Combining Heat Induction and Laser Ablation for the Removal of Potentially Hazardous Bridge Coatings

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Thursday, September 12th, 1:00 -1:30 PM

Outline

- Conventional Approach
- Motivation for Investigating New Coating Removal Methods
- Questions to Consider
- What is Induction Coating Removal = ICR
- What is Laser Ablation Coating Removal = LACR
- Air Emission Control System
- Overview of LACR and then the ICR plus LACR Evaluation
- Recent Field Results
- Conclusions
- Resources
- ICR + LACR Project Team and Questions

Conventional Approach

- Traditionally, abrasive grit blasting used to remove coatings
- Large volume of waste generated
- Abrasive blasting fills the air with pellets that contain lead or zinc

Conventional Approach, cont.

- To do properly, requires containment, extensive PPE, and proper waste disposal

Containment

PPE

Waste Disposal

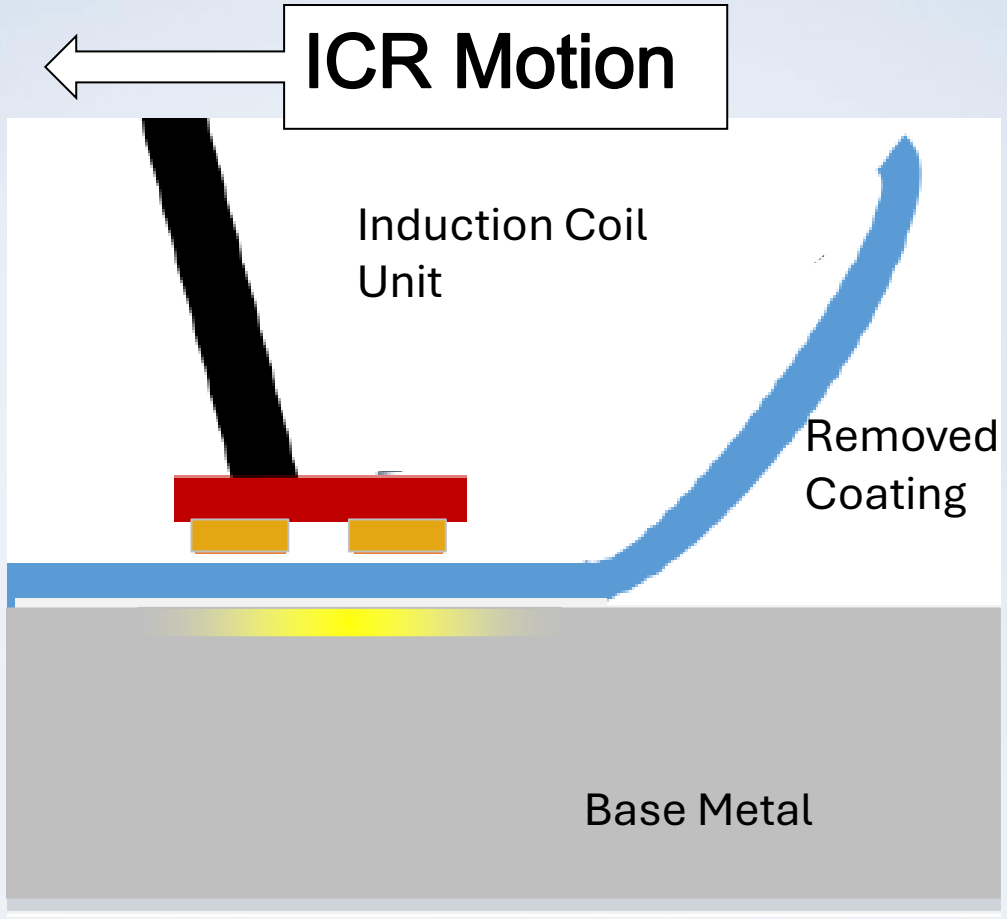
Motivation for Investigating New Coating Removal Methods

•This approach makes sense for large scale bridge recoating work.

