 2, 2020 11:09:25 AM

Kevin,

We have completed our review and concur with this latest revision.

Thanks.

-Tom

Thomas Page
Mechanical Engineer

APS-TD / Magnet Systems
Fermi National Accelerator Laboratory
P.O. Box 500, MS 312
Batavia, Illinois 60510 USA

630 840 8019 office
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tpage@fnal.gov

From: Spieldenner, Kevin <Kevin.Spieldenner@ga.com>
Sent: Tuesday, October 27, 2020 3:32 PM
To: Thomas M. Page <tpage@fnal.gov>; Mackintosh, Robert F. <Robert.Mackintosh@ga.com>; Sandor Feher <fehers@fnal.gov>; Karie E. Badgley <kbadgley@fnal.gov>; Clark, Paul <Paul.Clark@ga.com>; Miller, Jonathan <Jonathan.Miller@ga.com>; James A Hocker <hocker@fnal.gov>; Vadim Kashikhin <vadim@fnal.gov>; Michael J Lamm <lamm@fnal.gov>; Ronald E Ray <rray@fnal.gov>; Juliana Whitmore <jaws@fnal.gov>; Chitwood, Neil <Neil.Chitwood@ga.com>; Davenport, Sharon <Sharon.Davenport@ga.com>; Hearsum, Andrew <Andrew.Hearsum@ga.com>; Myers, Mark <Mark.Myers@ga.com>; Hickey, Kevin <Kevin.Hickey@ga.com>; Selby, James <James.Selby@ga.com>
Subject: RE: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.

Tom and all,
Good afternoon. Revised QN 7071839 – Damaged thermal bridges – PS2 Coil Assembly, for FNAL review and concurrence. Changes from earlier version have been highlighted in yellow.

Very respectfully,

Kevin Spieldenner
Quality Engineer, Quality Assurance Division
General Atomics
Electromagnetic Systems Group (GA-EMS)
858-676-8750 Office
16470 West Bernardo Drive
San Diego, CA 92127

From: Thomas M. Page <tpage@fnal.gov>
Sent: Monday, October 26, 2020 1:48 PM
To: Spieldenner, Kevin <Kevin.Spieldenner@ga.com>; Mackintosh, Robert F. <Robert.Mackintosh@ga.com>; Sandor Feher <fehers@fnal.gov>; Karie E. Badgley <kbadgley@fnal.gov>; Clark, Paul <Paul.Clark@ga.com>; Miller, Jonathan <Jonathan.Miller@ga.com>; James A Hocker <hocker@fnal.gov>; Vadim Kashikhin <vadim@fnal.gov>; Michael J Lamm <lamm@fnal.gov>; Ronald E Ray <rray@fnal.gov>; Juliana Whitmore <jaws@fnal.gov>; Chitwood, Neil <Neil.Chitwood@ga.com>; Davenport, Sharon <Sharon.Davenport@ga.com>; Hearsum, Andrew <Andrew.Hearsum@ga.com>; Myers, Mark <Mark.Myers@ga.com>; Hickey, Kevin <Kevin.Hickey@ga.com>; Selby, James <James.Selby@ga.com>
Cc: Thomas M. Page <tpage@fnal.gov>
Subject: -EXT-RE: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.

Kevin,

We completed our review, here are our comments.

1) Add the following to the "Cause of Discrepancy" section.
- This work was out of scope work. This was not called out in the Work Instruction and an approved procedure / technique was not documented. (Add this work to Work Instructions.)
- The technicians were not trained nor properly supervised when starting the work. The damage went unnoticed until 24 thermal bridges were damaged.

2) On Page 31 of the QN (Slide 28 on the attached PowerPoint file), there are 7 Future Actions. Two of them (number 3 and 6, listed below) are not specifically listed as the corrective actions in the QN document. Please add these to the Corrective Actions in the QN document.

- Number 3. Revise future work instructions to prevent the use of chisels on thermal bridges and to show how to use the putty knife technique instead.
- Number 6. If glass skirt on PS1 is not removed, provide more explicit guidance on how to remove it to insure no damage to thermal bridges.

3) If the glass skirt is not removed by the machining, GA should notify FNAL and discuss how to proceed before doing any manual work.

Thanks.

-Tom

Thomas Page
Mechanical Engineer

APS-TD / Magnet Systems
Fermi National Accelerator Laboratory
P.O. Box 500, MS 312
Batavia, Illinois 60510 USA

630 840 8019 office
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From: Spieldenner, Kevin <Kevin.Spieldenner@ga.com>
Sent: Monday, October 19, 2020 2:53 PM
To: Thomas M. Page <tpage@fnal.gov>; Mackintosh, Robert F. <Robert.Mackintosh@ga.com>; Sandor Feher <fehers@fnal.gov>; Karie E. Badgley <kbadgley@fnal.gov>; Clark, Paul <Paul.Clark@ga.com>; Miller, Jonathan <Jonathan.Miller@ga.com>; James A Hocker <hocker@fnal.gov>; Vadim Kashikhin <vadim@fnal.gov>; Michael J Lamm <lamm@fnal.gov>; Ronald E Ray <rray@fnal.gov>; Juliana Whitmore <jaws@fnal.gov>; Chitwood, Neil <Neil.Chitwood@ga.com>; Davenport, Sharon <Sharon.Davenport@ga.com>; Hearsum, Andrew <Andrew.Hearsum@ga.com>; Myers, Mark <Mark.Myers@ga.com>; Hickey, Kevin <Kevin.Hickey@ga.com>; Selby, James <James.Selby@ga.com>
Subject: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.

Tom and all,
Good afternoon. QN 7071839 – Damaged thermal bridges – PS2 Coil Assembly, for FNAL review and concurrence.

Very respectfully,

Kevin Spieldenner
Quality Engineer, Quality Assurance Division
General Atomics
Electromagnetic Systems Group (GA-EMS)
858-676-8750 Office
16470 West Bernardo Drive
San Diego, CA 92127

General Atomics Electromagnetic Systems

Documentation of Damage to PS2 Outer Thermal Bridges for QN 7071839 **29 Sept 2020**

Presented to: FNAL

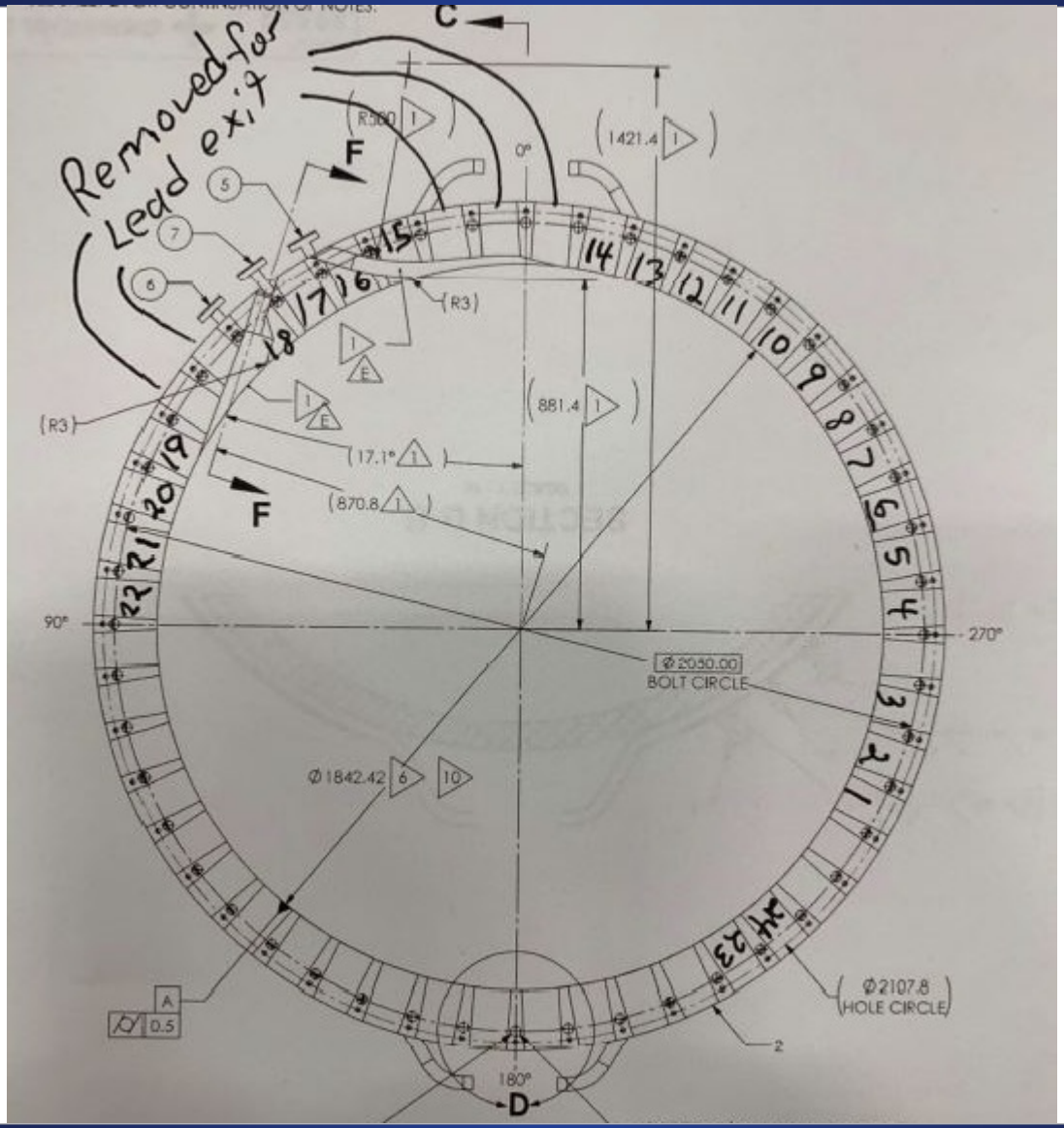
Presented by:

GENERAL ATOMICS ELECTROMAGNETICS

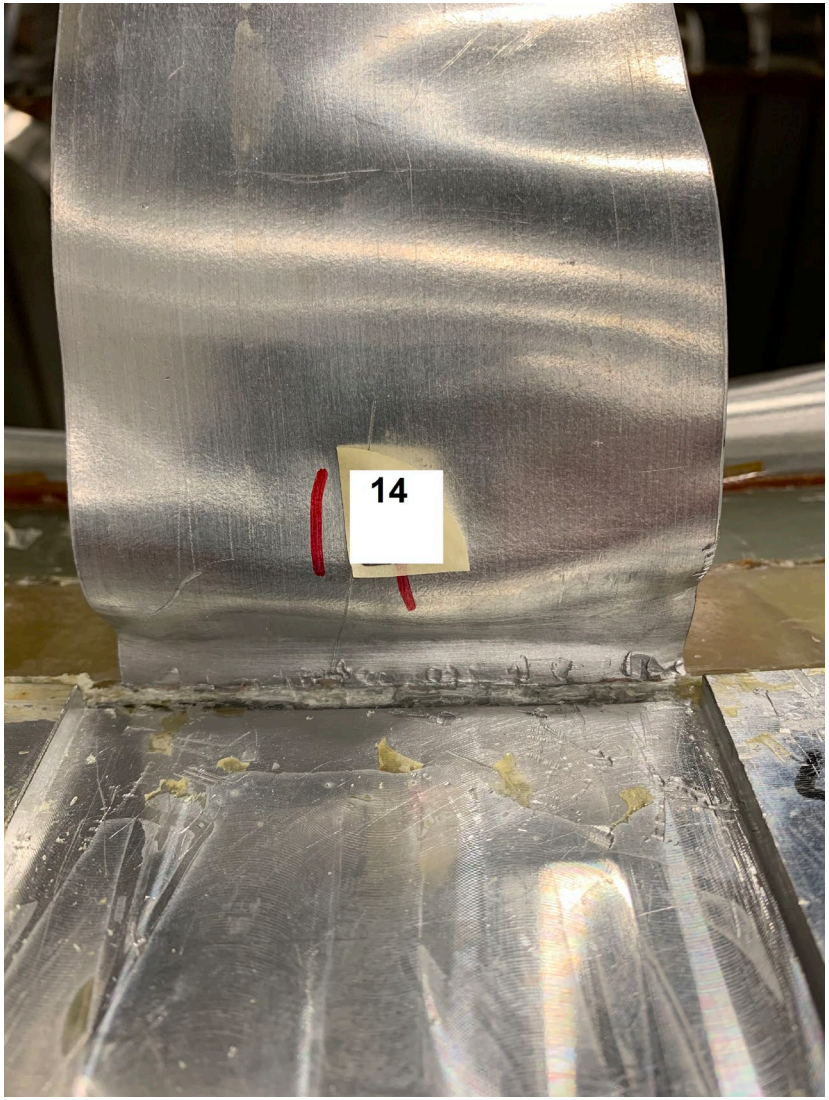
Thermal Bridges (TB)

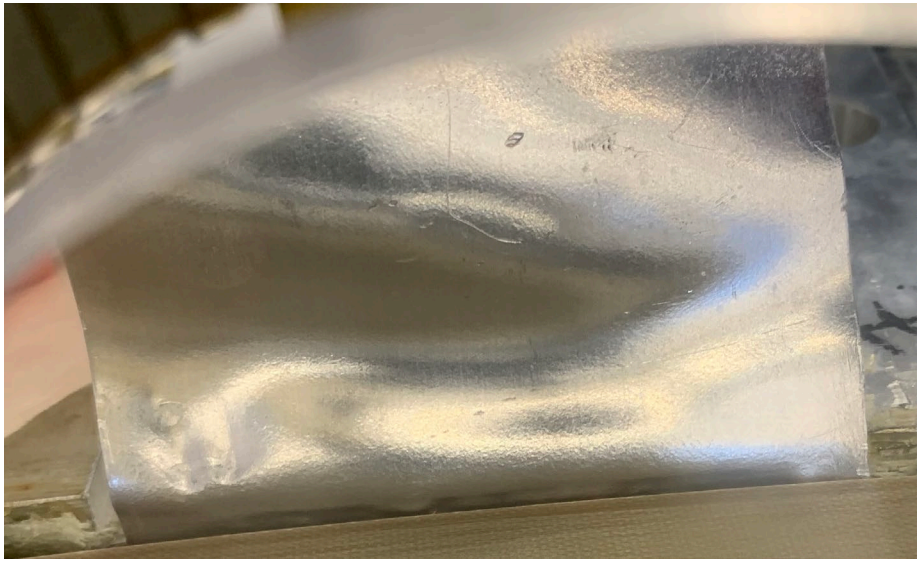
- Reference: PS2 Damage to Thermal Bridges-1.pptx 09/09/20 presented by Paul Clark
- Reference: PS2 TB Damage.pdf 09/11/20 by Jonathan Miller
- This presentation is in support of QN 7071839 (Damage to 24 Outer Diameter TB's on the lead end of PS2)

