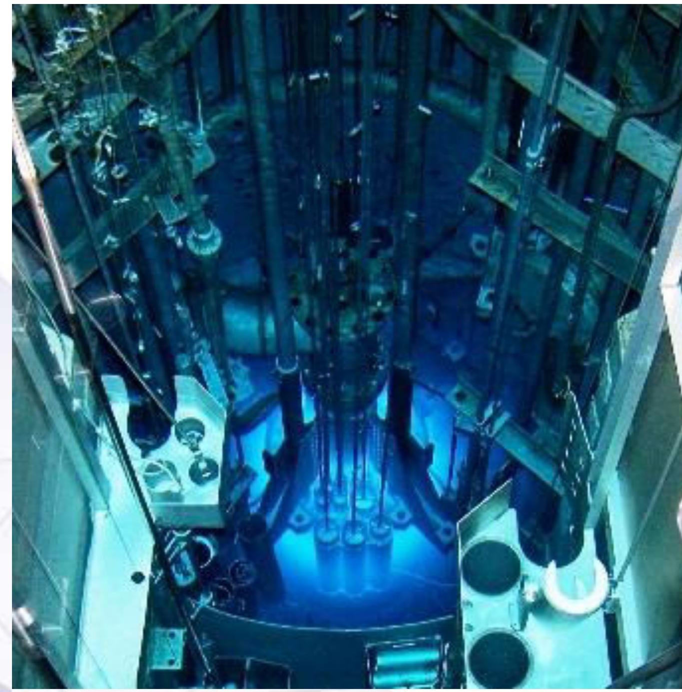
Control Blade Design and Fabrication Improvements using Laser Welding



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MURR® TR
2013
TEST RESEARCH AND TRAINING REACTORS

Overview

- MURR Facility
- Control Blade History
- Project Background
- The Part
- The Idea
- Making It Happen
- Lessons Learned
- Q & A