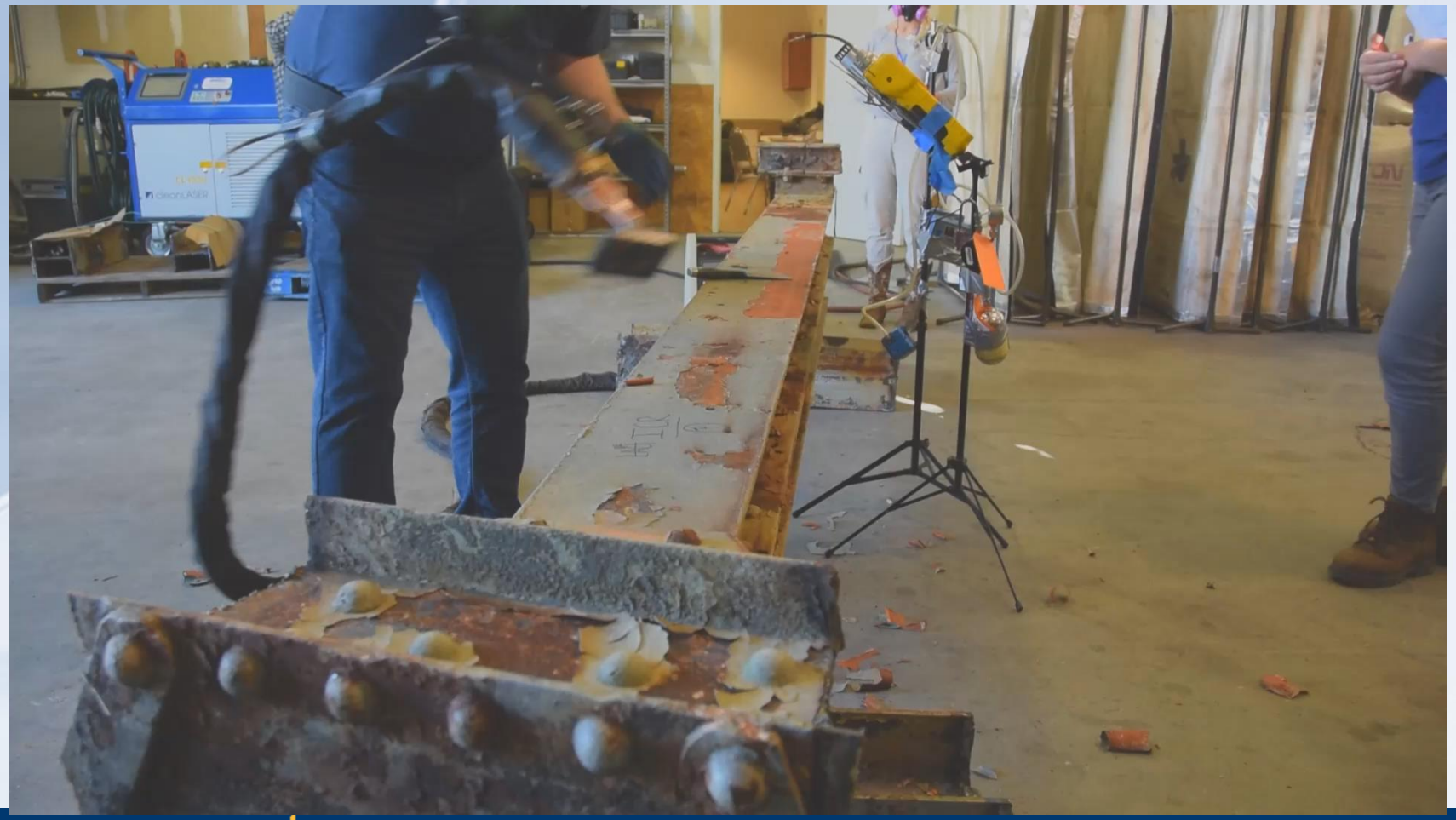
•Are there techniques that could simplify containment and PPE, reduce waste, and are suited for doing smaller repairs earlier in the damage cycle, and thus saving more steel from corrosion? Media-less ICR+LACR?

What is ICR → Induction Coating Removal

- Initial work was with LACR, but to removal rate needed improvement.
- ICR debonds coating, so not sensitive to thickness like LACR
- Localized heating at coating/steel interface disrupts bond