Numbering of damaged Thermal Bridges



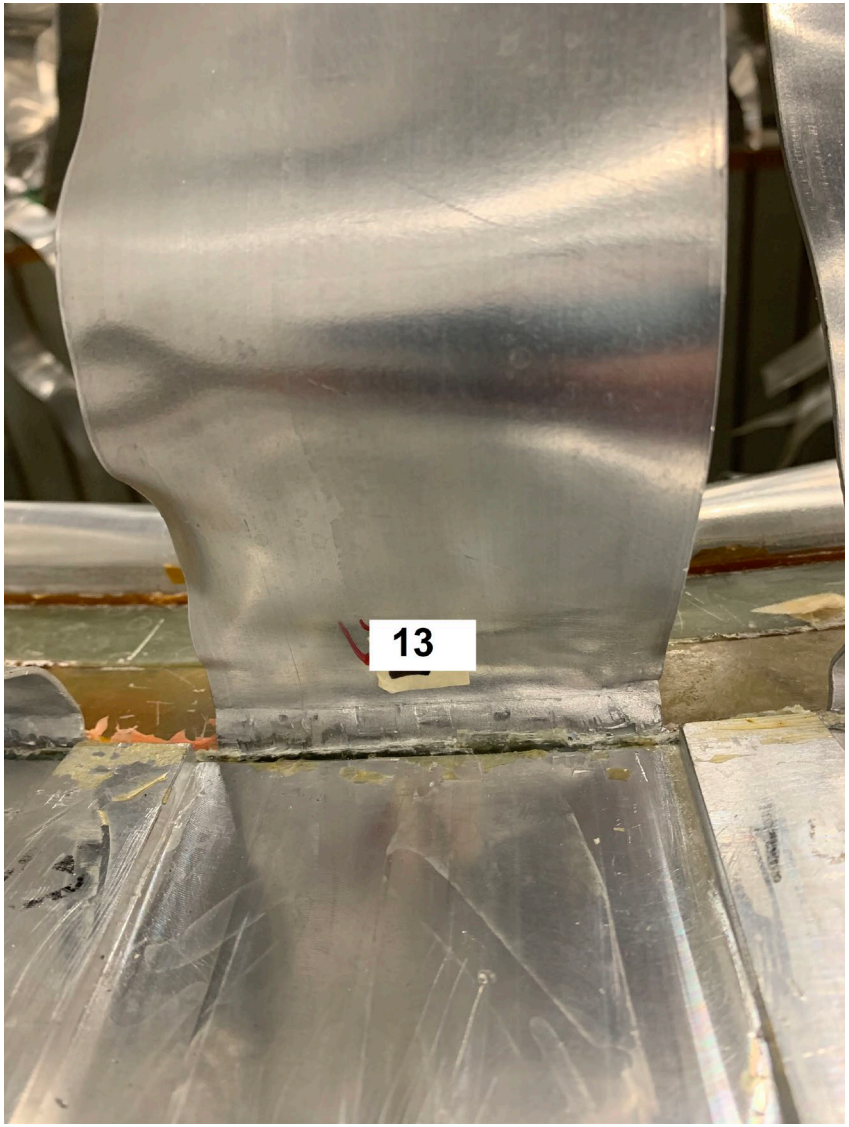
Pictures of Thermal Bridge 14

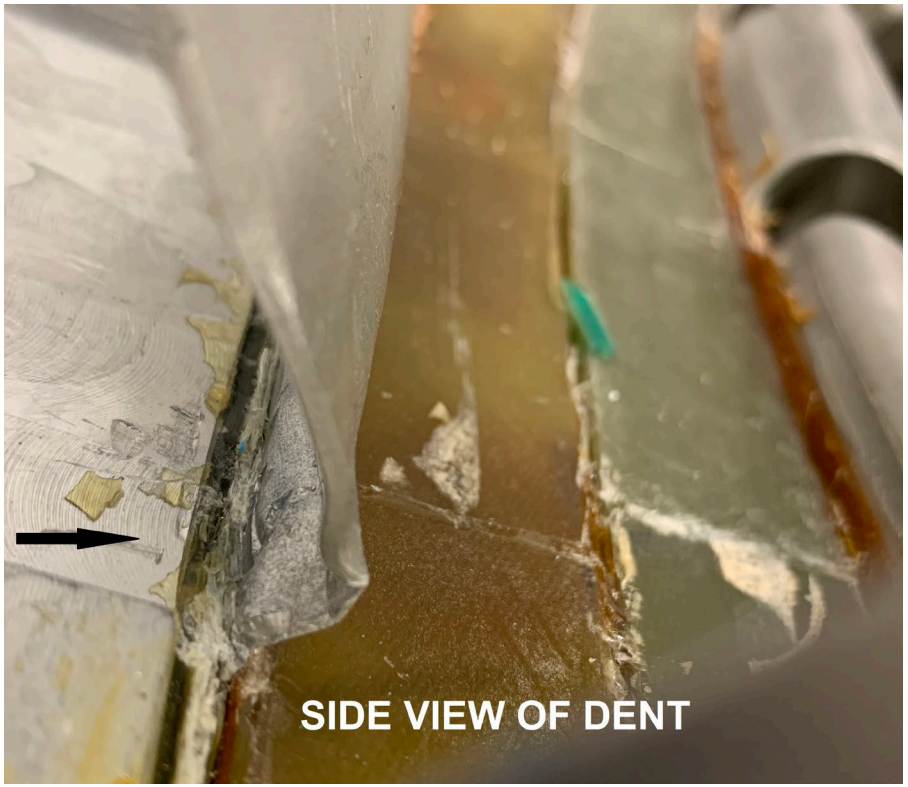


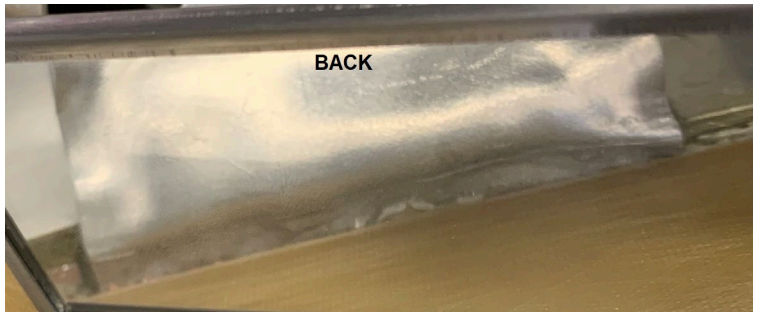


Back

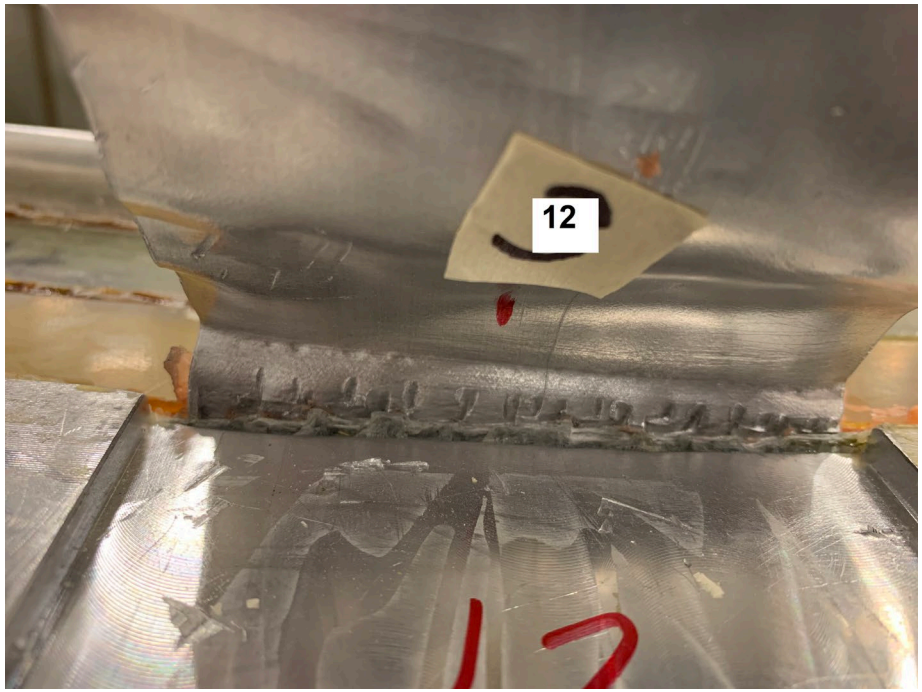
Picture of Thermal Bridge 13

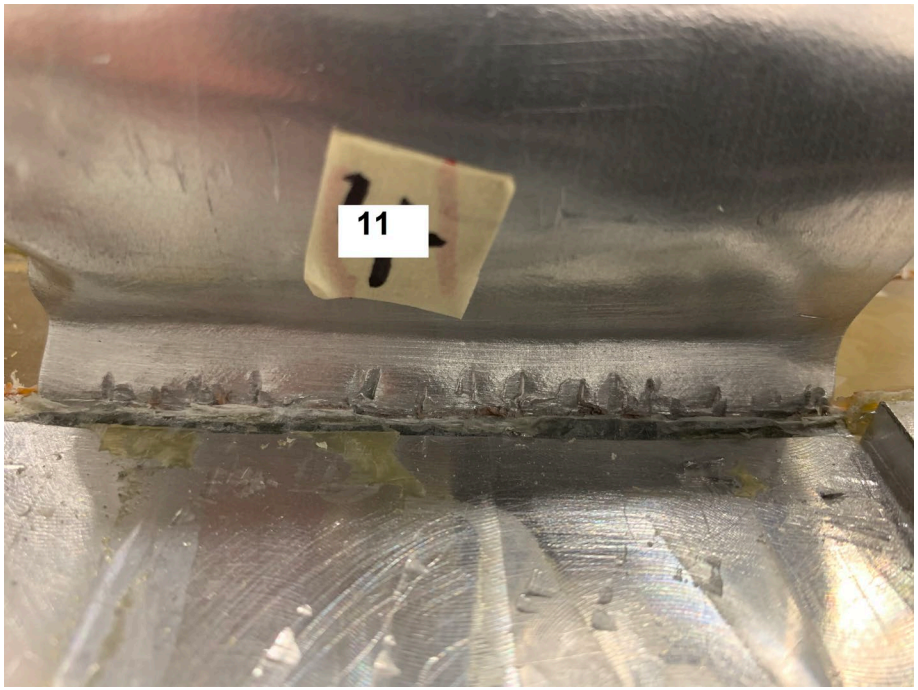


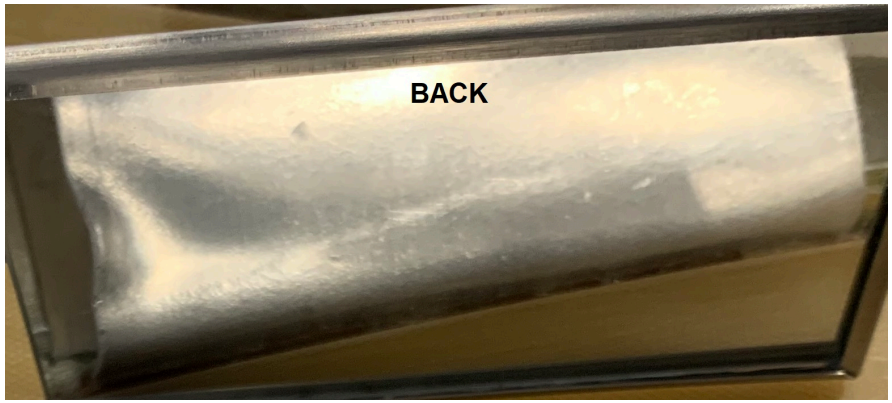




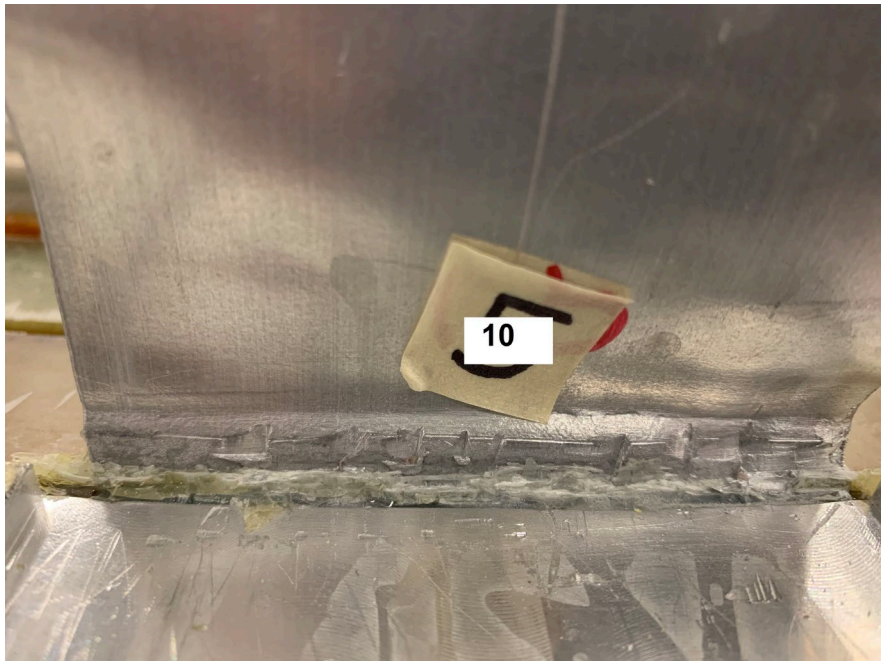
Pictures of Thermal Bridges 12 & 11

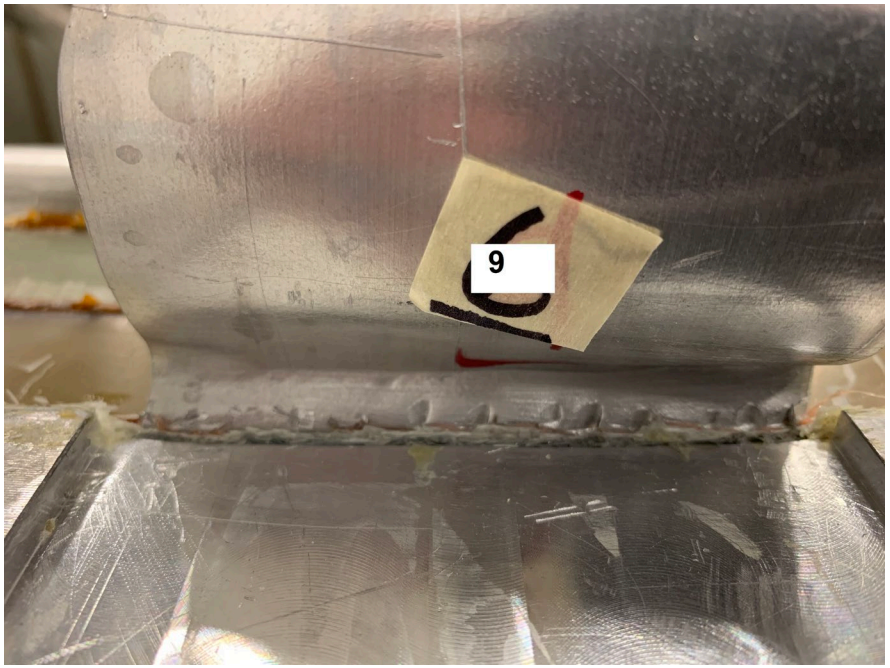


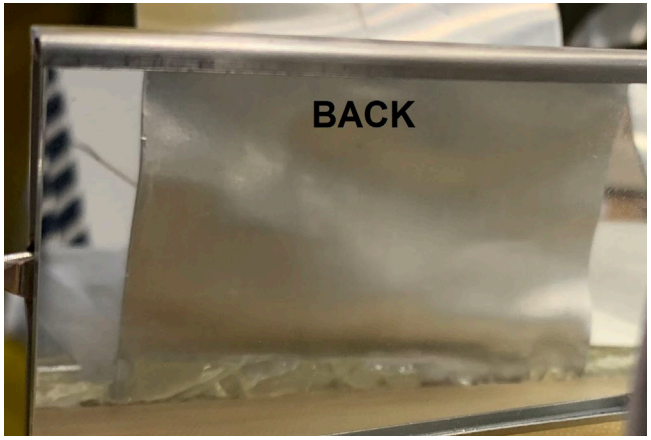




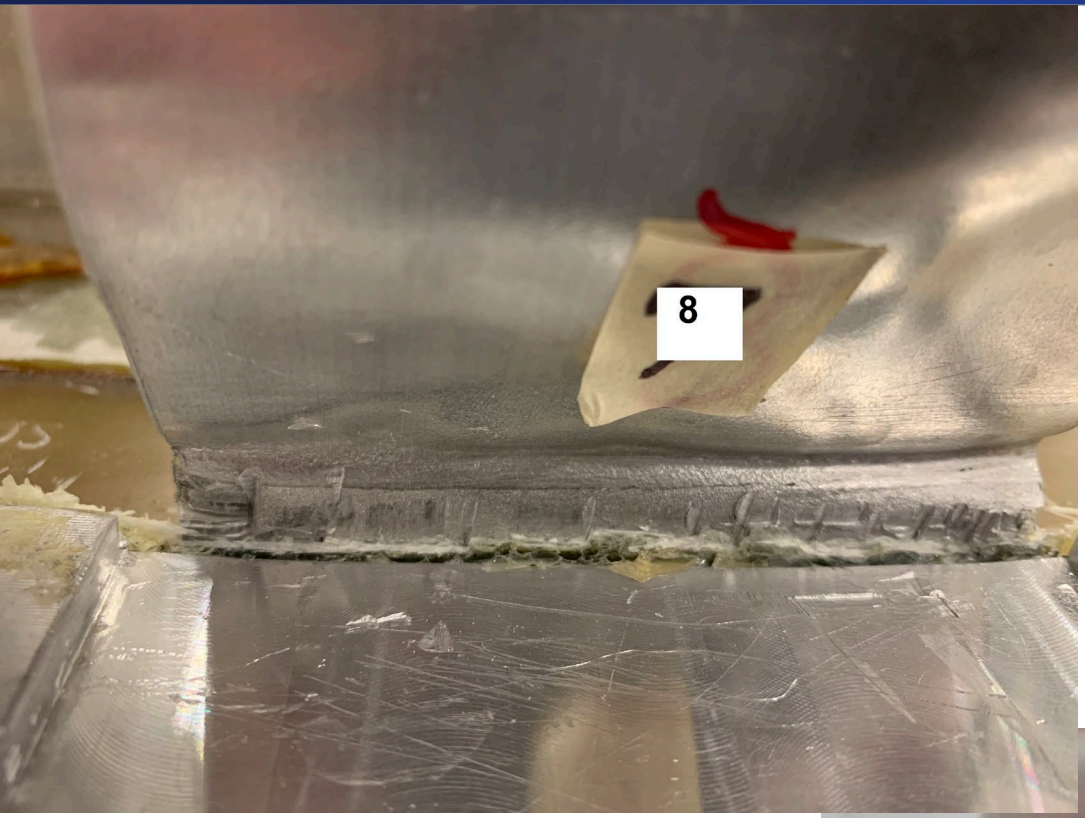
Pictures of Thermal Bridges 10 & 9

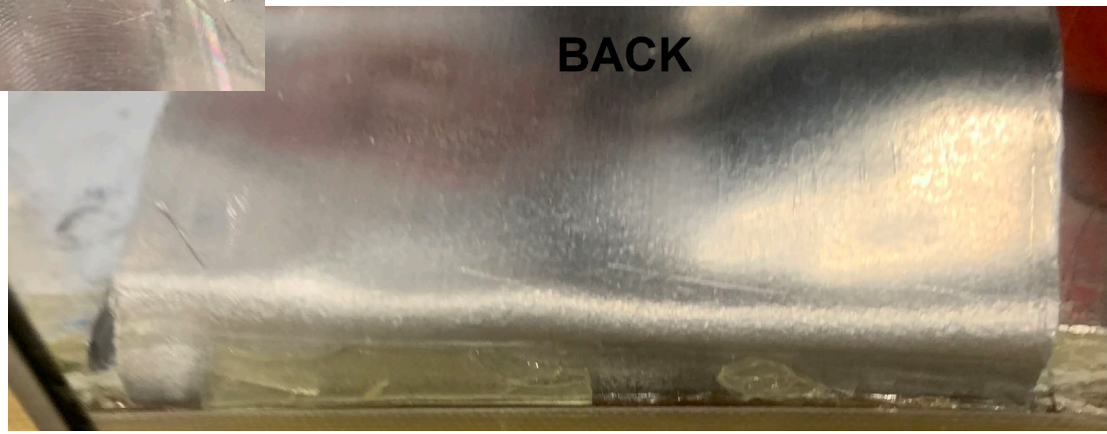




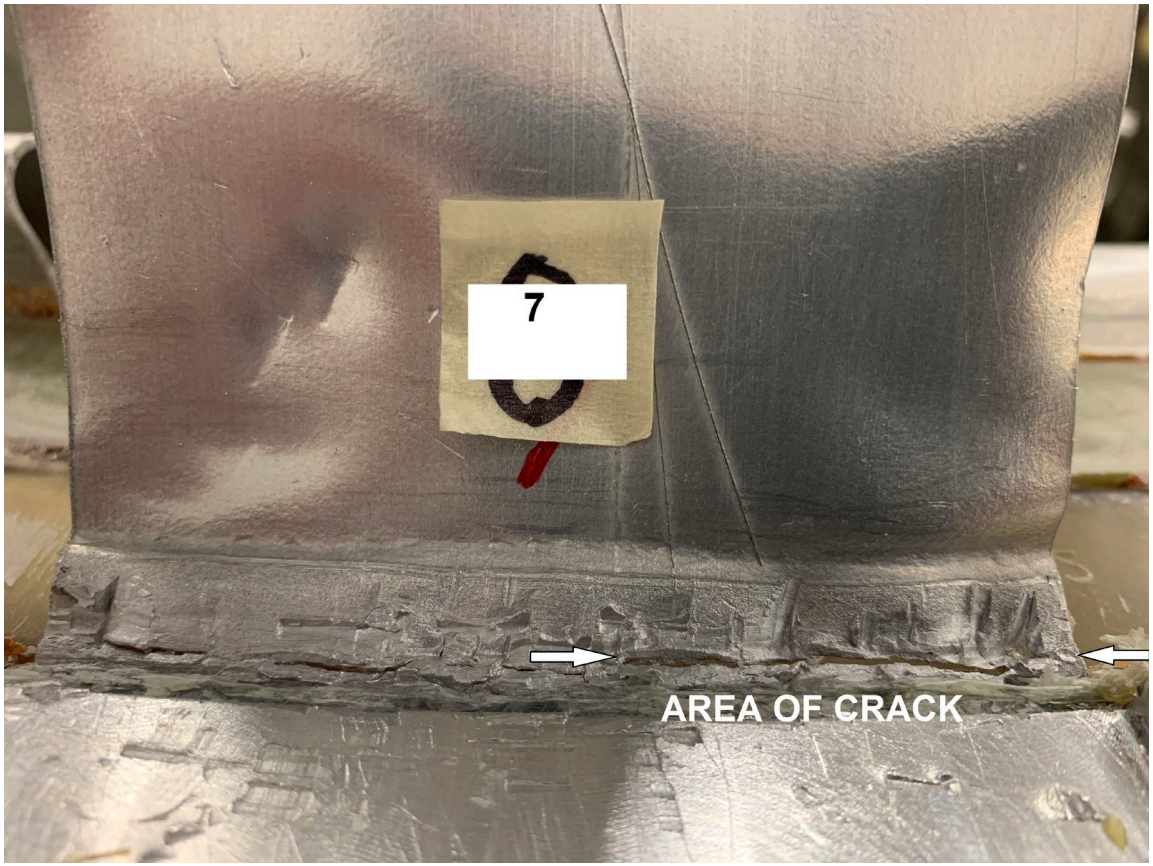


Picture of Thermal Bridge 8



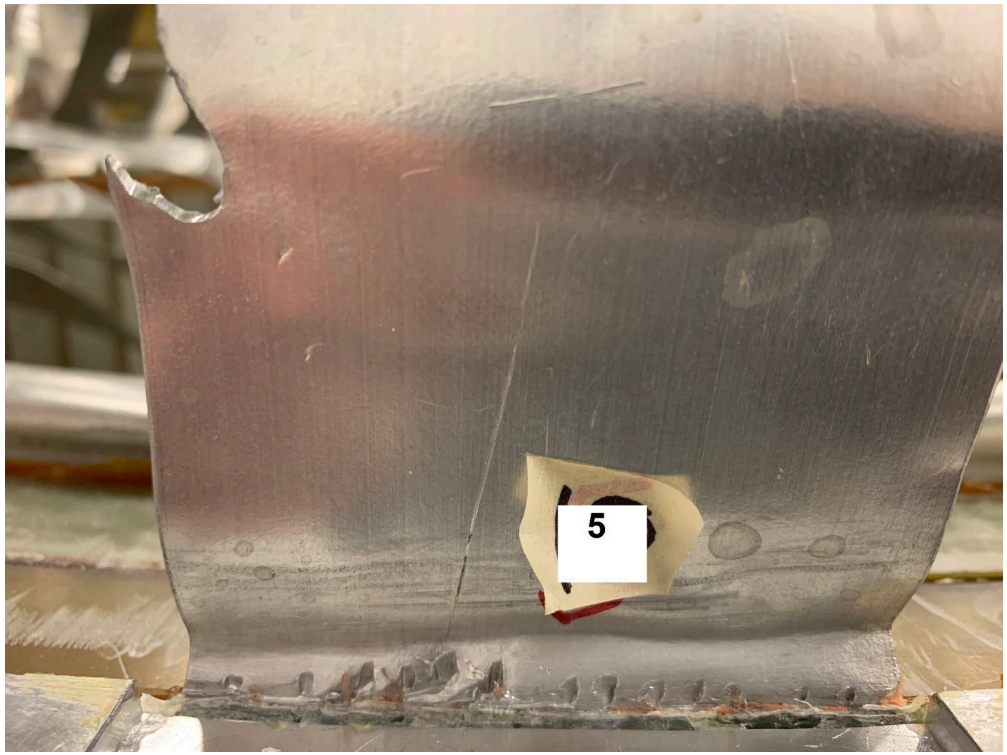


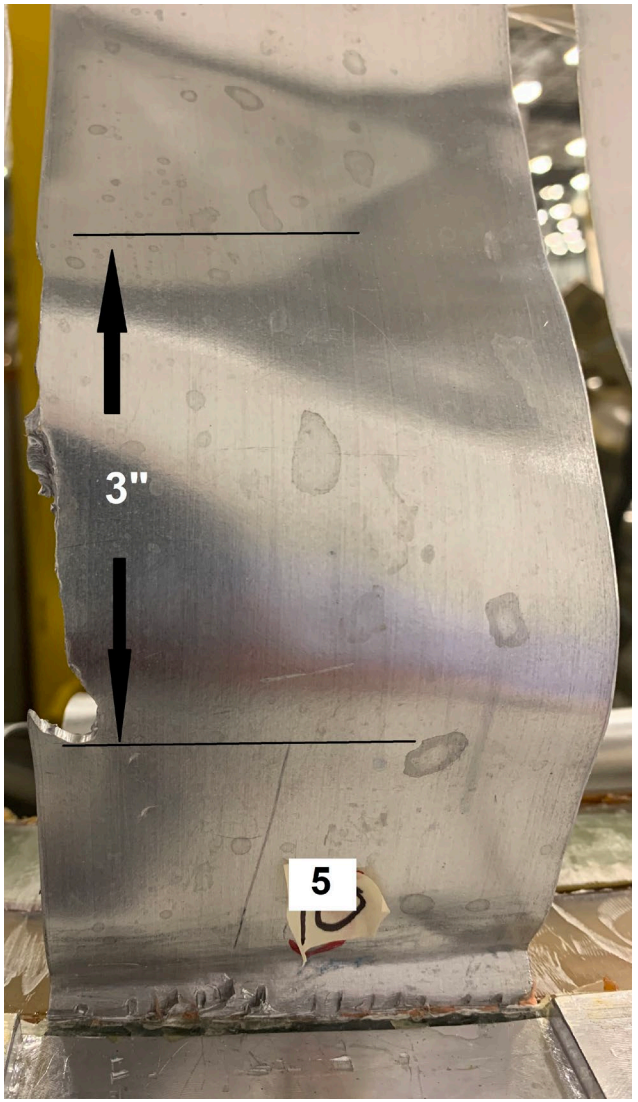
Picture of Thermal Bridge 7



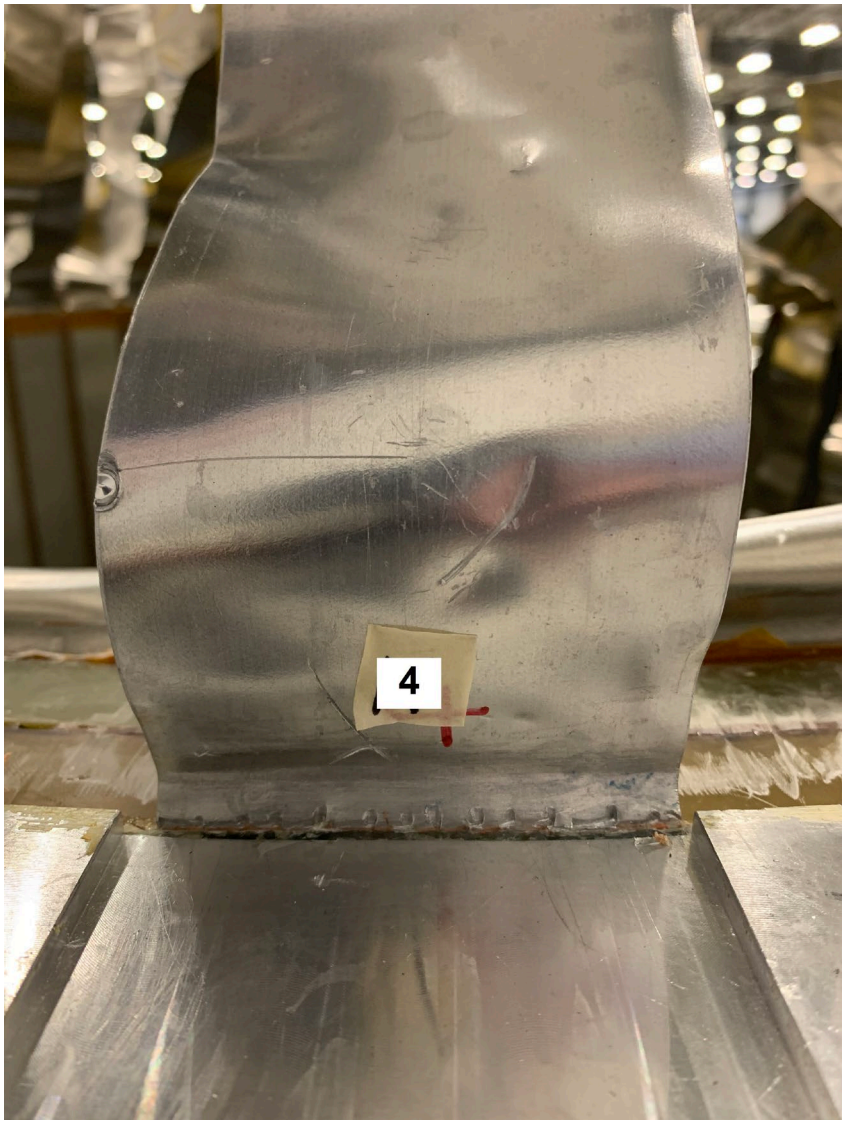
Pictures of Thermal Bridge 6

Pictures of Thermal Bridge 5

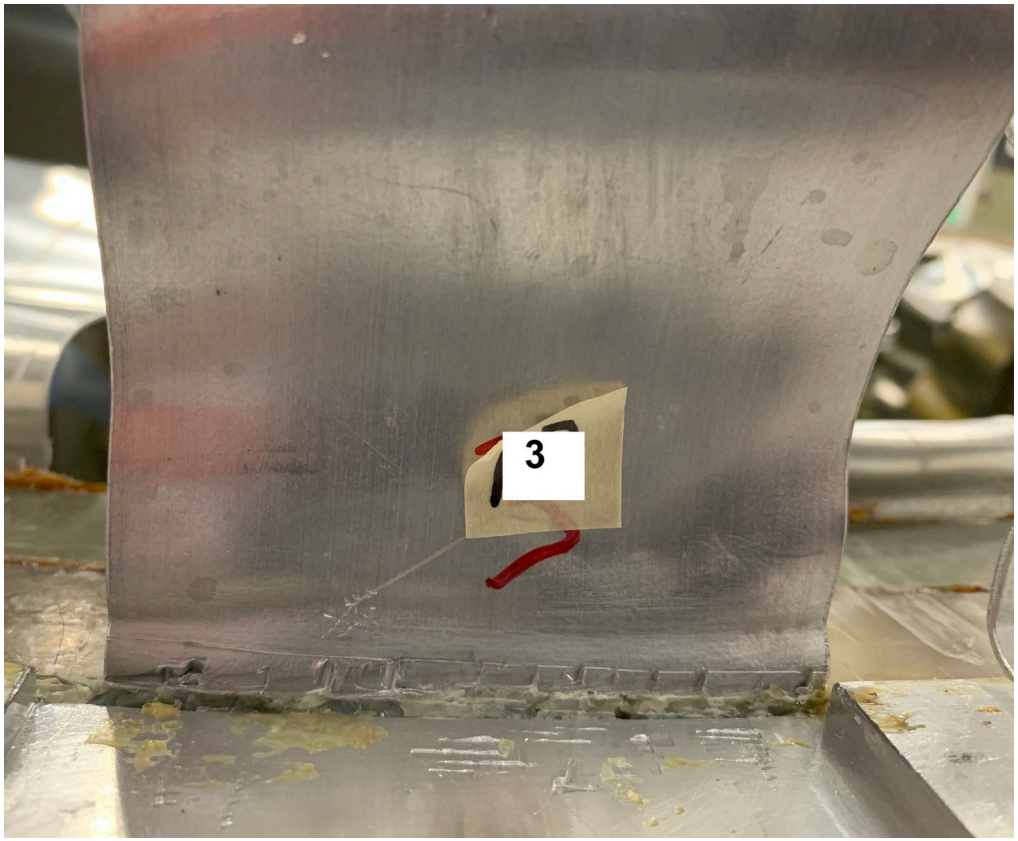




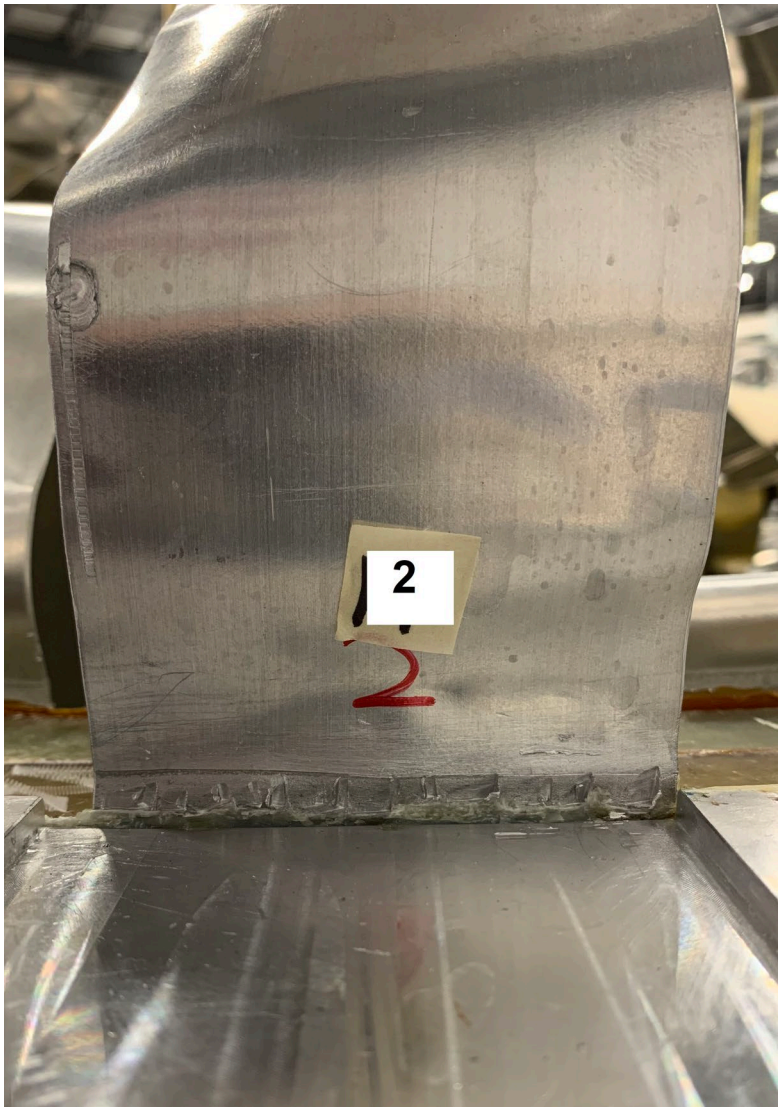
Pictures of Thermal Bridge 4



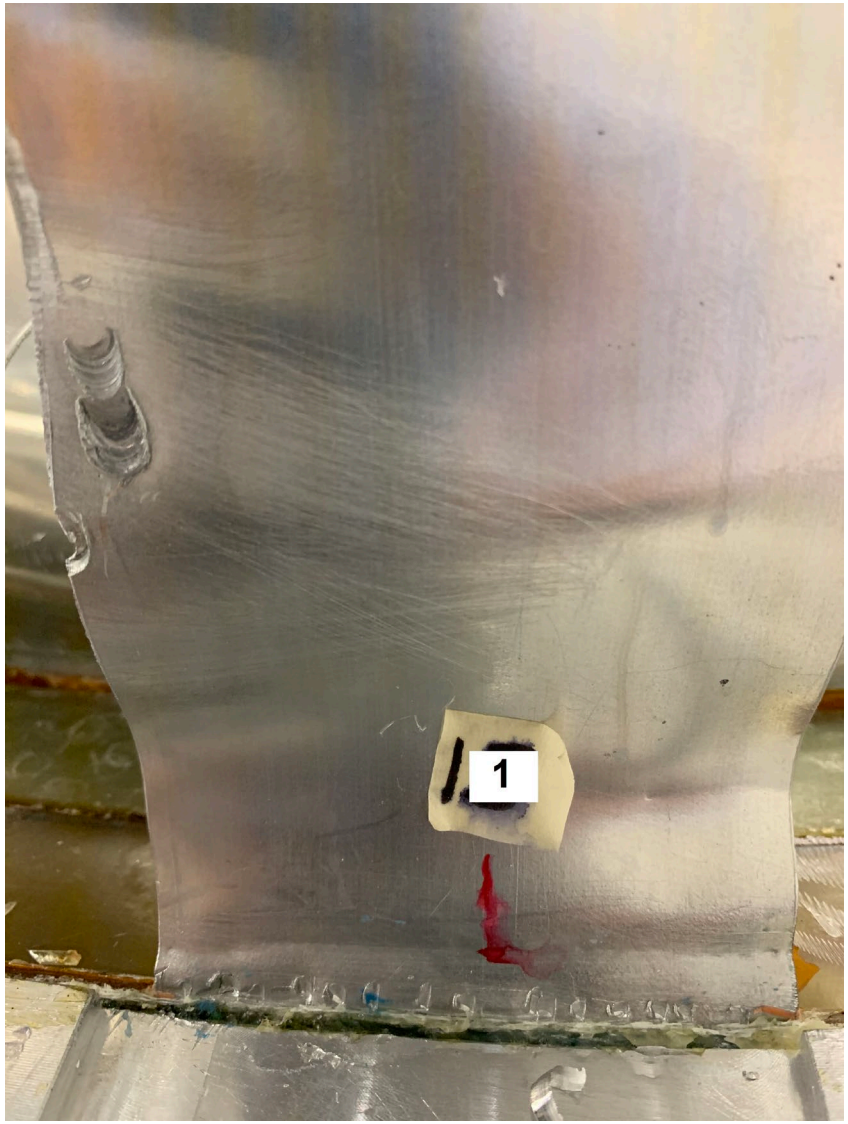
Pictures of Thermal Bridge 3

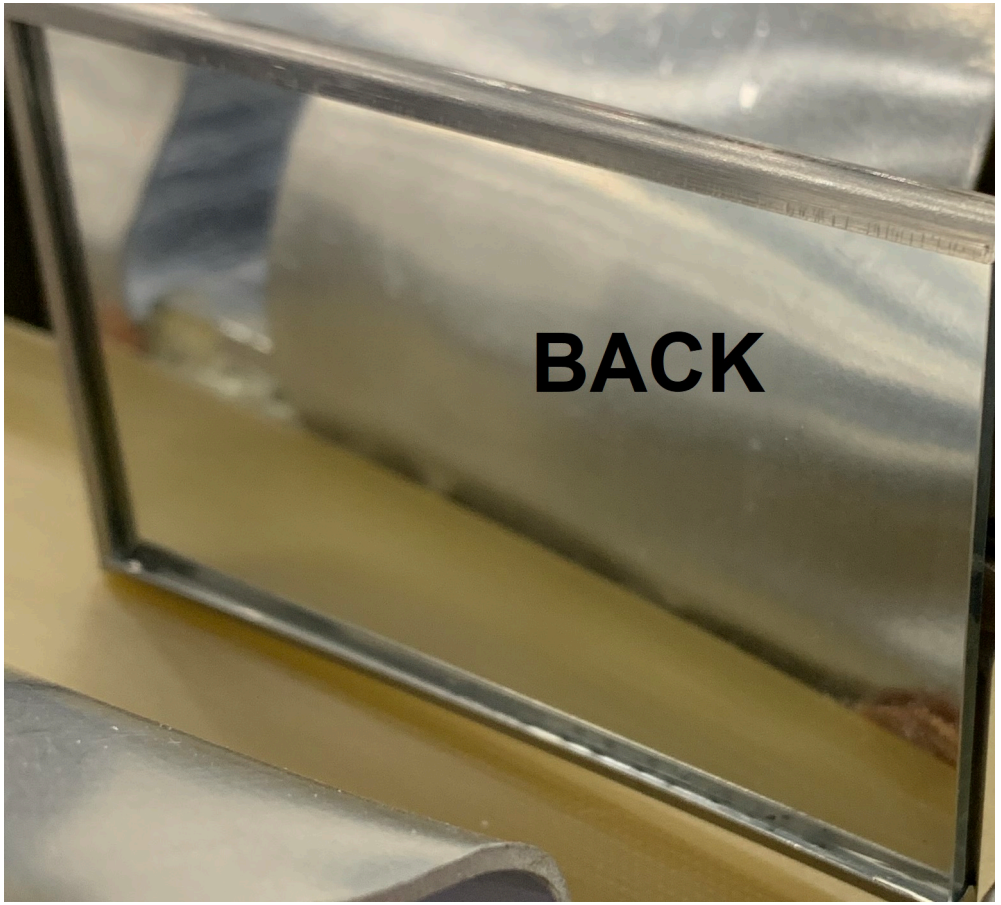


Pictures of Thermal Bridge 2