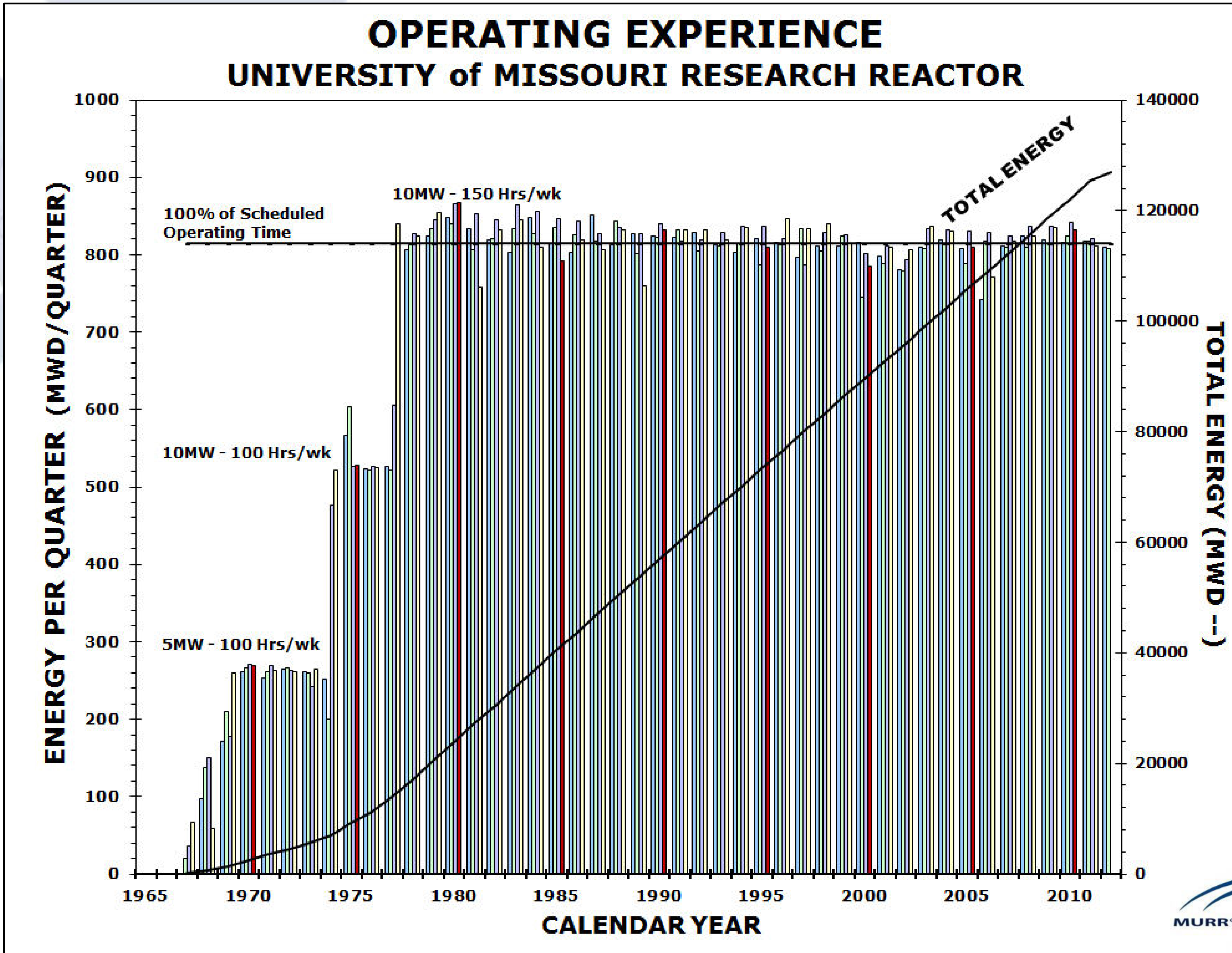
History of MURR

- Located in Columbia, Missouri
- October 13, 1966 – Facility established initial criticality and licensed to operate at 5 MWs
- July 18, 1974 – Facility uprated to 10 MWs
- September 1, 1977 – Facility starts a 10 MW, 150-hour-per-week operating schedule
- September 1, 2006 – Facility submits 20-year license renewal application to the NRC

Key Reactor Parameters

MURR® is a pressurized, reflected, heterogeneous, open pool-type, which is light-water moderated and cooled

- Maximum thermal power – **10 MW**
- Peak flux in center test hole – **6.0E14 n/cm^2-s**
- Core – **8 fuel assemblies (775 grams of U-235/assembly)**