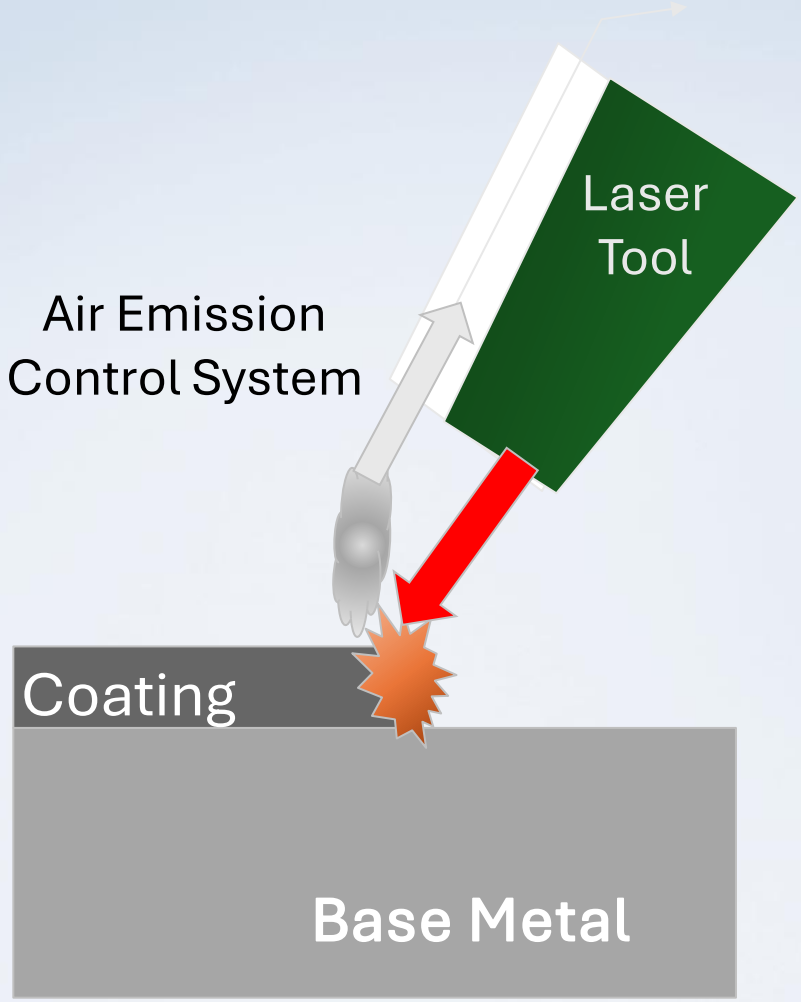


ICR in Action



What is LACR → Laser Ablation Coating Removal

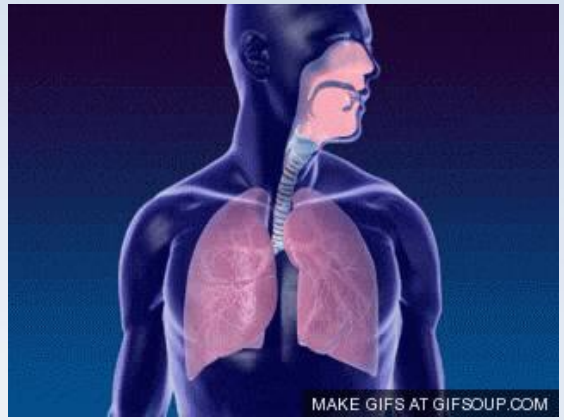
- In the past, evaluated both continuous and pulsed.
- Focusing on pulsed laser
- Coating absorbs most of the pulsed laser energy and converts into vapor (particles) from thermal energy.
- Integrated 3-stage air emission control system



LACR with Air Emission Control System in Action

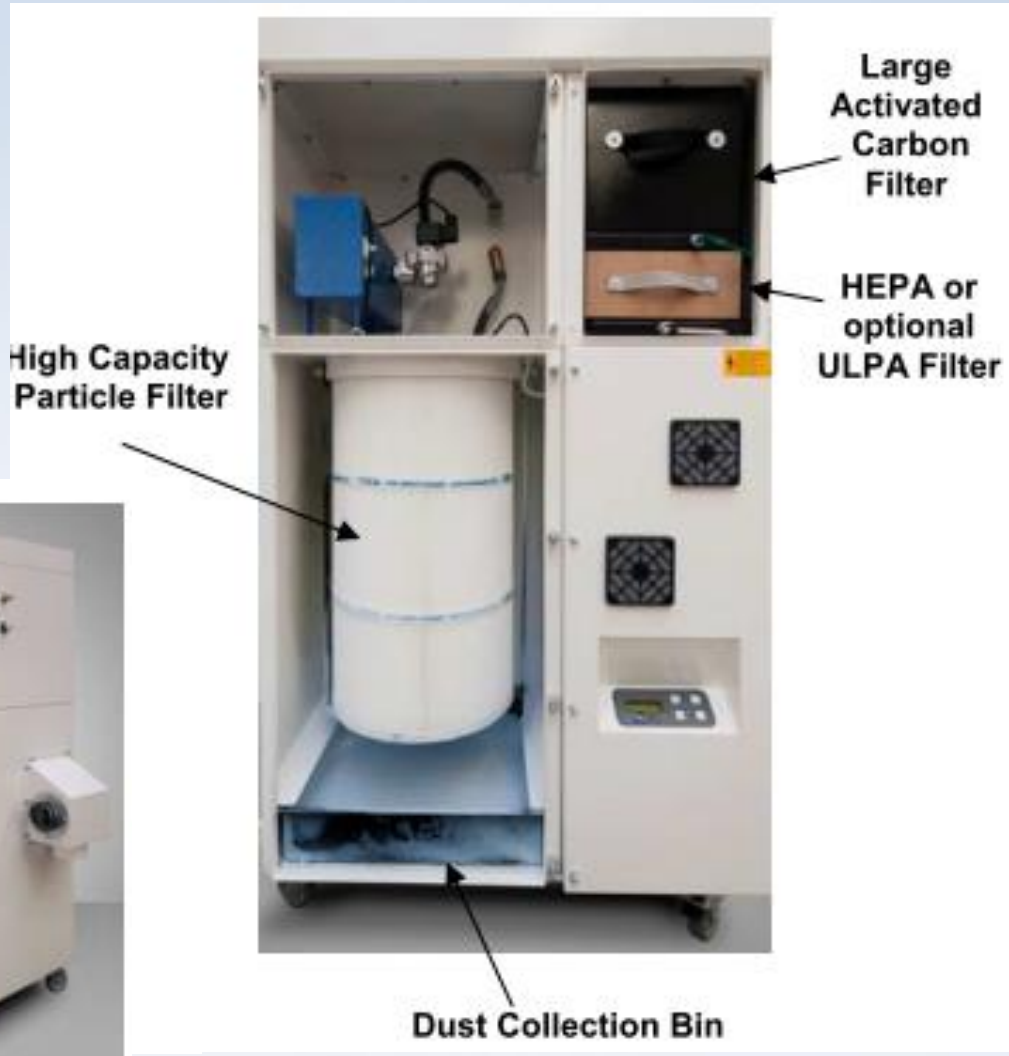
Laser Generated Air Contaminants/Hazards

- LACR process releases hazardous Laser Generated Air Contaminants (LGACs)
  - Organic Products of Thermal Decomposition: Vapors and Organic dust/particulate, such carbon
  - Inorganic Products – metal fumes and particulate, such as lead or zinc
- Users must consider hazards of laser light for LACR
  - Eye and Skin Damage, Fire
- Users must consider electro-magnetic field hazards for ICR
  - Damage to pacemakers, sensory-neuro effects, heat generation in body
- Noise
- Other Environmental Hazards: hazardous waste generation
  - reduced from blasting but still produces some waste
  - Haz classification dependent on coating removed