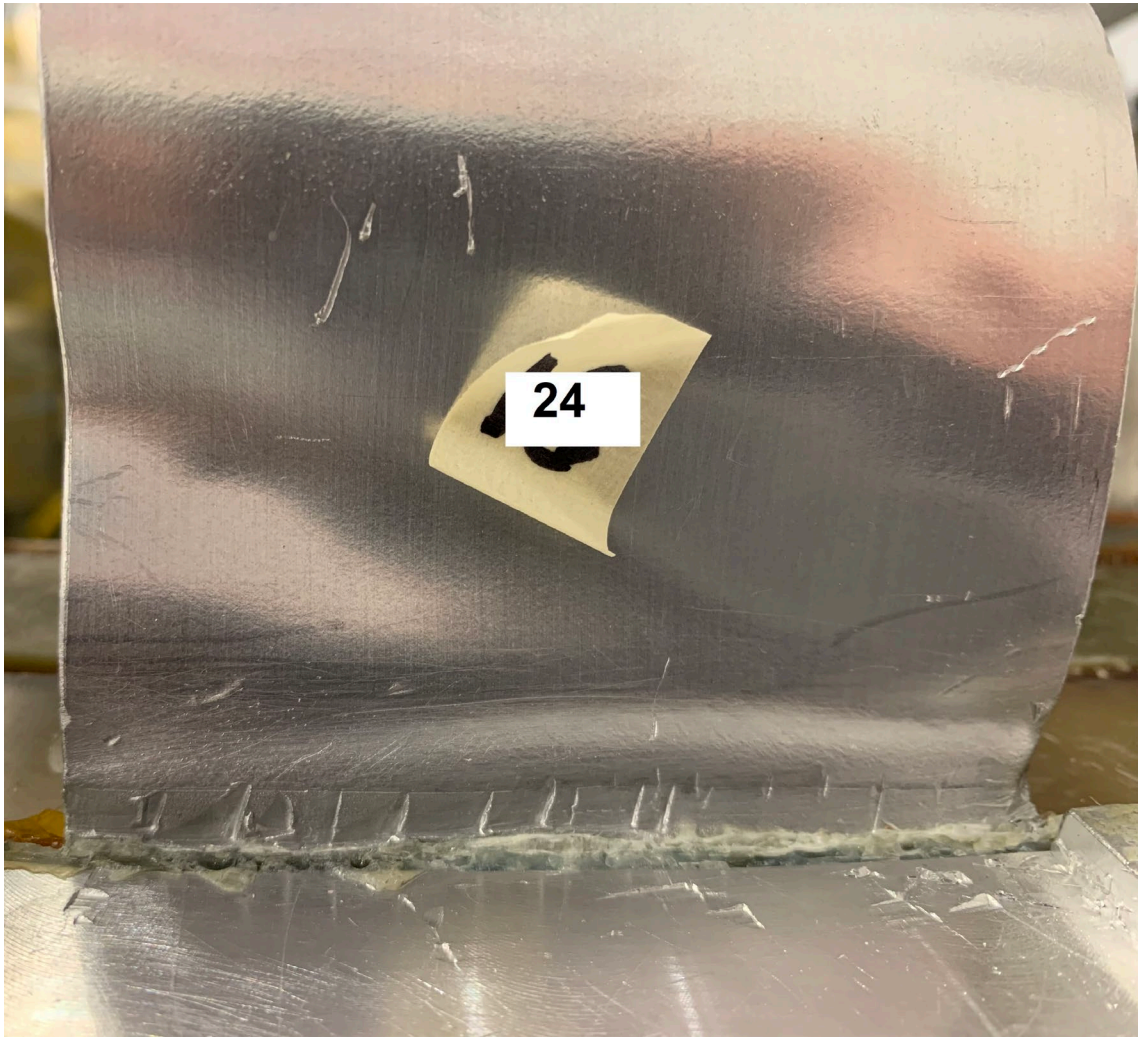


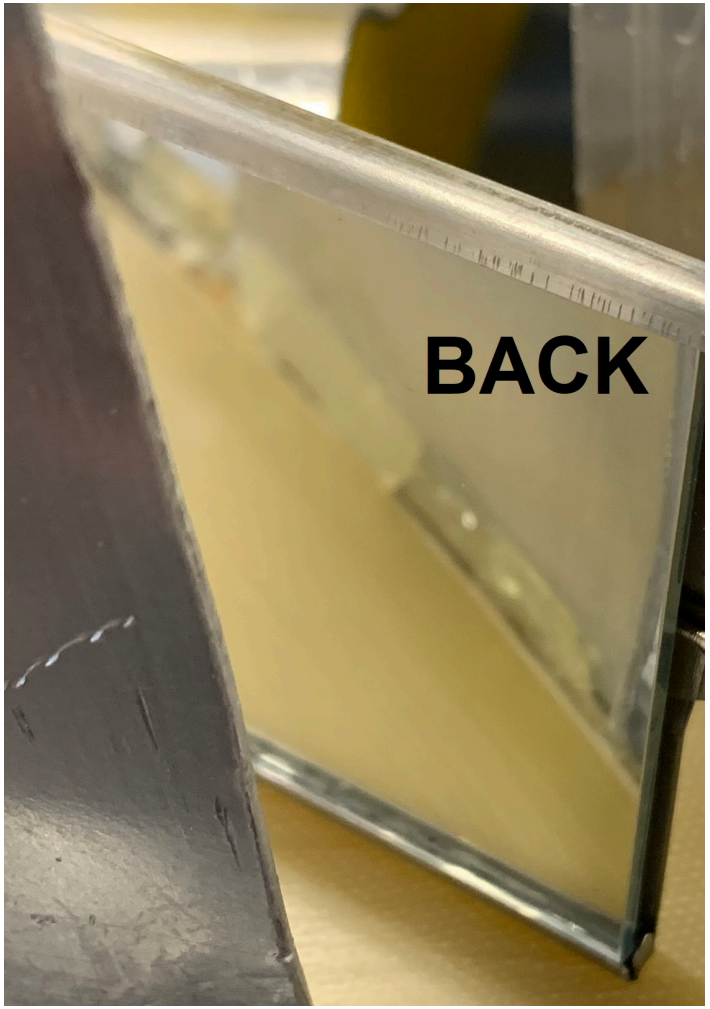
Pictures of Thermal Bridge 1



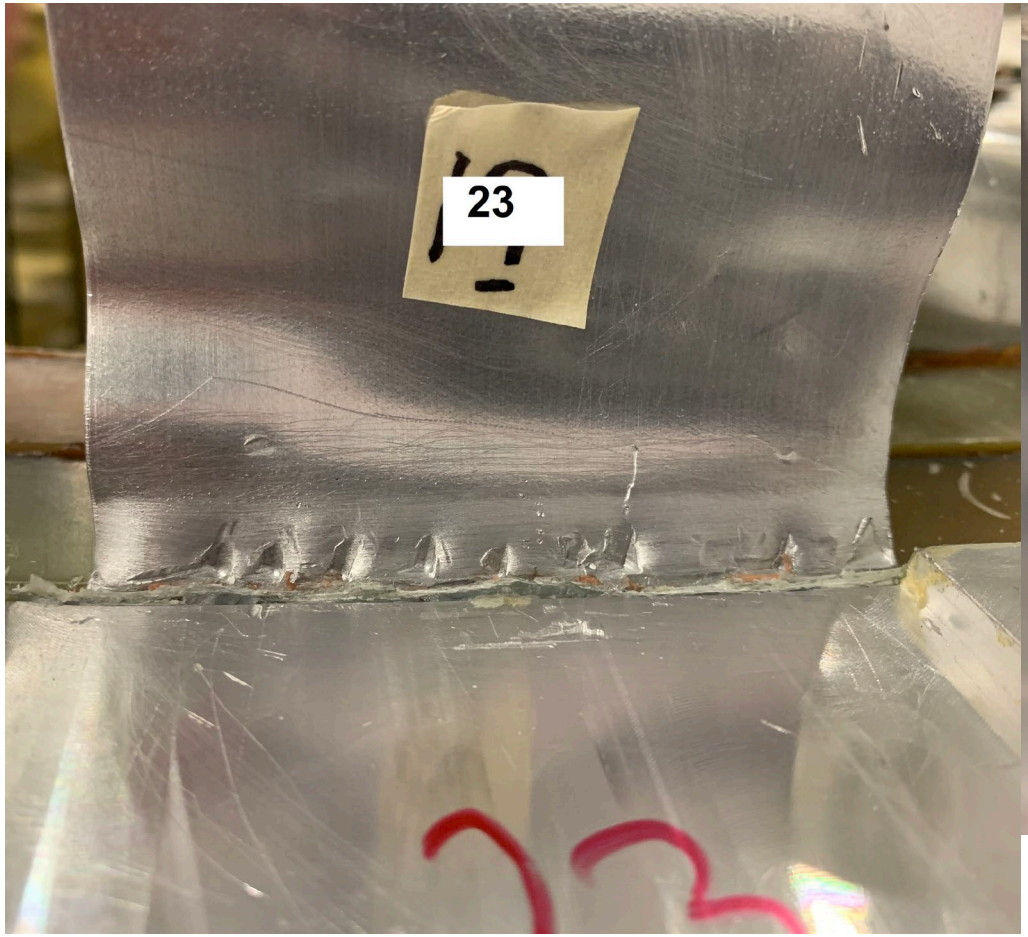


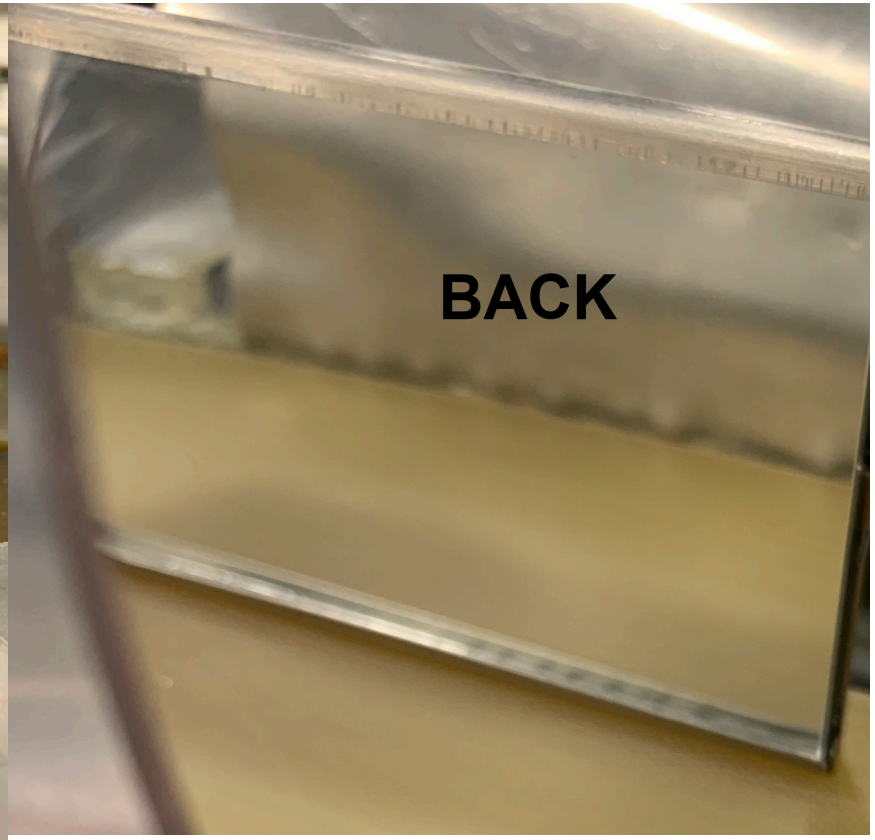
Pictures of Thermal Bridge 24



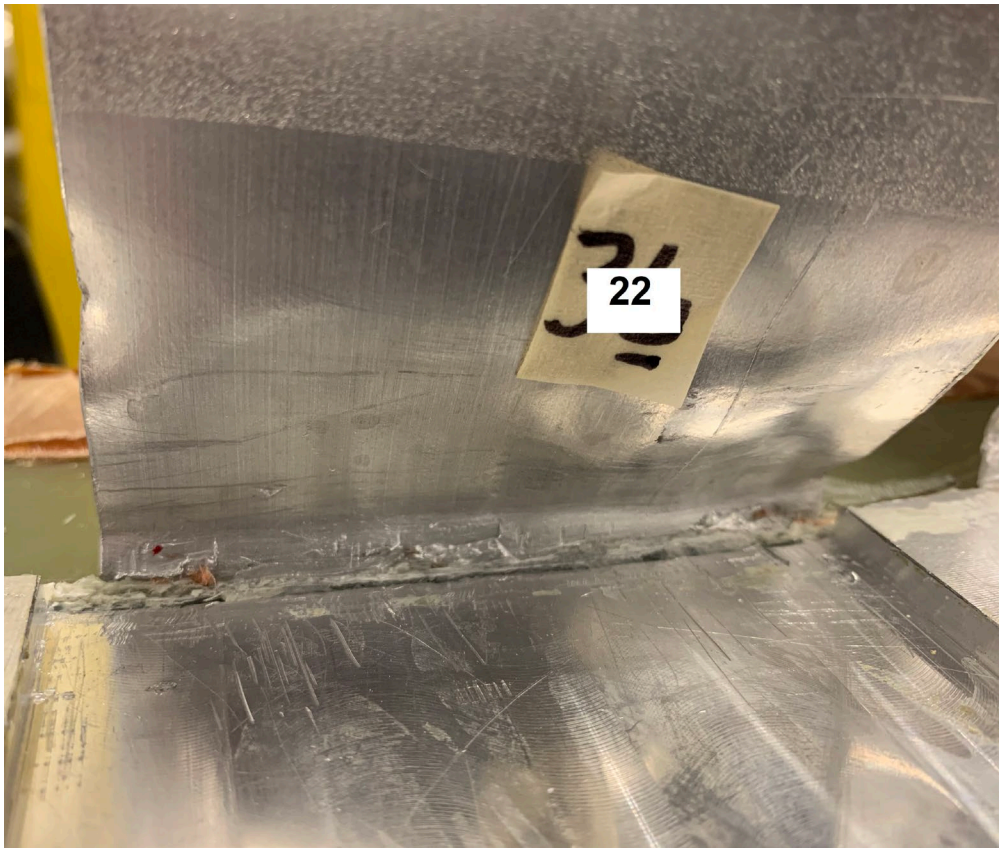


Pictures of Thermal Bridge 23

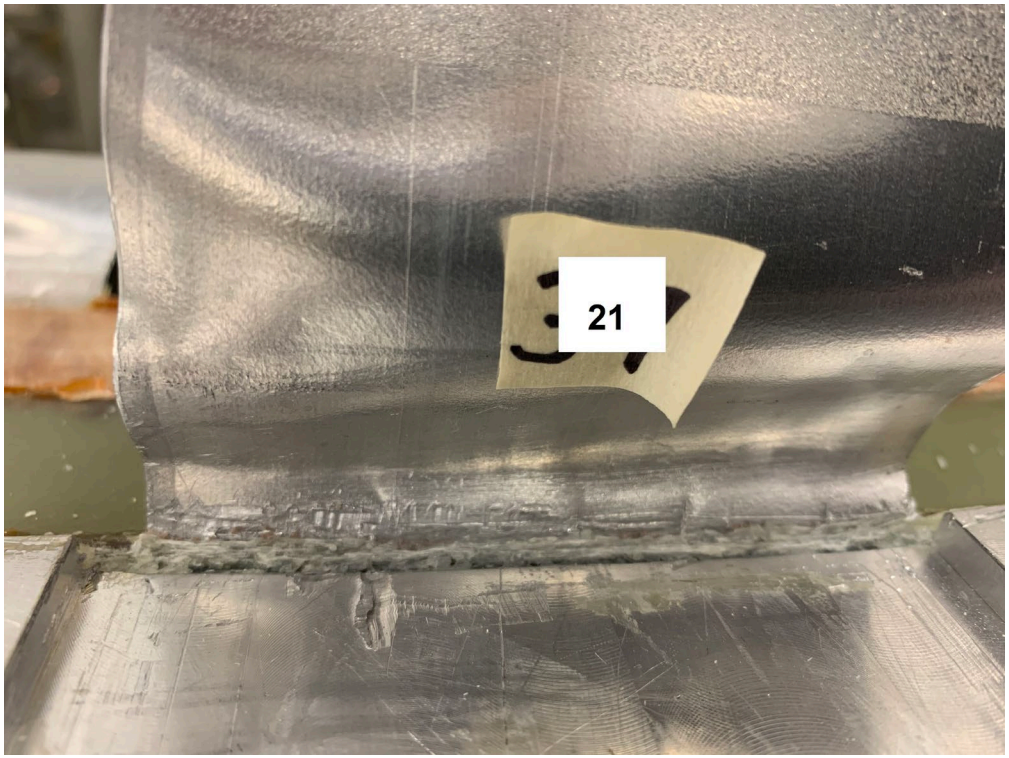




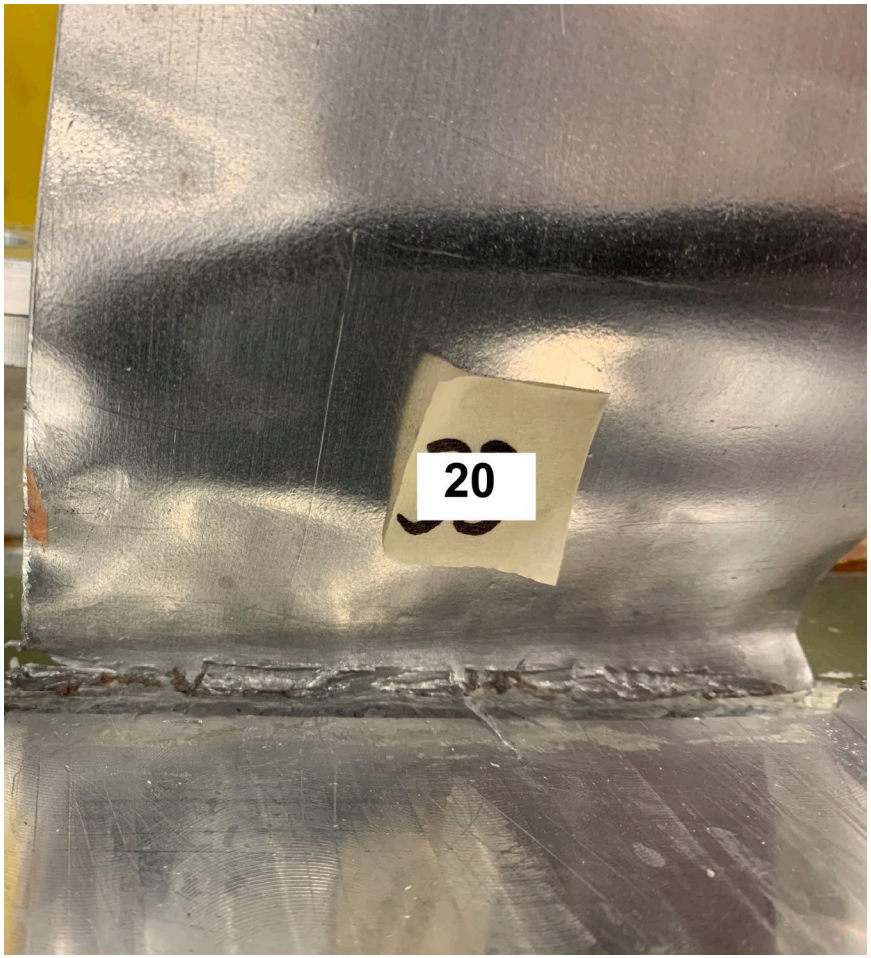
Pictures of Thermal Bridge 22



Picture of Thermal Bridge 21



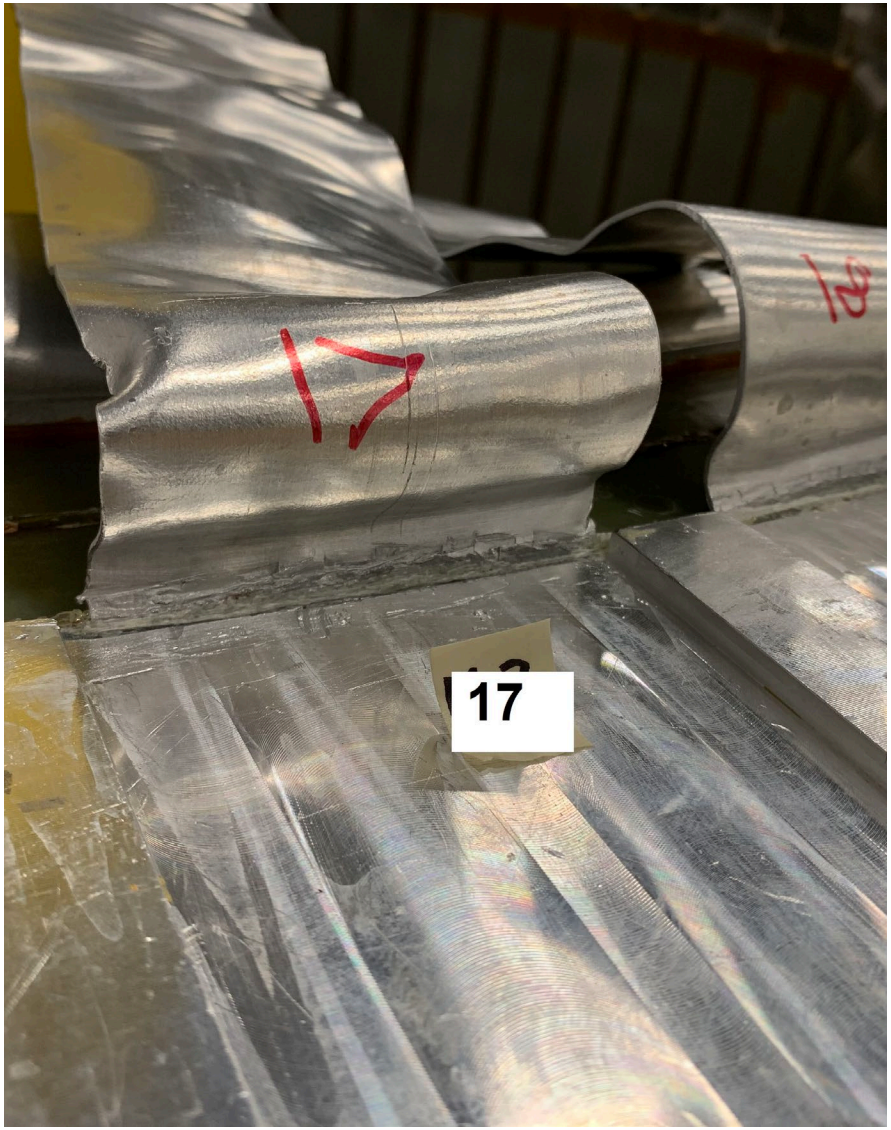
Pictures of Thermal Bridge 20



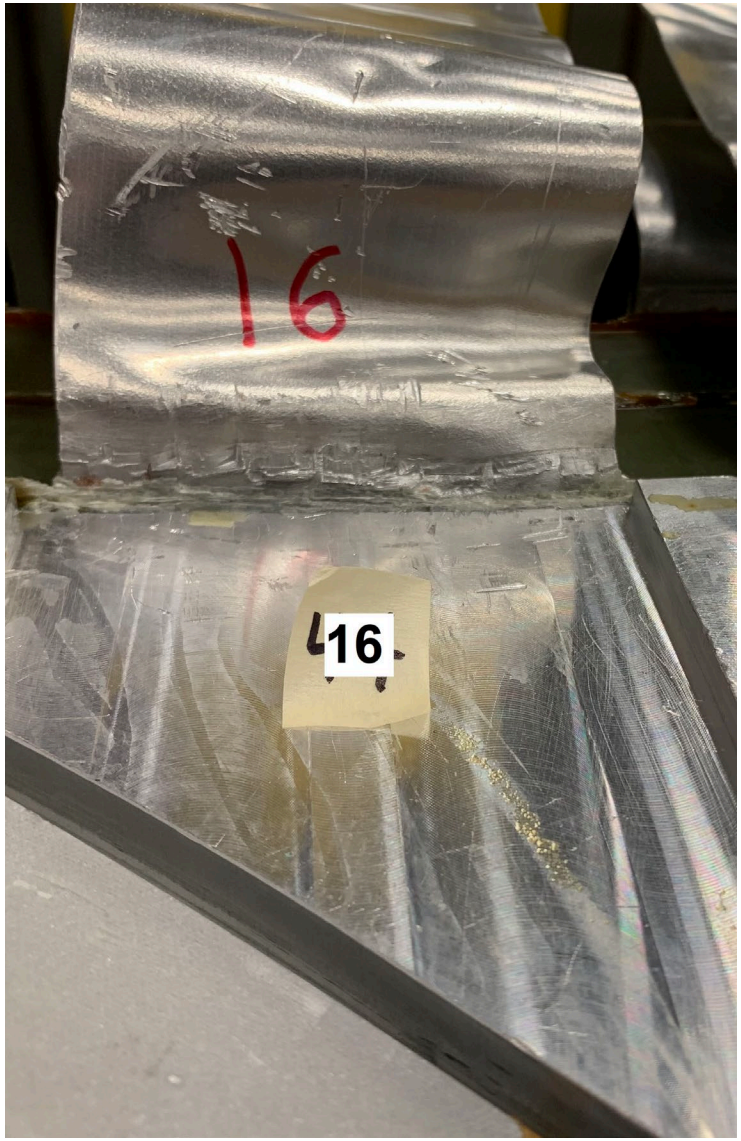
Pictures of Thermal Bridge 19

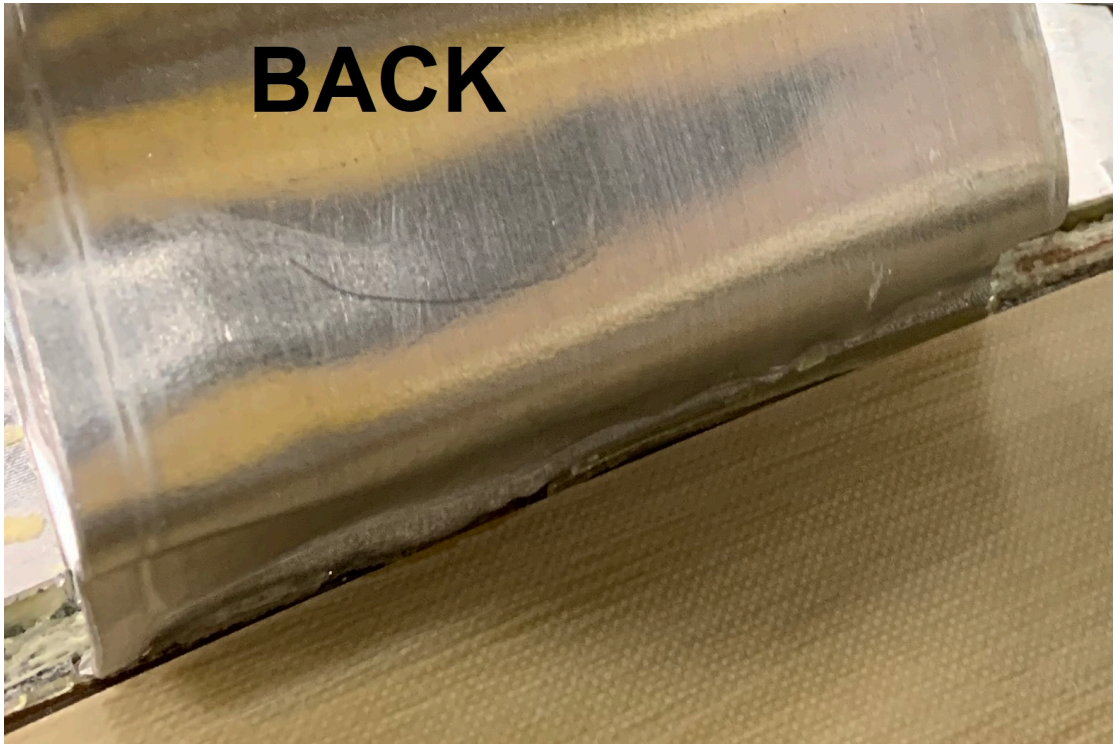
Pictures of Thermal Bridge 18

Pictures of Thermal Bridge 17

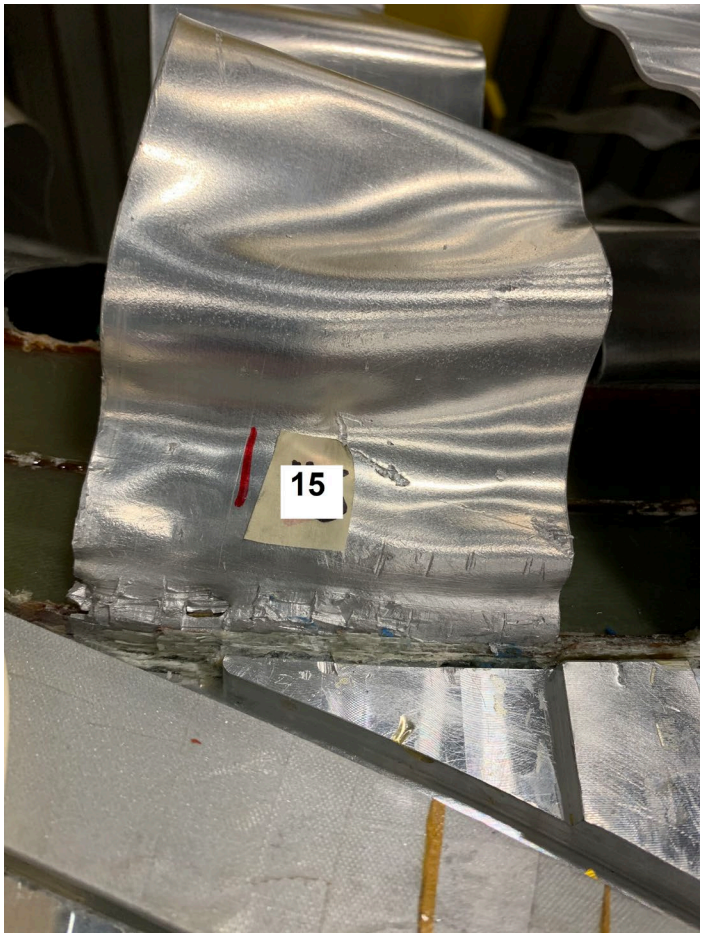


Pictures of Thermal Bridge 16





Pictures of Thermal Bridge 15



Small tear on left side at base

Depth of dent measurements

QN7071839 Damaged thermal bridge dent measurements
using ReproRubber and Optical Comparator on 9/20-9/22/20

All measurements in inches

TB#	Height of Dent Band	TB Damage Scale	Min	Max	NOTES:
14	0.1875	2	0.0054	0.033	
13	0.375	1	0.0209	0.0209	
12	0.25	3	0.015	0.0255	
11	0.1875	3	0.0053	0.0304	
10	0.375	3	0.0239	0.0263	
9	0.1875	3	0.0144	0.0691	