- Control blades – **5 total: 4 boral shim-safety, 1 SS regulating**
- Reflectors – **beryllium and graphite**
- Forced primary coolant flow rate – **3,750 gpm (237 lps)**
- Forced pool coolant flow rate – **1,200 gpm (76 lps)**
- Primary coolant temps – **120 °F (49 °C) inlet, 136 °F (58 °C) outlet**
- Primary coolant system pressure – **85 psia (586 kPa)**
- Pool coolant temps – **100 °F (38 °C) inlet, 106 °F (41 °C) outlet**
- Beamports – **three 4-inch (10 cm), three 6-inch (15 cm)**



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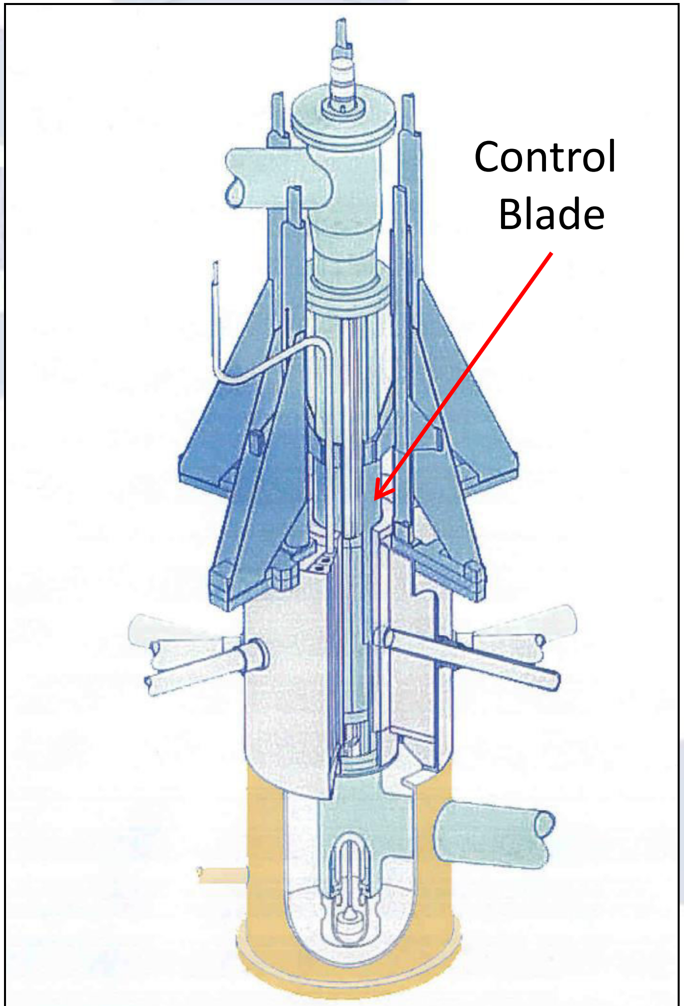
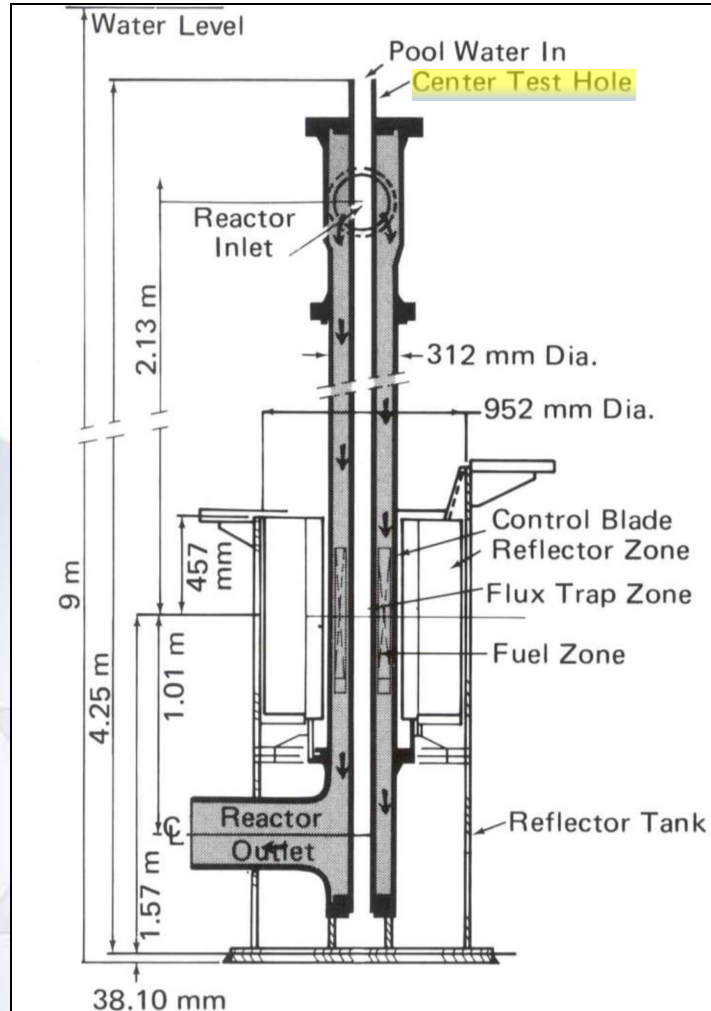
Reactor Core Assembly