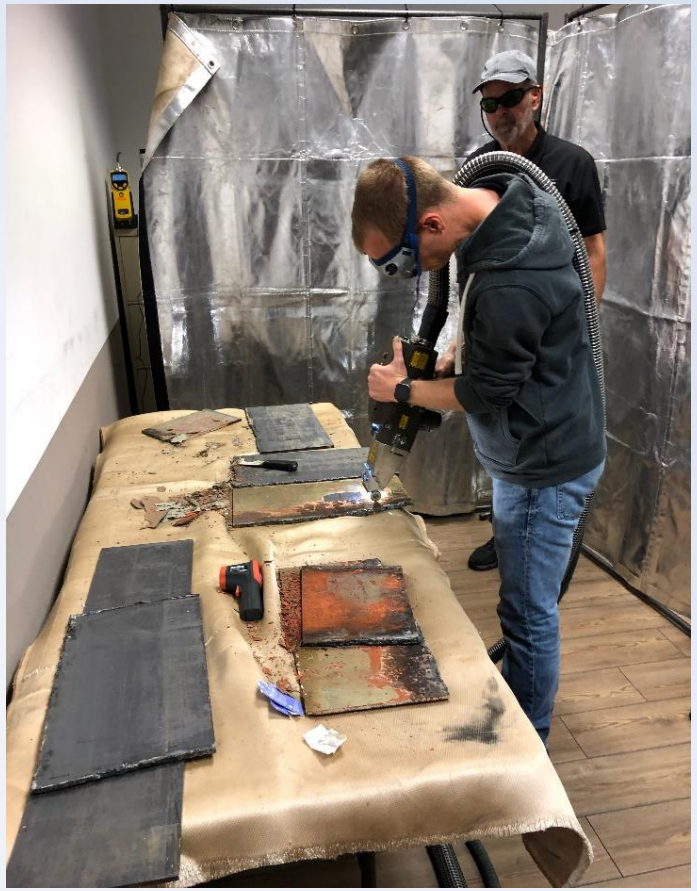
What is an Air Emission Control System

- Air emission control system
- comprised of three filters
- sealed in a control cabinet



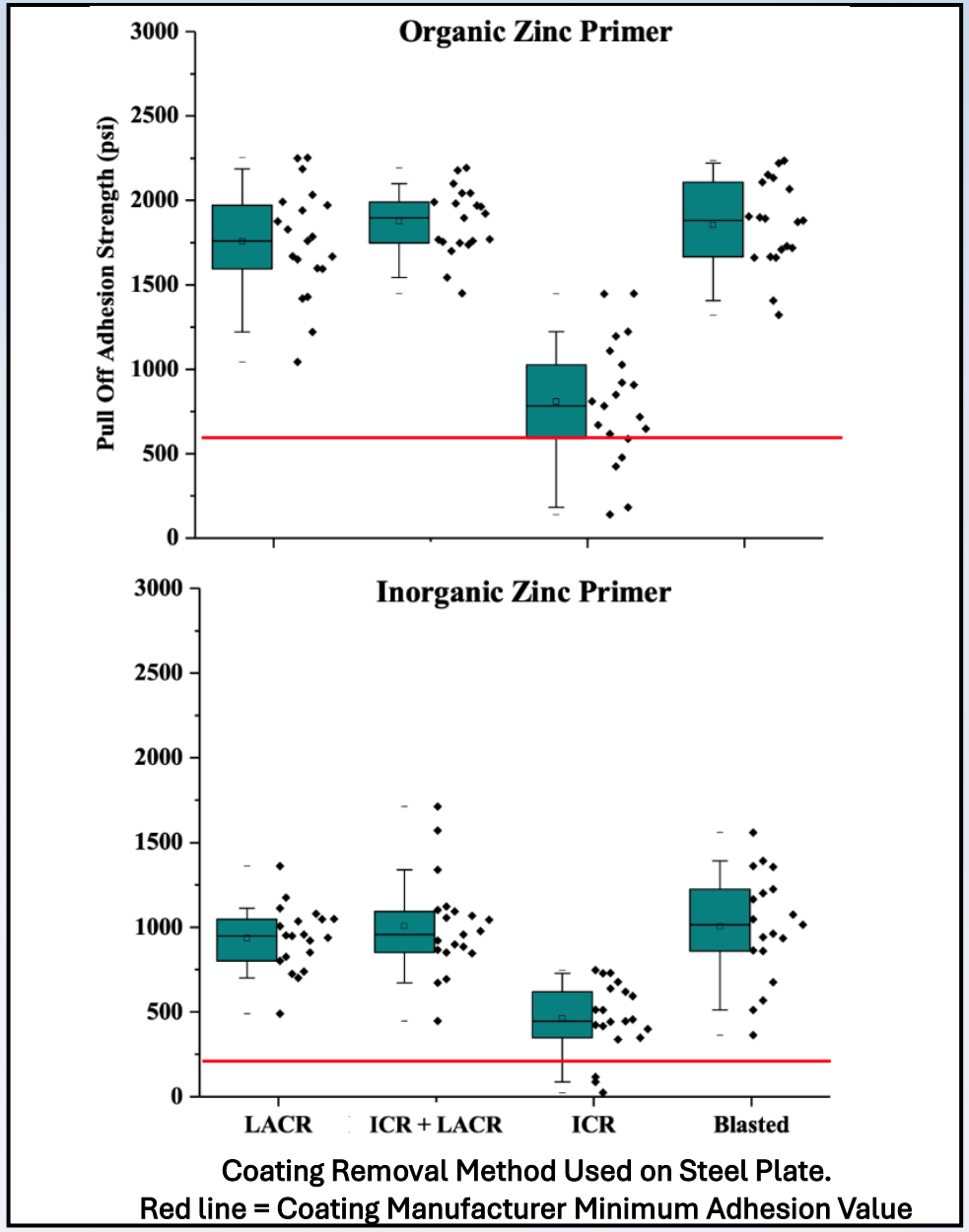
Overview of LACR Evaluation by VDOT/VTRC

