

Diagnoses and Repair of a Crack in the Drift Tube LINAC Accelerating Structure at LANSCE

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AOT-MDE



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RF Unable to Maintain Full Power in DTL Module 3

Sustainable Power Desired: 260 kW @ 120 Hz

Date	PRF	RF Gate Length	Beam Pulse	Average RF Power	
	Hz	usec	usec	kW	
7/16/2017	120	1010	625	153.75	
11/16/2017	120	810	<mark>4</mark> 75	116.85	
11/17/2017	120	830	<mark>525</mark>	129.15	
11/27/2017	120	830	565	138.99	
6/28/2018	120	880	625	153.75	
9/18/2018	120	760	520	127.92	
9/20/2018	120	700	400	98. <mark>4</mark>	
9/24/2018	60	1010	625	76.875	
9/24/2018	60	1060	625	76.875	
9/26/2018	60	1060	725	89.175	
10/9/2018	60	1040	725	89.175	
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Layout of LANSCE Beamlines – DTL Location







Troubleshooting – Multiple Teams

- The Usual Suspects:
 - Thorough cleaning, vacuum window integrity and vacuum leak reduction did not affect the arcing
- X-ray detectors were arrayed at prescribed distances from both the module and each other to narrow down the area in the tank to search. This diagnostic confirmed that the arcing was near the RF window, approximately 6 meters from the upstream end [1].
- Opening the vacuum system to look more closely at the module's copper surfaces with cameras required the design and fabrication of special tooling to feed the cameras through the small ports and grates available to access the tank.





Troubleshooting – Crack Discovered with Camera

A borescope was supplemented by a special, highresolution camera. purchased specifically for the job. These cameras allowed close-up viewing and photography of geometric features that could be compared against previous photos to distinguish changes revealing the cause.



After a careful and systematic effort, the 201 RF Team was able to find the likely cause of arcing; a crack (approximately 30 cm long and 3 mm wide) in the ion pump grate at one of the transverse copper welds.



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LANSCE Drift Tube LINAC (DTL) – Design Features



- Tank Inside Diameter 0.88 m
- Clad inner wall: Steel 15.9 mm thick, Copper 3.2 mm thick



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LANSCE Drift Tube LINAC (DTL) – Design Features



- Ribs for cooling water channels
- Ion pump ports: 30.5 X 44.5 cm rectangular (12 X 17.5 in)
- Frequency tuner ports: 16.2 cm ID (6.375 in)
- Post coupler ports: 5.7 cm ID (2.25 in)



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Repair: Non-Intrusive Options



Copper foil tape applied to crack

This option was tried first and, by the behavior witnessed in the RF power, proved that the source of the issue was indeed the crack. Tape blistered when the power was ramped up proving this option not viable.

Copper bridge covering the crack

This option was installed but was not successful in preventing arcing and multi-packing



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CAD Model of Fabricated Patch



• Design discussions to decide on:

- Thickness: 3.2 mm
- > Arc Length: 35.5 cm
- Rounded versus square edges
- Bottom groove (weld relief)



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Guiding Documents [2]

- AOT-MDE-IWD-19-001, DTL Tank 3 Inspection, Clean Out and Repair
- AOT-MDE-IWD-19-011, SOW, Tank Welding Repair, Module 3
- 29 CFR 1926 Subpart J, Welding 1926.353(a)(2)
- ANSI Z49.1:2012 Safety in Welding Cutting and Allied Processes, Section 7.1 Ventilation in Confined Spaces
- Radiological Work Plan (RWP)
- LANL Policy P101-27, Confined Spaces
- LANL Policy P101-27, Confined Space Entry Permit
- LANL Policy P101-27, Confined Space Rescue Plan
- LANL Policy P101-25, Cranes, Hoists, Lifting Devices, and Rigging Equipment
- LANL Policy P101-26, Welding, Cutting, and Other Spark- or Flame-Producing Operations
- LANL Policy P101-26, Attachment A. Form 1563, Spark- Or Flame-Producing Operations Permit
- Air flow calculation email from Industrial Hygiene



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Photos from Original Build



Drift tube installation

Inside of tank - drift tubes and post couplers



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Constraints and Practice

- Confined Space
 - 0.8 m diameter pipe, 7 m from the only entry and exit point
- Welding
 - copper vapor exposure limits
 - welding in the prone (face down) position affects ability to see and guide the welding gun
 - radioactive base metal doubtful
 - chance of fire
- Breathing
 - available oxygen is displaced by CO₂ exhaled, copper vapor and Helium gas
- Communication
 - affected by the wearing of a respirator
 - affected by the limited number and size of ports



Performed mock up of tank and practiced welding to simulate actual conditions



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Many Teams Involved



Repair and Support Teams



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Repair



Tank 3 – End Wall Removed



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Welding Results







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Acknowledgments and References

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- 2. M.J. Borden, "Safety Challenges and Solutions LANSCE DTL Cracked Weld Repair," DOE Accelerator Safety Workshop 2019, September 19-21, 2019, Oak Ridge, TN.



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