3-D View



2-D View

Previous Control Blade History

2006	Contracted vendor ceases production, sells remaining material and equipment to MURR.
2008-2010	MURR produces several control blades using Tungsten Inert Gas (TIG) welding with moderate success.
2010	Laser welding is explored.
2012	Laser welding is used to produce MURR control blades.
2012	First laser welded blade is placed on service in MURR reactor.

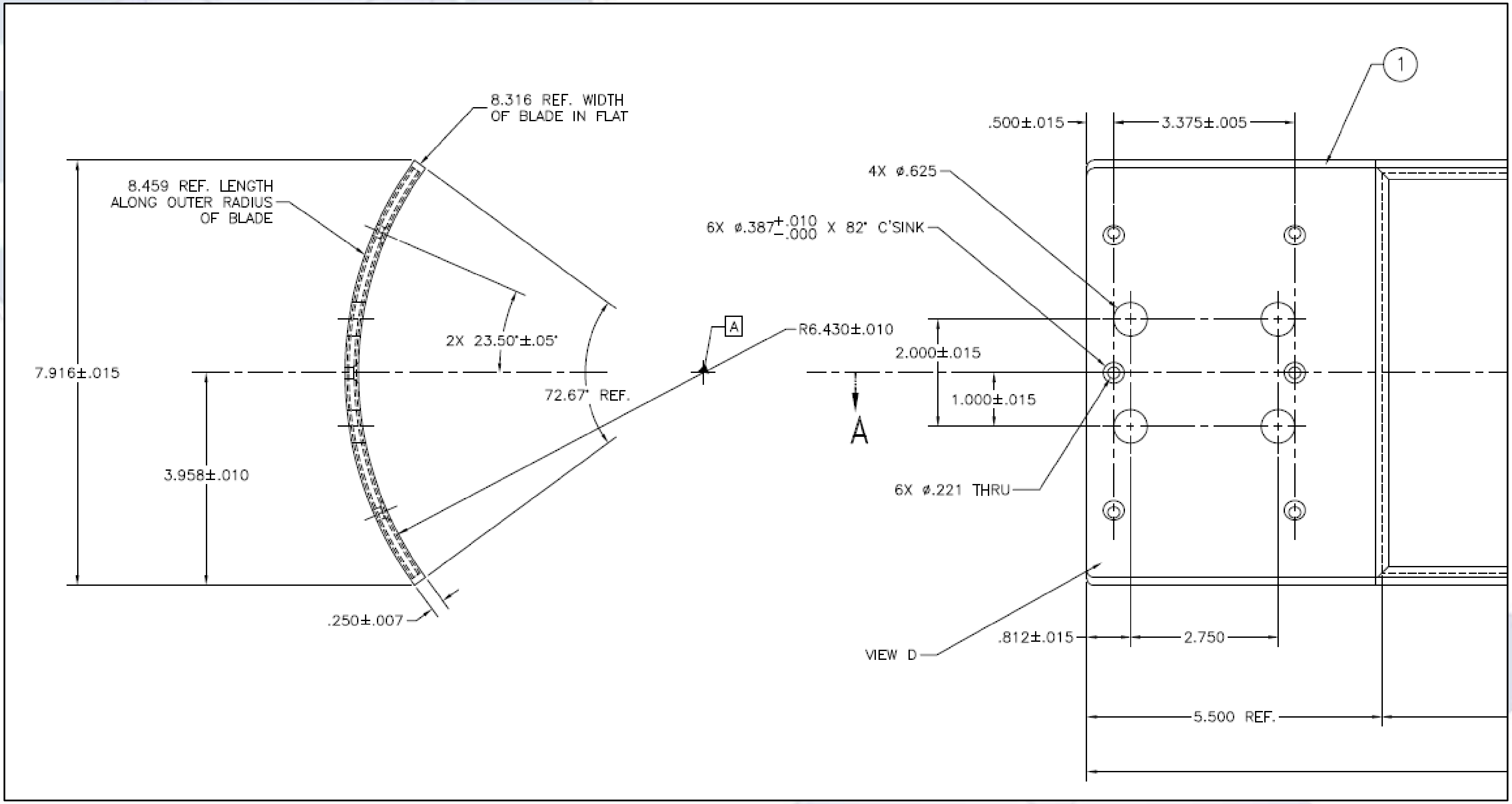
Project Overview

- Our overall task was to produce enough qualified Control Blades to serve the needs of MURR into the foreseeable future.
- Our specific task was to improve the sealing of welds in the manufacturing of Control Blades.
- In considering laser welding, we sought the help of a well-respected Laser Services job shop.
- Their development work and resulting feedback on coupon welding was invaluable.

The Part

- The MURR control blade is a composite of sintered BORAL® clad in Aluminum.
- Four blades are used as shim safety rods – can be dropped from electromagnets to ensure safe reactor shutdown.
- Each blade occupies a circular arc of 72 degrees between the outer reactor pressure vessel and the Beryllium reflector, in a water gap roughly one-half inch across.
- Each blade is mounted to an offset mechanism and controlled via the electromagnets by a drive mechanism.

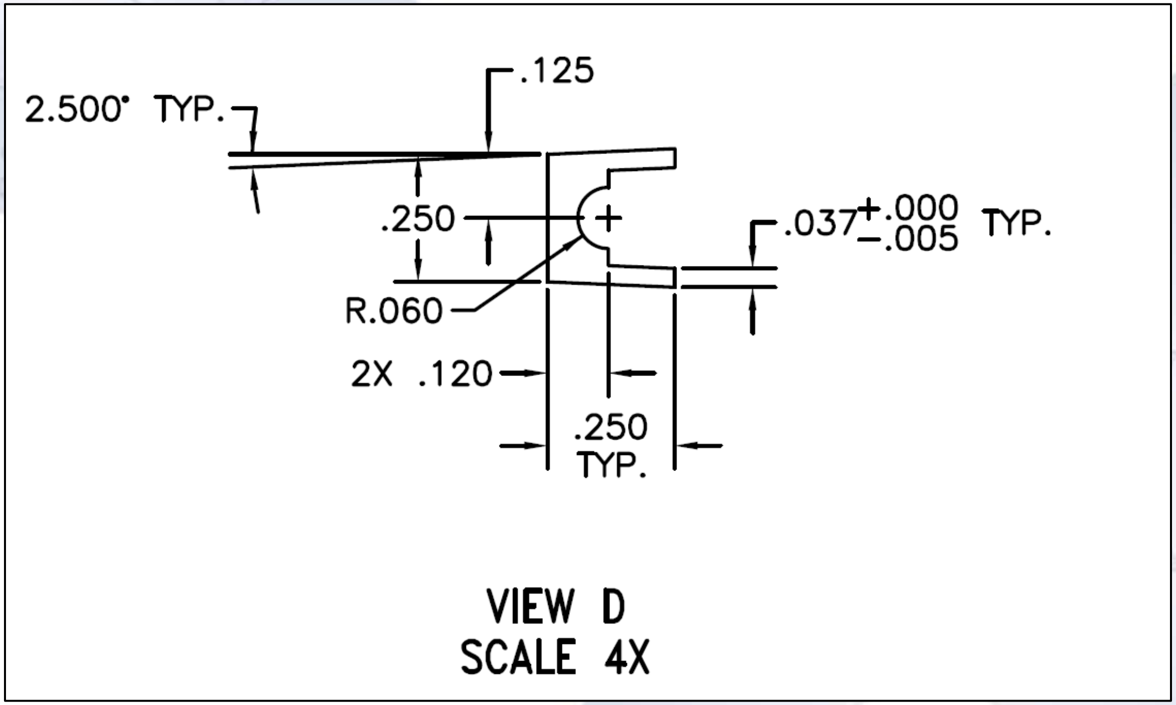
The Part



8.316 REF. WIDTH OF BLADE IN FLAT
8.459 REF. LENGTH ALONG OUTER RADIUS OF BLADE
7.916±.015
2X 23.50°±.05°
72.67° REF.
3.958±.010
.250±.007
A
R6.430±.010
.500±.015
3.375±.005
4X ø.625
6X ø.387 +.010 −.000 X 82° C'SINK
2.000±.015
1.000±.015
6X ø.221 THRU
VIEW D
.812±.015
2.750
5.500 REF.
1