- Initial work done at Norton Sandblasting and Farmville Bridge Site
- In August 2019, VTRC released a final report
  - Innovative Coating Removal Techniques for Coated Bridge Steel, which used a pulse LACR device
- Lessons Learned
  - LACR reduced waste/exposure and provided a relatively clean surface
    - Possible use is hot work
  - LACR was slow, therefore the VTRC report highlights the need to pursue induction coating removal
  - Need to better understand adhesion



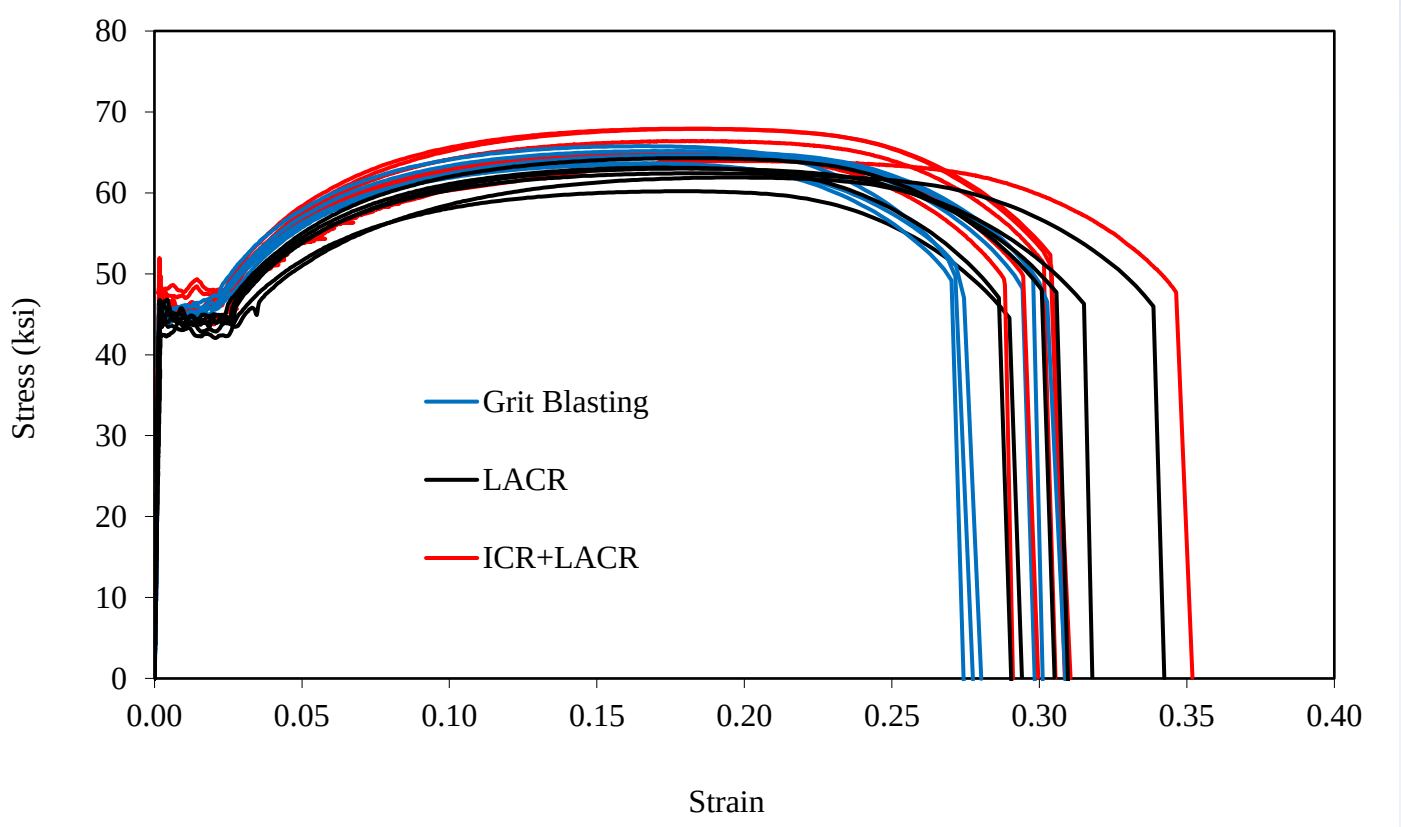
Overview of ICR plus LACR Evaluation by UVa/VDOT/VTRC

- Lessons Learned
  - Combining the two techniques increased speed
  - ICR plus LACR gave favorable adhesion test results
- Notable Accomplishments
  - Published adhesive study as part of a university thesis
  - Field trial to establish if ICR plus LACR is ready for selective cleaning of steel bridge beams
- Next step
  - Publish VTRC report