8	0.375	3	0.0082	0.0206	1/4" W dent near left edge at base
7		5	0.0155	0.0455	Cracked half-way across base from the right side
6	0.25	4	0.0102	0.0443	3/4"L x 1/4"W gouge at top end & 1" L x 1/8" wide missing chunk on left side
5	0.25	4	0.0131	0.0488	3" L x 1/2" W (at bottom tapering away towards top) missing chunk on left side
4	0.1875	2	0.0099	0.0296	1/4"L x1/8"W x.028 T gouge on left side
3	0.25	1	0.0194	0.0361	
2	0.3125	1	0.02	0.0361	1/4"Lx1/4"W gouge on left & 2-1/4"Lx1/16"W vertical scratch near same spot
1	0.1875	1	0.0231	0.0489	3"L vertical damaged spot on left x1/2"W (near center& tapering away at each end)
24	0.25	1	0.0135	0.0282	
23	0.1875	2	0.0188	0.0634	deep dent near left edge at base
22	0.1875	1	NA	NA	
21	0.1875	1	0.0269	0.0269	(Ctrl)
20	0.1875	2	NA	NA	5/16" long horiz tear at left side of base
19	0.125	1	NA	NA	
18	0.1875	3	NA	NA	
17	0.25	4	NA	NA	
16	0.75	4	0.025	0.0375	
15	0.25	5	0.0265	0.111	1/8" long horiz tear at left side of base & 5/16" long horiz tear in center of base

TB DAMAGE SCALE: % Surface area of dented band at base affected

1 - minimal (up to 5%)
2 - minimal to moderate (up to 10%)
3 - moderate (up to 20%)
4 - moderate to significant (up to 25%)