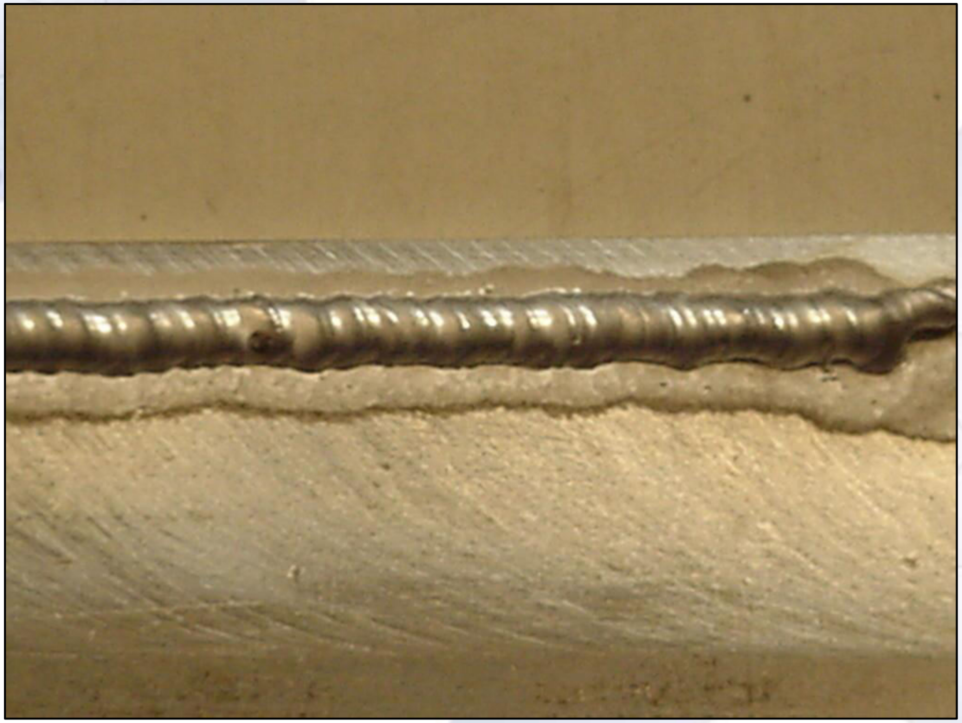
The Part

- An edge channel is welded to the entire perimeter of the BORAL® plate.



The Part

- TIG welding produced a large heat-affected zone, required grinding and often resulted in boron contamination of the weld.



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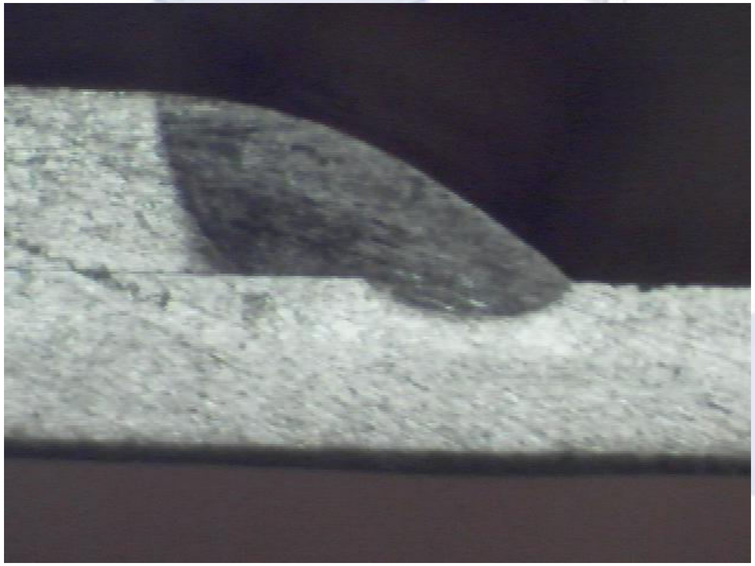
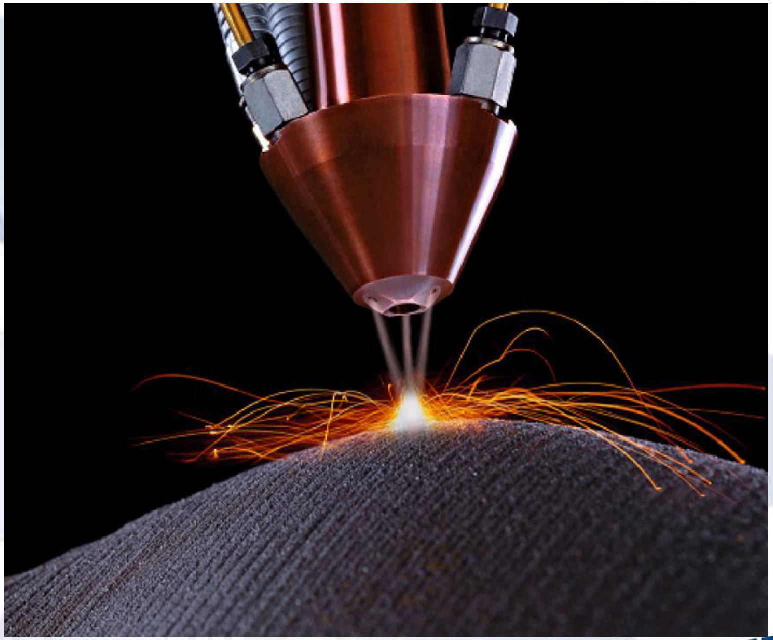
The Idea

- Laser welding offered a much smaller heat-affected zone, no grinding and the promise of preventing weld contamination.