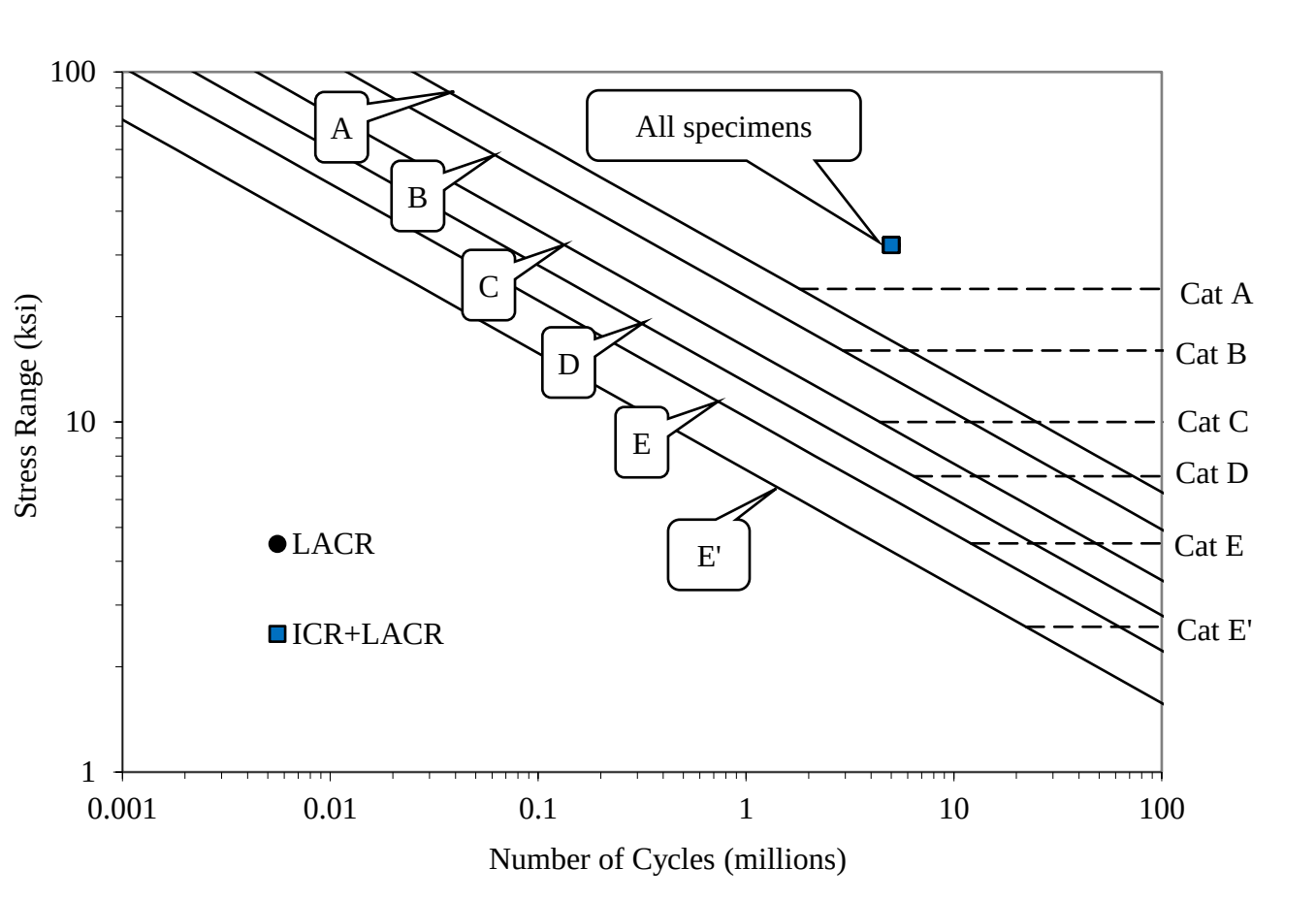
Coating Removal Method Used on Steel Plate.
Red line = Coating Manufacturer Minimum Adhesion Value

Tensile Test Results



- The average yield stress, average ultimate strength, and average percent elongation the three conditions are similar, and all exceed the expected results for an ASTM A36 steel.

Fatigue Test Results



- All samples reached 5 million cycles and were considered run-outs
- The samples subjected to either LACR or ICR + LACR can be expected to have similar fatigue performance compared to steel base metal not subject to any coating removal process.

Recent Field Results: Route 695 Bridge over Route 460

- The Route 695 Bridge over Route 460 had several areas cleaned using LACR, which is covered in VTRC Final Report No. 20-R1.
- Approximately 50 ft^2 of surface area was recoated with an epoxy mastic aluminum II primer with an Acrolon 218 HS finish coating (VDOT specifications for Coating System F).

Observations on Route 695 Bridge over Route 460 after Seven Years

The coating is adhering to the steel surface and providing protection. Some small rust spots and stains are evident

Field Project: Route 301 Bridge over Pamunkey River

This project was designed to determine if coating removal work using ICR plus LACR could be successfully performed under actual field condition by a specialty contractor.