5 - significant (greater than 25%)

Disposition

- Use the thermal bridges as per the following instructions except for the cracked thermal bridge (labeled #7) which is to be removed.

- Special instructions for PS2 Outer Thermal Bridges:
  1. Bend the outer thermal bridges (except #7) into place per Operation 350 of 39532P00060 Rev. A (PS2 Coil and Shell Assembly Work Instructions). While gripping the free end of the thermal bridge start to bend it over 90° and using a plastic head mallet, gently tap the thermal bridges to its final horizontal position.

  2. If *any* thermal bridge cracks or breaks, Stop work and immediately notify Engineering for further direction.

  3. Remove the cracked thermal bridge (labeled #7) at Operation 350 and gently file down any sharp edges ensuring cleanliness is maintained.

Future Actions

1. Train all technicians on the incident to help prevent reoccurrence (provide training OQE).
2. Supervisor to conduct a pre-job brief prior to non-routine (error prone) evolutions (see the GA-EMS Human Performance Tool Pre-Job brief checklist as an example).
3. Revise future work instructions to prevent the use of chisels on thermal bridges and to show how to use the putty knife technique instead.
4. OD machining of PS1 potted coil prior to insertion shall incorporate a wider (e.g., 1 inch) machined groove in the thermal bridge OD area near to the ends of the coil.
5. Depth of groove on PS1 shall be increased (but breakthrough of Teflon not allowed).
6. If glass skirt on PS1 is not removed, provide more explicit guidance on how to remove it to insure no damage to thermal bridges.
7. Add a thicker and wider layer of Teflon to this area pre-VPI.

General Atomics Electromagnetic Systems

PS2 Bending Test

13 Oct 2020

Presented to: FNAL

Presented by:

Bending Experiment

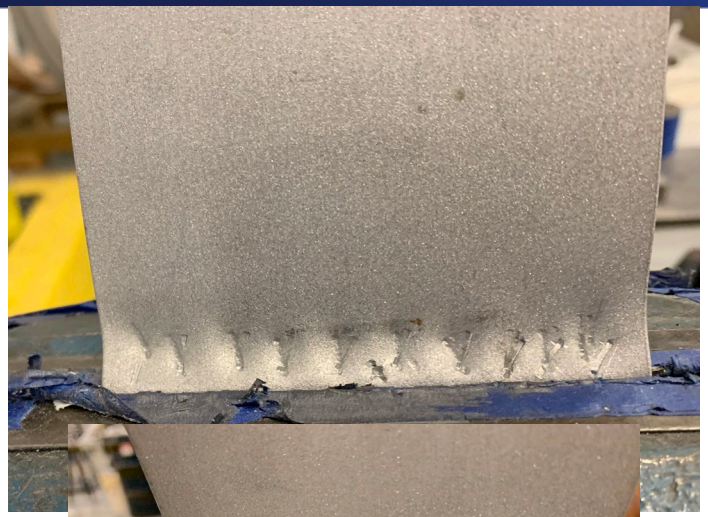
- During Coil/Shell Assembly, the thermal bridges get bent 90° over the shell (sharp bend) and flattened to fit into their respective slots.
- This experiment was to see how a dented/damaged thermal bridge might be affected during the bending process

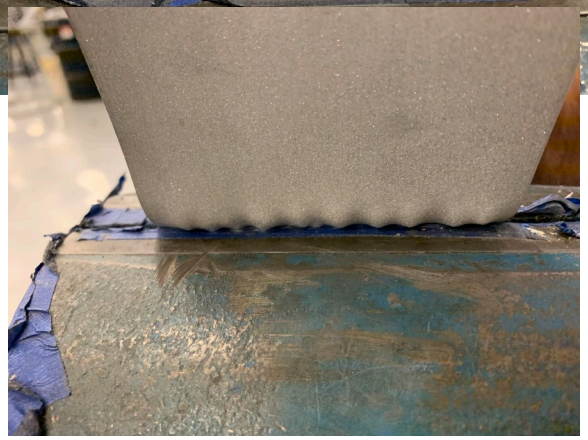
Thermal Bridge Fold Test

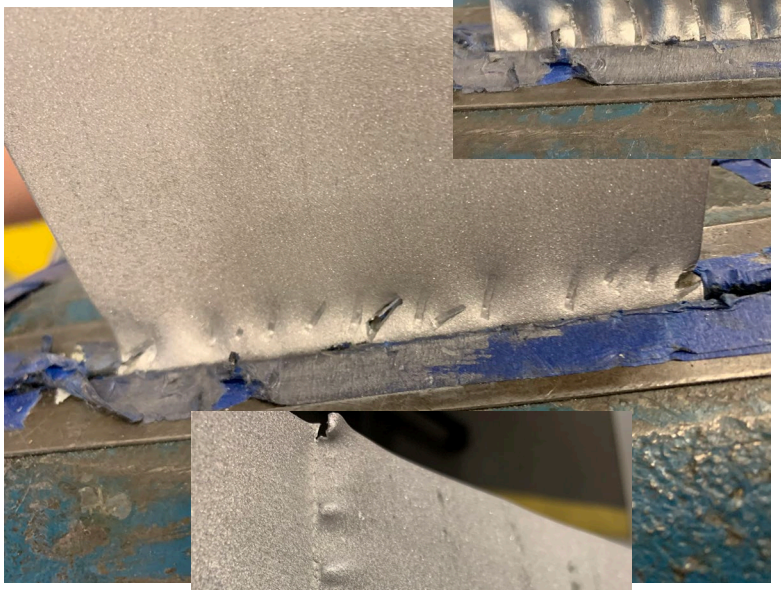
- A strip of thermal bridge (worst case/grit blasted) was put into a vise and dented with a chisel covered by a cloth and a plastic head mallet… to best duplicate the dents seen on PS2 thermal bridges.
-