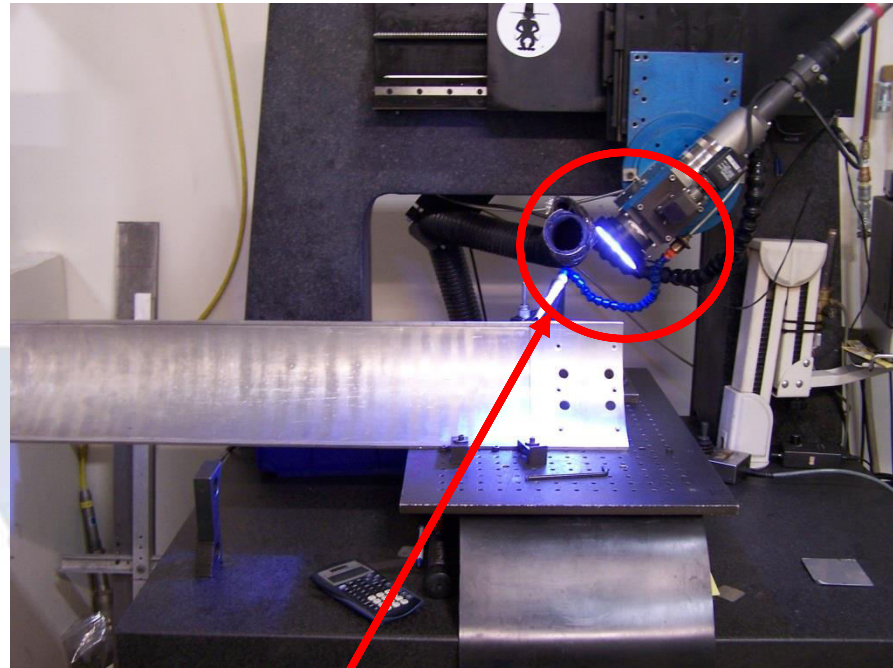


Making It Happen

- Laser welding came with the tradeoff that a better fit between parts was needed.
- Alloy 1100 needed alloy 4047 to work.
- Fixturing was developed to ensure better fitments.
- The outside channel was replaced with alloy 4047, including the top channel, which was incorporated into the top mounting plate.

Making It Happen

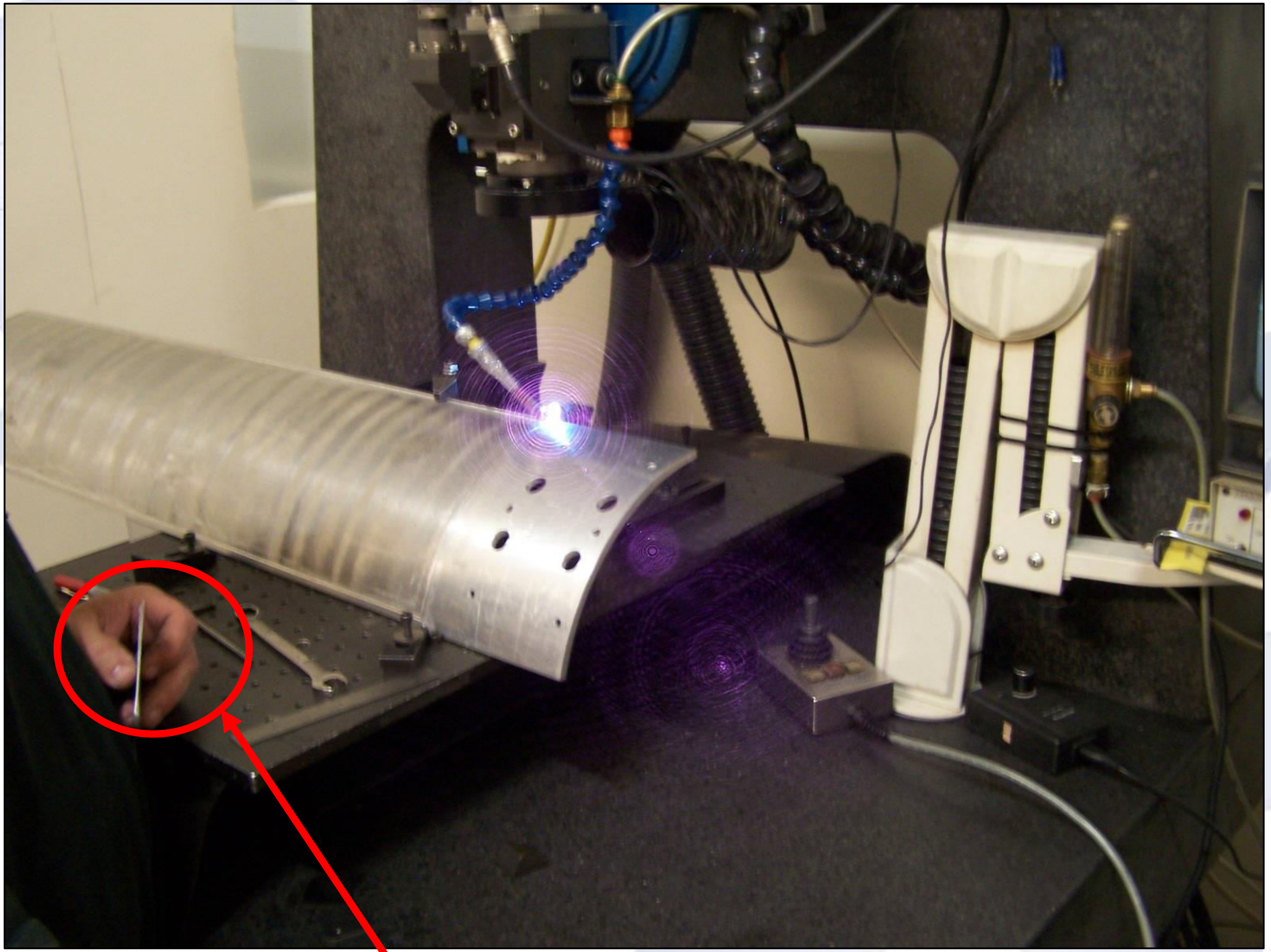
Head Piece



Laser Head

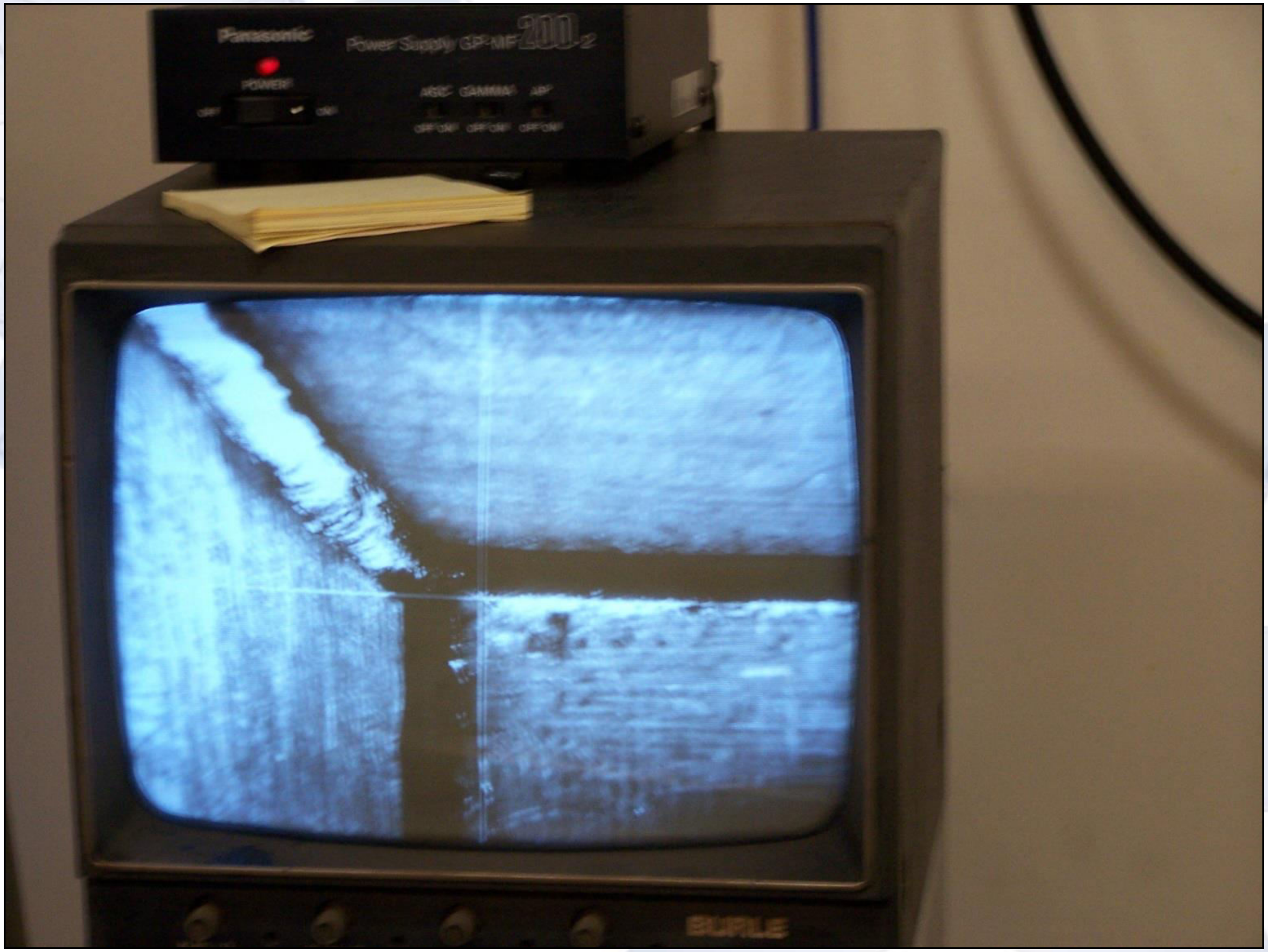
- Lens
- Camera
- Argon Supply

Making It Happen

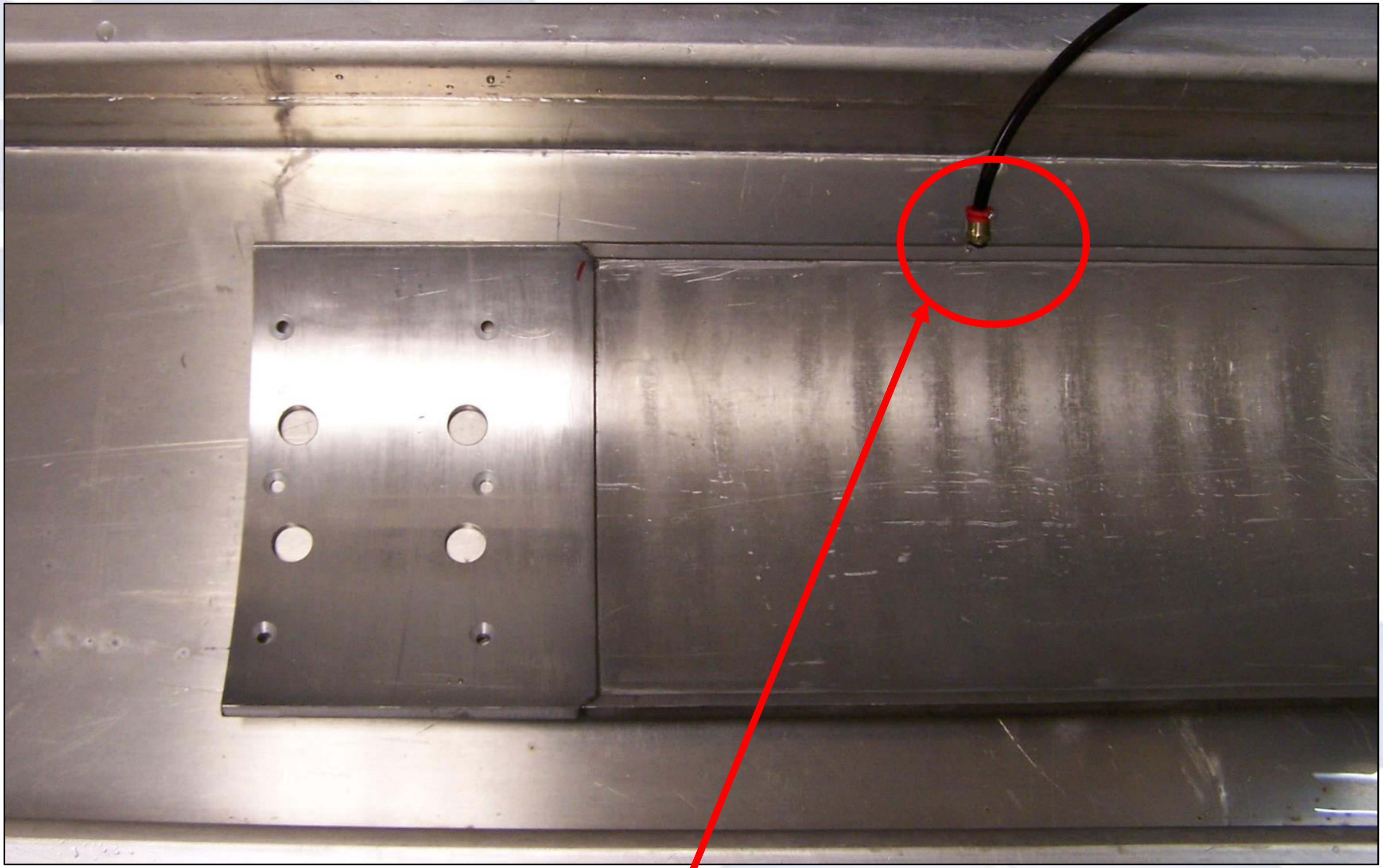


Really High Tech

Making It Happen



Making It Happen



Nitrogen applied inside channel

Making It Happen

- Modification Record documentation was performed to capture design changes and to authorize laser welding as a fabrication alternative.
- 10 CFR 50.59 documentation was performed to ensure reactor safety and regulatory compliance.
- The first laser welded blade was placed into service in December, 2012.

Lessons Learned

- Laser welding meets the objectives of producing leak-free control blades, but comes with its own challenges.
- Proper fit of the parts becomes a major focus of the effort.
- Weld repairs can be done more easily.
- Quality still depends greatly on the skill of the welder.

Thank You For Your Attention, Any Questions???

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