- Specialty contractor using ICR/LACR combination for cleaning
  - Three of the beam end bearing lines
- Prime contractor using conventional methods for cleaning
  - Five of the beam end bearing lines
- Work was performed in late October/ early November 2023

After Abutment Cleaning with ICR plus LACR then Recoating

Comparing Techniques: Before and after with favorable conditions

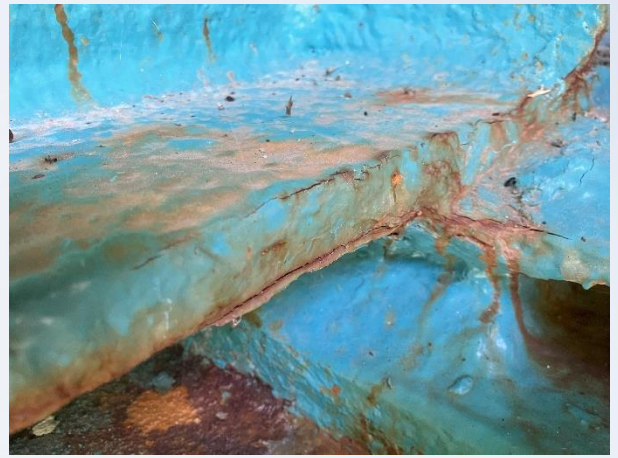
- Before and after abrasive blast cleaning on diaphragm connection to beam

- Before and after ICR then LACR cleaning on diaphragm connection to beam

Comparing Techniques: Before and after with restricted access

- Before and after abrasive blast cleaning where difficult access limits cleaning and recoating

- Before and after ICR then LACR cleaning where cable for containment limits access for ICR and LACR



Comparing Techniques: Remaining rust product insufficiently cleaned

- Incomplete removal of pack rust resulting in salt initiated corrosion again after abrasive blast cleaning

- Incomplete removal of pack rust resulting in salt-initiated corrosion again after ICR then LACR cleaning

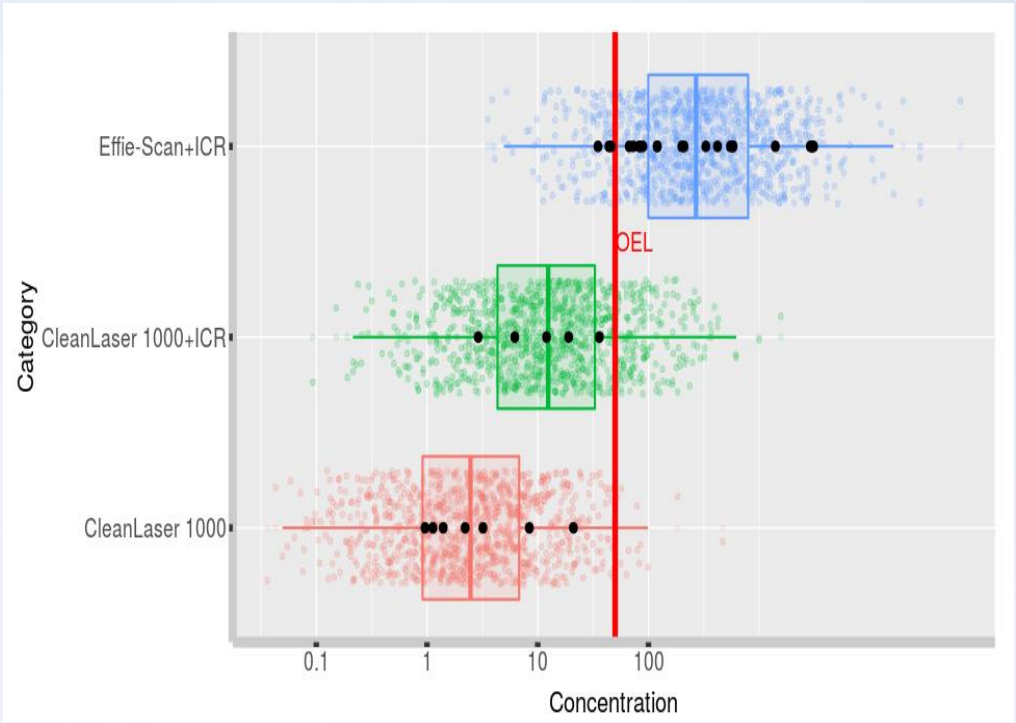
Other ICR plus LACR Field Notes

- Difficulty accessing backwall area with ICR and LACR, so coating removed mechanically

- Diaphragm coating was mechanically removed and the steel was left uncoated overnight (less than 24 hours), but the LACR cleaned surface area hasn't changed after several days.