- The dented strip was then clamped to the ID of a DS mold and bent 90° over the edge of the mold by tapping it with a plastic head mallet until it was flat against the edge. A plastic block was also used afterward to flatten out any kinks or projections on the back of the thermal bridge.

- The thermal bridge was then raised back to vertical and lowered back to horizontal (a “full bend”) a number of times until a crack first appeared and finally until it broke entirely.

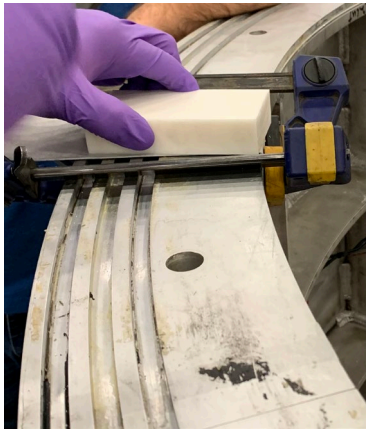
Simulated damage







Bending Test

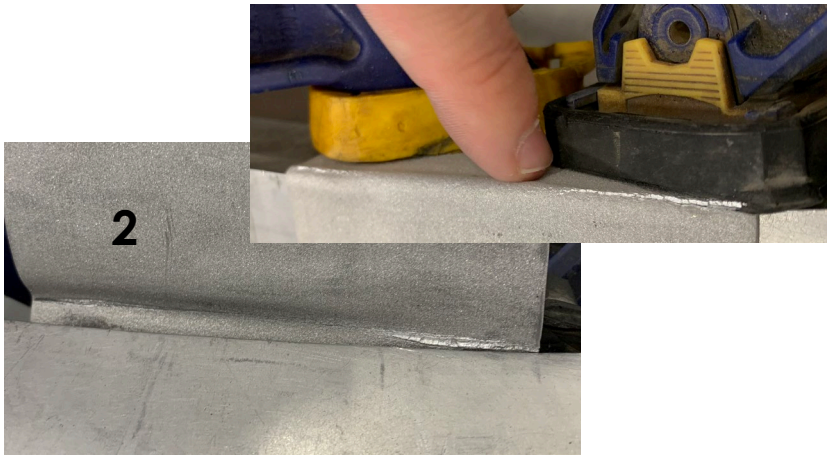


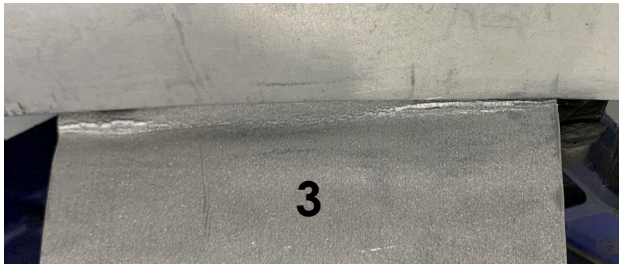
Thermal Bridge Fold Test (Variations)

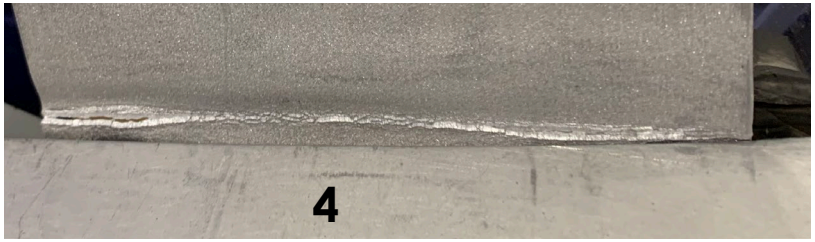
- A heat gun was used at one point to warm the TB to 260° F during the bending processes, but it showed little improvement in the number of times that the TB could be bent to failure.
- Two thermal bridges were severely damaged (added cracks on the right & left edges and punched a hole towards the center) before testing. Did not significantly affect the number of bends achieved.
- A smooth-surface (unblasted) thermal bridge was tested in the same way and lasted a few more bends than the grit-blasted ones.