VDOT EH&S Findings

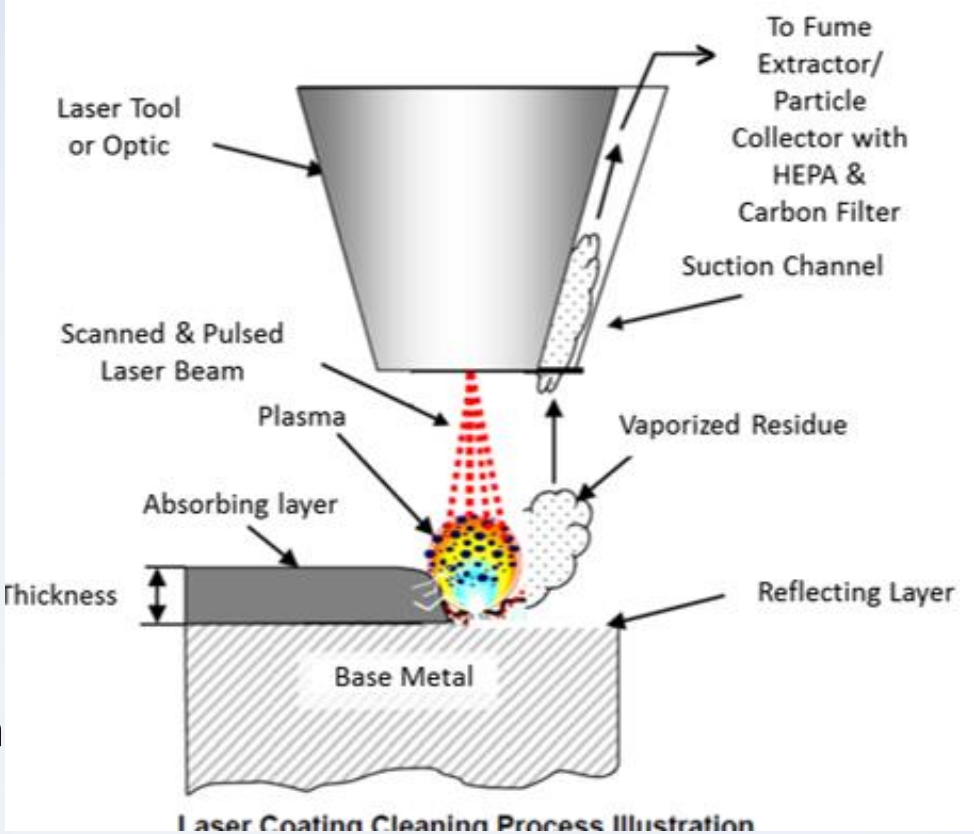
- Employee exposure to LGACs dependent upon LACR and ICR Fume capture effectiveness:
  - Built-in (LACR1000)
  - Mounted (Effie-scan LACR)
  - Not-present (ICR)
- Availability of Additional Ventilation Systems:
  - Positionable Local Exhaust Ventilation (PLEV)
  - General Mechanical/Dilution Ventilation (GMV)
- Type of Space
  - Enclosed in Curtains/Under Bridge Abutment vs. Open Areas
  - Use PLEV or GMV in enclosed spaces
- Type of Coating Removed
  - Leaded Coating/Other Heavy Metals
- Ergonomics
  - Rotate workers to reduce trigger fatigue and arm and muscle strain and stress



Concentration of Lead in µg/m³. Red line is 50 µg/m³

EH&S Recommendation for ICR and LACR Use

- Choose LACR Units with Built-in Fume Extraction
- Consult with Safety/Industrial Hygiene for:
  - Recommended and required personal and area air monitoring for LGACs
  - Recommended PPE based on coating constituents and previous sampling results for LGACs
  - Recommended eyewear/gloves/etc. for LACR and ICR skin and eye protection
  - Recommended LACR set-back distances
- Consult with Environmental for:
  - Hazardous waste sampling, storage, and disposal needs
  - Containment/capture needs: tarpaulins/catchalls on ground, laser curtains, negative air machines, etc.
  - Perimeter area monitoring per State requirements, varies by State



Laser Coating Cleaning Process Illustration

Conclusions

- ICR + LACR and LACR alone all provide equivalent adhesion to the traditional method of grit blasting, all of which met the coating producer's requirements for both zinc rich organic and inorganic primer coating systems (VDOT System B Paints).
- ICR alone did not provide sufficient coating adhesion to meet the manufacturers requirements.
- Combining ICR with LACR increased the costing removal rate.
- The tensile test results for the three conditions tested, LACR, ICR with LACR, all exceed the expected results for an ASTM A36 steel.
- ASTM A36 steel subjected to either LACR or ICR + LACR is expected to have similar fatigue performance compared to steel base metal not subject to any coating removal process.

Conclusions

- For abrasive blast, LACR, and ICR plus LACR, access to surfaces for proper cleaning is important
- The removal of pack rust and other thick oxides that can form as steel corrodes is important and should be done prior to using LACR
- ICR and LACR equipment require modifications by the manufacturer to clean all areas due to tight access
- Mechanically cleaned surfaces exhibited flash rust much more quickly when compared to LACR cleaned surfaces
- Seven-year field data indicates that a coating meeting the requirements of VDOT specifications for Coating System F is performing adequately on a LACR surface

Conclusions

- Utilize LACR devices with built-in fume extraction at the LACR face. Nozzle/mounted extraction devices were less effective than built-in systems
- Utilize positionable local exhaust ventilation or general mechanical/dilution ventilation in enclosed spaces such as bridge abutments or within laser curtained areas
- Utilize tarpaulins or other debris capture methods for ICR generated wastes
- Coordinate LACR and ICR use with Environmental, Industrial Hygiene, and Safety to ensure proper worker and environmental controls are implemented

Resources

VDOT/VTRC Documents

- VDOT Alternate Bid Item Special Provision
- VDOT Equipment LACR ICR Acceptance Criteria
- VDOT LACR Standard Operating Procedure Template
- VTRC Report: Innovative Coating Removal Techniques for Coated Bridge Steel
- TRB Paper: Evaluation of a Continuous Laser Ablation Coating Removal Device for Steel Bridges.

University of Virginia

- Implementation of Laser Ablation Coating Removal Technique for Steel Components on VDOT Bridges
- The Effects of Laser Ablation Coating Removal on the Fatigue Performance of a High Strength Structural Steel

ICR + LACR Project Team & Questions

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- Jeff Milton, Former VDOT Structure and Bridge Division
- C. Wayne Fleming, VDOT Materials Division
- David Wilson, VDOT Environmental Division
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- Dr. Jim Fitz-Gerald, Department of Materials Science and Engineering, University of Virginia
- Dr. Sean Agnew, Department of Materials Science and Engineering, University of Virginia
- Dr. William Moffat, Ph.D. University of Virginia
- VDOT Districts, Contractors, Consultants, and Suppliers

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