Control Sample Test

A grit blasted strip of thermal bridge with no dents or imperfections was tested as a control sample. Although the first small (1/2") stress crack was seen after 12 full bends, the strip did not completely break in two until bend#34







Conclusions

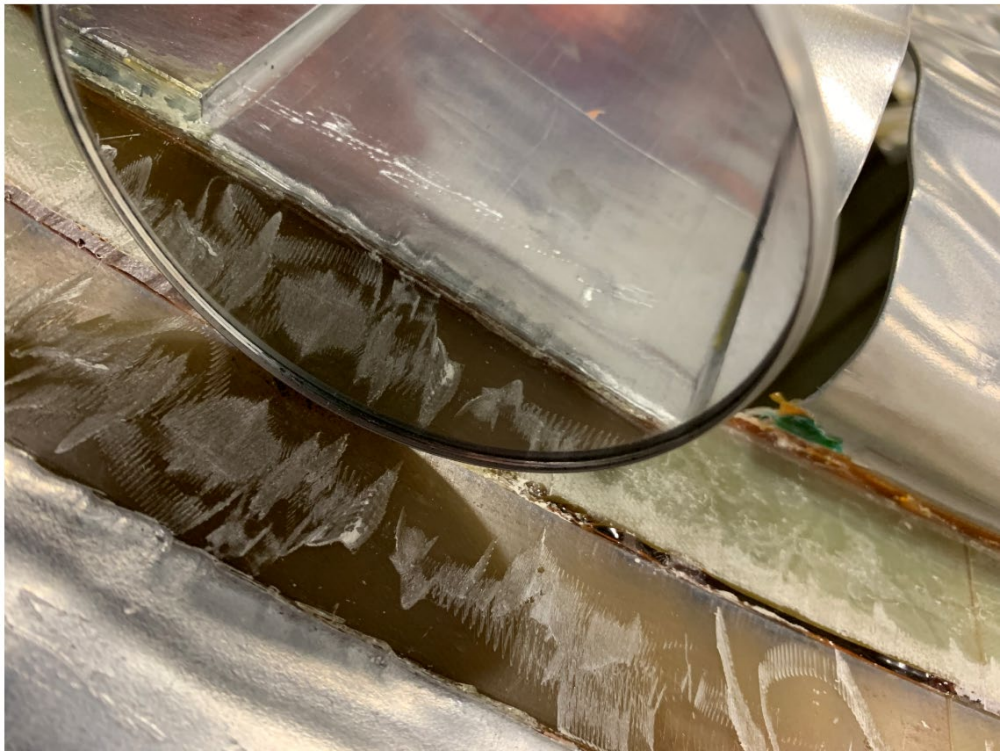
- Most damaged thermal bridges began to crack after 7-8 “full bends” and to fully break around 13-17 full bends versus the control sample which lasted longer before breaking in two. One particularly damaged one had a crack at 4 bends, cracked through to the back at 7 bends, and broke fully at 10 bends.
- The work hardening from the flexing seemed to lead to final breakage of the parts more so than the dents (unless extreme). Any bending of the thermal bridges during assembly should be minimized as much as possible.

From: Miller, Jonathan
To: Thomas M. Page; Spieldenner, Kevin; Mackintosh, Robert F.; Sandor Feher; Karie E. Badgley; Clark, Paul; James A Hocker; Vadim Kashikhin; Michael J Lamm; Chitwood, Neil; Selby, James; Davenport, Sharon
Subject: RE: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.***Clarification***
Date: Tuesday, November 3, 2020 8:32:11 AM
Attachments: image001.png
image002.png
image003.png

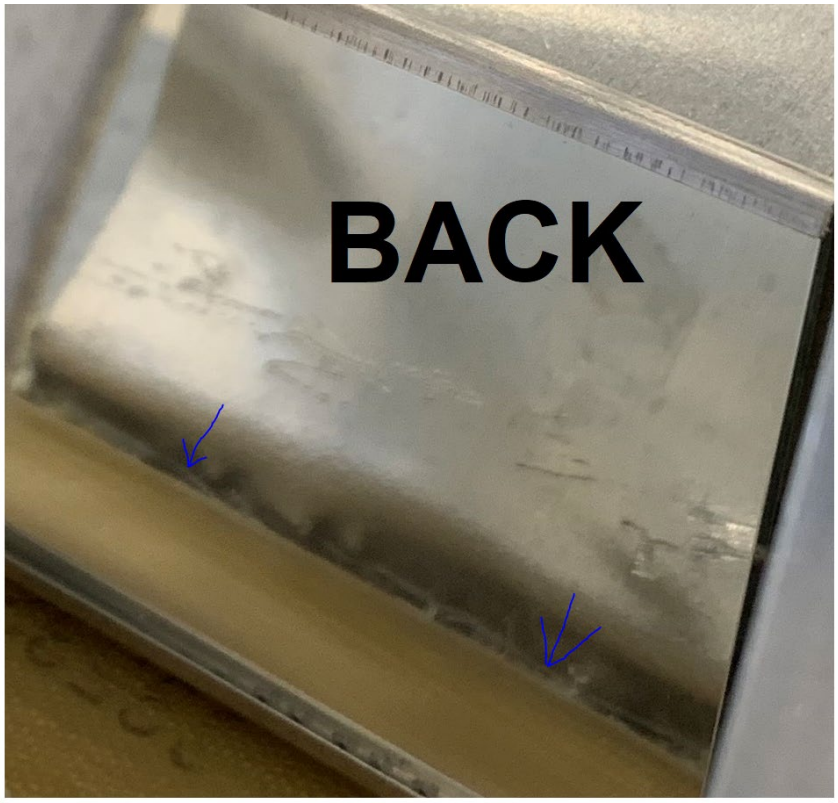
All,

TB# 5 does have a small surface crack on the O.D. of the bend. It still feels "secure" not loose. Also, after reviewing the before pics it appears that this is not a new crack and was present before being formed into the slot.

TB#5 after forming



TB#5 before forming/ back side.

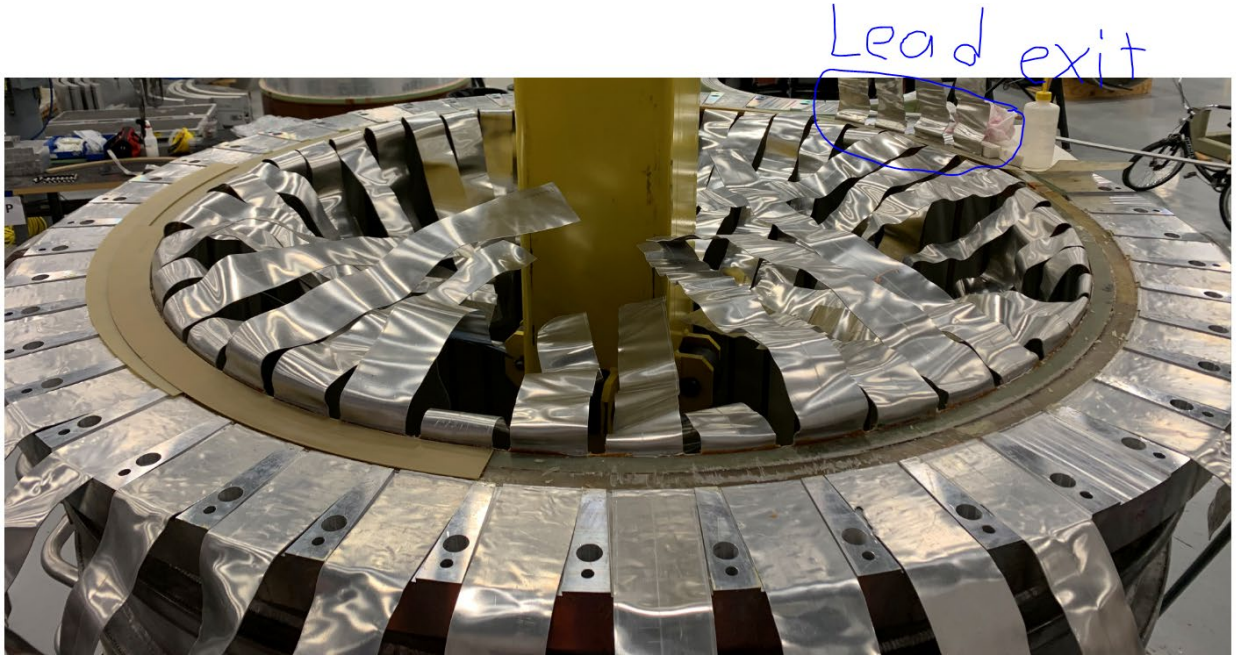


From: Miller, Jonathan
Sent: Tuesday, November 3, 2020 10:04 AM
To: 'Thomas M. Page' <tpage@fnal.gov>; Spieldenner, Kevin <Kevin.Spieldenner@ga.com>; Mackintosh, Robert F. <Robert.Mackintosh@ga.com>; Sandor Feher <fehers@fnal.gov>; Karie E. Badgley <kbadgley@fnal.gov>; Clark, Paul <Paul.Clark@ga.com>; James A Hocker <hocker@fnal.gov>; Vadim Kashikhin <vadim@fnal.gov>; Michael J Lamm <lamm@fnal.gov>; Chitwood, Neil <Neil.Chitwood@ga.com>; Selby, James <James.Selby@ga.com>; Davenport, Sharon <Sharon.Davenport@ga.com>
Subject: RE: QN 7071839 - Damaged thermal bridges - PS2 Coil Assembly, for FNAL review and concurrence.

All,

The tech training was performed this morning per the QN7071839, and the work on PS2 was resumed. So far all accept four of the outer thermal bridges have been formed into the slots on the lead end. TB# 7 has been removed per the QN. No new cracks have been observed at this point. The last remaining four thermal bridges are in the lead exit area. They will not be formed into the slots until after the "wet layup" of the leads into their respective grooves. These 4 remaining thermal bridges are 15, 16, 17, & 18. FYI, #15 has the 2nd worse initial damage.

Thanks,
Jonathan



From: Thomas M. Page <tpage@fnal.gov>
Sent: Monday, November 2, 2020 1:09 PM
To: Spieldenner, Kevin <Kevin.Spieldenner@ga.com>; Mackintosh, Robert F. <Robert.Mackintosh@ga.com>; Sandor Feher <fehers@fnal.gov>; Karie E. Badgley <kbadgley@fnal.gov>; Clark, Paul <Paul.Clark@ga.com>; Miller, Jonathan

RECORD OF MEETING

DATE	LENGTH OF MEETING *(HRS)*
11-3-2020	.5 hrs

SUBJECT
QN7071839 (PS2 Damaged Thermal Bridges)

REFERENCES *(ATTACH OUTLINE/AGENDA IF APPLICABLE)*
~~Lifting Plan for Mu2e DS Shell Assys.docx~~ J. Miller 11-3-2020 QN 7071839

CHAIRPERSON	COMPANY/TITLE	PHONE NUMBER/EXTENSION
Jonathan Miller	ME	662-297-0403

NOTES: PRINTED NAMES ACKNOWLEDGE ATTENDANCE.

PRINT NAME	COMPANY/TITLE *(Abbreviations OK)*	PHONE NUMBER/EXTENSION
Jonathan Miller	ME - Mu2e	662-297-0403
~~Steve Young~~	Local Mu2e	
James D. Selby	ME - Mu2e	662-206-8891
Terrance Osborne	Mu2E- Technician	
Matthew Smith	Mu2e Tech	662-321-8444
Sheila Aron	Tech	Mu2E
Shenna Cook	Mu2E	

CONTINUED ON REVERSE

Example checklist

HUMAN PERFORMANCE TOOL FOR ERROR REDUCTION Re+Md=0E

Reducing **e**rrors and **M**anaging **d**efenses **l**eads to **ZERO** significant **E**vents

PRE-JOB BRIEF

GENERAL ATOMICS ELECTROMAGNETICS

HOW DO I USE THIS TOOL?

- Schedule the pre-job brief; ensure all participants are present, and ensure active participation during the discussion (use the checklist)
- Conduct the pre-job brief as close to the start of the job task as practical (a task is an activity to work towards the job)
- Keep the pre-job brief focused, short, and concise to avoid inattention or lack of interest
- State the job objective and provide a "big picture" including procedures or work instructions required for the task
- Identify roles and responsibilities and summarize task sequence in adequate detail, discuss schedule/timeline and milestones if applicable
- Verify that required qualifications and training for the task are current
- Anticipate challenges using **S-A-F-E-R** (five questions for every task)
  - **Summarize Critical Steps**
    Identify activities/tasks where the results of an error are intolerable
  - **Anticipate Error-Likely Situations**
    Consider the complexity, risk, and logistics of the task
  - **Foresee Consequences**
    Consider the worst case if an error is made. Ask, "How bad can it get?"
  - **Evaluate Defenses**
    Identify how to prevent and catch errors and identify other actions that should be taken to mitigate identified risks. Defenses are any human, technical, or organizational features used to protect property, environment, and personnel against hazards, such as procedures, training, self-check, peer-check, three-way communication, seat belts, danger signs, alarms, color-coding, PPE, eye wash stations, etc.
  - **Review Previous Organizational Knowledge**
    Consider lessons learned and good practices relevant to the tasks

WHY SHOULD I USE THIS TOOL?

- To allow the worker to think through a task and use his/her knowledge to make the job as safe and efficient as possible
- To ensure those involved understand the scope of the tasks and their roles and responsibilities
- To anticipate problem areas and identify expected responses to reduce errors
- To review previous experience, past mistakes and lessons learned to improve performance

WHEN SHOULD I USE THIS TOOL?

- Prior to beginning a task that is non-routine OR routine yet significant
- For a new task assignment
- Following task or shift turnover
- For jobs where errors would have a moderate or significant negative impact to the company

HUMAN
PERFORMANCE TOOL
FOR ERROR REDUCTION Re+Md=0E

Reducing errors and Managing defenses leads to ZERO significant Events

PRE-JOB BRIEF

GENERAL ATOMICS
ELECTROMAGNETICS

PRE-JOB BRIEF
CHECKLIST

- ☐ State the job objective and provide the “big picture”
- ☐ Ensure all participants are present and concur they are qualified
- ☐ Identify roles and responsibilities
- ☐ Summarize the task sequence in adequate detail and the schedule/timeline
- ☐ Discuss:
    - Safety rules
    - Potential problems
    - Response to changes in the plan
    - Back-out criteria if the task isn’t proceeding as expected
    - Communications
    - Critical interactions between participants
- ☐ Conduct a SAFER conversation (five questions for every task):
    1. What are the critical steps?
    2. What are the error-likely situations?
    3. How bad can it get?
    4. What defenses are in place?
    5. Is there applicable organizational knowledge?

Notes: