



## **VDOT's Laser Coating Removal Research**

**Report to Southeast Bridge Preservation Partnership –  
April 2019**

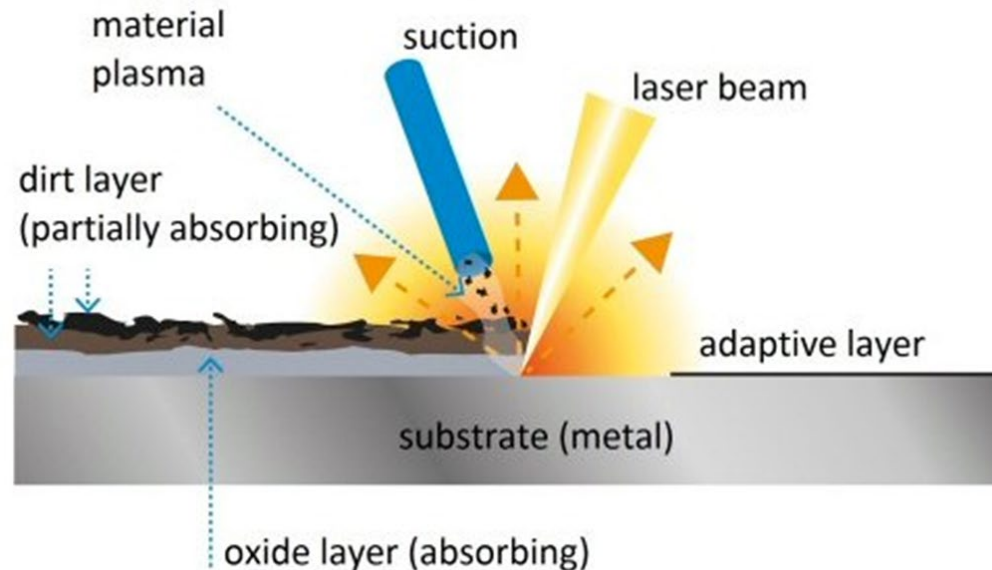
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## VDOT's Laser Coating Removal Research

- **The Virginia Department of Transportation is conducting research investigating the use of high-wattage Lasers for laser ablation coating removal (LACR) systems for removing coatings from existing bridges.**
- **High-wattage, hand-held lasers are now commercially available at costs that have increased their potential value for use in removing coatings on bridges.**
- **The objective of this project is to determine the feasibility of utilizing high-wattage LACR systems to remove coatings from VDOT bridges.**

## VDOT's Laser Coating Removal Research

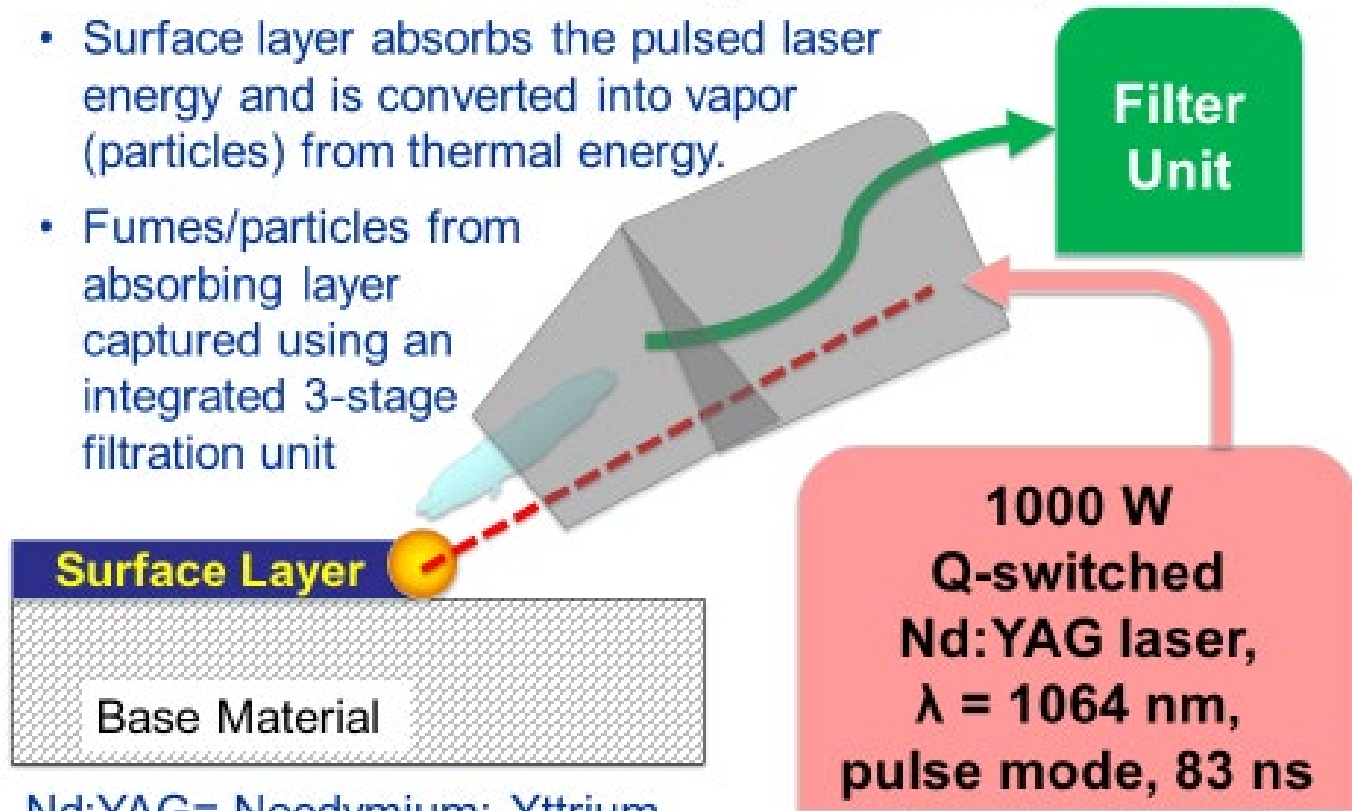
- Laser coating removal is an ablative process that can be applied to a variety of substrates, including metal. Laser energy is focused onto the surface and is absorbed into the coating, resulting in decomposition and removal of the coating and causing only a minimal increase in substrate temperature. The key advantages in the use of lasers for coating removal include their non-contact nature and the fact that they use no secondary medium that contributes to waste streams.



# VDOT's Laser Coating Removal Research

## Laser Ablation Coating Removal (LACR)

- Surface layer absorbs the pulsed laser energy and is converted into vapor (particles) from thermal energy.
- Fumes/particles from absorbing layer captured using an integrated 3-stage filtration unit



Nd:YAG= Neodymium: Yttrium Aluminum Garnet



## VDOT's Laser Coating Removal Research

- Coatings on steel bridge beams generally tend to fail at the ends of the beams under expansion joints.



## VDOT's Laser Coating Removal Research

- **Current practice requires containment structures for removal of existing coatings.**
- **Although coating failures are generally limited to 15% of the total beam length, the economics of containment structures often lead to the decision to recoat entire structures rather than only the beam ends.**
- **If alternate technologies were available to allow contractors to remove coatings only at the ends of beams and to do so without containment, VDOT could potentially address more of its coating needs with current budgets.**

# VDOT's Laser Coating Removal Research

## PHASE I

## VDOT's Laser Coating Removal Research – Phase I

- Phase I was conducted on October 26, 2016 at Norton Sandblasting Inc. located in Chesapeake, VA
- Samples taken from bridge on Rt. 685 (Telegraph Road) Pittsylvania County, Structure #6096, b. 1932
- Some samples were grit blasted for a different processing condition
- El Group retained to conduct personal, area, and filter monitoring along with filter sample collection





## VDOT's Laser Coating Removal Research – Phase I

### ➤ Industrial Hygiene (EI Group) Summary

- Air monitoring results indicated that personal and area concentrations were below the OSHA Permissible Exposure Limit (PEL) as an 8-hour Time Weighted Average (TWA).
- All area and personal samples were below laboratory detection limits for sampled contaminants, except lead. However, concentrations of lead were well below the action level (AL).
- Toxicity characteristic leaching procedure (TCLP) analysis for eight metals was performed. Of the three filters, the particle filter was hazardous for lead, recommended that the filter is disposed of as hazardous waste.

# VDOT's Laser Coating Removal Research – Phase I

- Adapt Laser Systems CL 1000, 1 KW hand held laser



# VDOT's Laser Coating Removal Research – Phase I

## ➤ Laboratory LACR Work on Beam



## VDOT's Laser Coating Removal Research – Phase I

- Removal of thicker debris by hand accelerates LACR from beams



## VDOT's Laser Coating Removal Research – Phase I

- Laser cleaned flange



## VDOT's Laser Coating Removal Research

# PHASE II

## VDOT's Laser Coating Removal Research – Phase II

Phase II was conducted as an onsite demonstration at an in service bridge on Rte. 695 in Farmville, VA on August 15, 2017

- Laser system was transported to the bridge and operated from a trailer
- Biggest issue was cleaning hard to reach places such as beam ends, bulk heads, and bearings with unusual geometries
- All within industrial hygiene limits (VDOT contracted testing)



## ➤ VDOT's Laser Coating Removal Research – Phase II





## ➤ VDOT's Laser Coating Removal Research – Phase II

Not all areas were accessible with the laser for cleaning



## VDOT's Laser Coating Removal Research

# PHASE III

## VDOT's Laser Coating Removal Research – Phase III

- **Phase III was conducted on bridge bearings at Norton sandblasting on November 9, 2017**
  - **This phase was conducted to determine the capability of the 500W Adapt Laser system to effectively clean minimally accessible areas such as bridge beam ends and bearings**
  - **The Clean Laser 500W system was used with the CleanCUBE H15 head (henceforth denoted CC), which consists of a laser optic head with a light aperture that is 90 degrees to the incoming optic cable line, allowing for a more maneuverable optic that also takes up less space**
  - **A robotically mountable optic head was used which was not ergonomically designed for human use**
  - **An external vacuum source was used, industrial hygiene not in place**

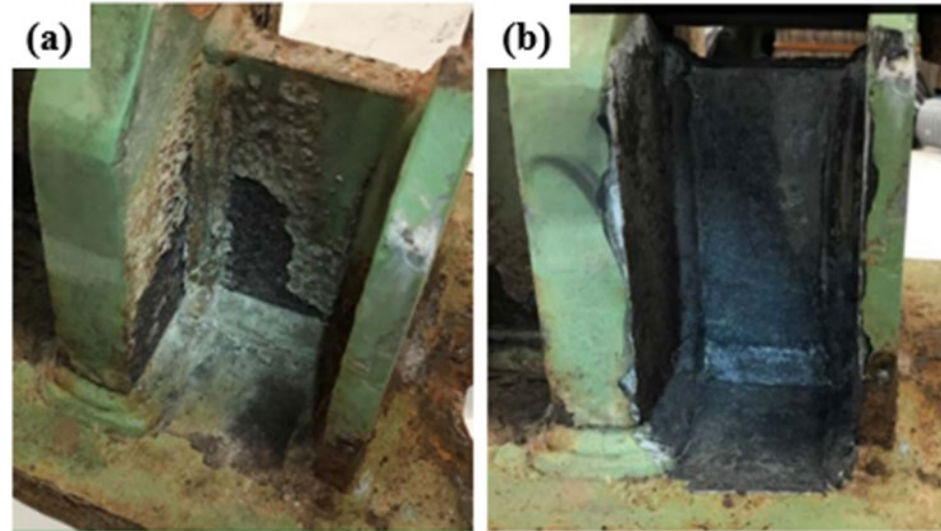
## VDOT's Laser Coating Removal Research – Phase III

- The 500W laser and CC optic appeared to remove most of the outer layer of rust and remaining paint after multiple passes, however the 1000W laser was also tested. After removing the vacuum nozzle to shorten the laser optic head length, the 1000W laser was tested leaving a surface comparable to that observed after cleaning with the CC. However even with the vacuum nozzle on the 1000W optic laser head removed, the optic was still too large for use in cleaning bridge beam ends and bearings.

Therefore the 500W laser with the CC head was determined to be the only viable option for cleaning these tighter and recessed areas.

## VDOT's Laser Coating Removal Research – Phase III

- The bearing both (a) before and (b) after laser cleaning using the 500W and 1000W laser systems.



## VDOT's Laser Coating Removal Research

# PHASE IV

## VDOT's Laser Coating Removal Research – Phase IV

- Phase IV was conducted during July and August of 2018
- Two coated VDOT beams were delivered to Norton Sandblasting on July 29th, 2018 for use during the testing. Beams showed variability in coating appearance, coating characterization, and structure.
- On July 30th and August 1st, 2018 an industrial hygiene survey was conducted as a means of determining whether the laser ablation system can be used as a feasible engineering control and whether the laser ablation system successfully reduced the risk of employee exposure to lead and other toxic metals during coating removal and subsequent hot work operations. Hot Work is defined as work that utilizes a flame or can generate a spark and has the potential to cause sublimation of toxic coatings.

## VDOT's Laser Coating Removal Research – Phase IV

- On July 30th, Norton Sandblasting employees used a Laser ablation system to completely remove 55 linear inches of coating on the two VDOT beams.





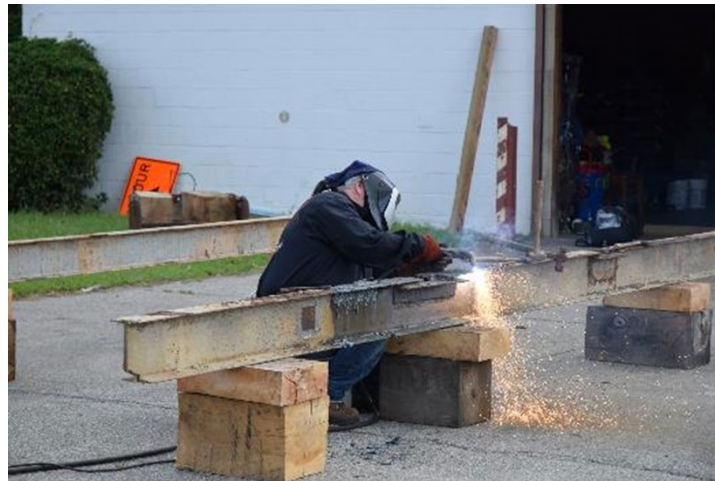
## VDOT's Laser Coating Removal Research – Phase IV

- On August 1st, 2018, VDOT employees completed task based hot work rotations on each beam as a means of evaluating whether the laser ablation system effectively removed enough leaded coating to reduce worker hazard to leaded fume during hot work operations.

Oxyacetylene Torch



Plasma Torch



Grinding



## VDOT's Laser Coating Removal Research – Phase IV

- **The industrial hygiene survey showed that the laser ablation process can successfully reduce the risk of employee exposure during VDOT beam de-leading and during hot work conducted on de-leaded beams where the coating was completely removed.**

## VDOT's Laser Coating Removal Research

# PHASE V

## VDOT's Laser Coating Removal Research – Phase V

- Phase 5 was performed at Turner-Fairbank Highway Research Center (TFHRC) and included the evaluation of steel samples from Phase 1. During Phase 5, TFHRC coated the Phase 1 panels using coatings provided by VDOT.
- The following tests were performed by TRHRC to evaluate the steel surface preparation for corrosion and coating performance compared to the grit-blast coating removal method:
  - Surface profile (ASTM D4417)
  - Tensile strength of the steel (ASTM E8 / E8M)
  - Adhesion strength of the coating systems (ASTM D4541)
  - Soluble salts on the surface (SSPC Technology Guide 15)
  - Electrochemical tests (corrosion potential, instant corrosion rate, and polarization resistance)
  - Coating performance after cyclic exposure tests

## VDOT's Laser Coating Removal Research – Phase V

- **Coatings were applied to the Phase 1 samples at TFHRC following the coating materials manufacturers' instruction. Tests were performed on the coated panels to evaluate the performance of the coating systems as the panels went through cyclic exposure conditions. These performance-related factors include surface defects, rust creepage, and changes in physical and chemical properties such as color, gloss, and adhesion. The following tests were performed on the coated panels:**
  - **Dry film thickness (ASTM D7091 or SSPC-PA2)**
  - **Gloss loss (ASTM D5230)**
  - **Color change (ASTM D2244)**
  - **Adhesion (ASTM D4541)**
  - **Average rust creepage (ASTM D 7087)**

# **Summary From Phases I - V**

## VDOT's Laser Coating Removal Research – Summary From Phases I - V

- **LACR effectively removes the coatings investigated, including lead - based alkyd paints.**
- **LACR does not detrimentally affect the mechanical properties or chemical composition of the steel (ASTM structural steel A36) that was examined in this study**
- **The coating adhesion of LACR surfaces was determined to be satisfactory with adhesion testing revealing average pull-off pressures of 1800 psi using an epoxy binder for recoating**
- **Industrial Hygiene (IH) study results show that the engineering controls associated with LACR are effective in maintaining potential exposures for the laser operator below the current OSHA Permissible Exposure Limit (PEL) and OSHA Action Limit (AL)**

## VDOT's Laser Coating Removal Research – Summary From Phases I - V

- **LACR can be employed as a lead removal technique in preparation for other processes, such as cutting, grinding or welding, which are widely used by VDOT**
- **LACR will not remove coatings sandwiched between two steel surface**
- **Tight access areas Remain a Challenge: e.g. bearing interior surfaces, bolt heads, pursuing additional companies with 90° heads**
- **Production rate was slow during Phase II**
- **The laser ablation process can successfully reduce the risk of employee exposure during beam de-leading and during hot work conducted on de-leaded beams where the coating was completely removed**



## VDOT's Laser Coating Removal Research – Summary From Phases I - V

- **The recommendations from this project will provide VDOT with a safer and more environmentally friendly option for coating removal from steel bridge elements. Besides material, labor, and equipment costs, the traditional painting operation must also include the often increasing costs of containment, traffic control, waste disposal, and workers' safety. The use of LACR could reduce those costs while ensuring VDOT continues to be good stewards of the environment and maintains safe working conditions during recoating operations.**

## VDOT's Laser Coating Removal Research

# Next Steps

## VDOT's Laser Coating Removal Research – Next Steps

- **Publish a report documenting the results of the research – the draft report is currently under review**
- **Conduct two new research projects that are spinoffs from the current project**
  - 1) **LACR Beam End Repair.** This project will provide a chance to compare different coating removal methods and recoating options on beam ends in the Staunton District.
  - 2) **Novel Coating Removal Technologies.** This project will focus on improving LACR (increase production rate and power heads for bridge work) and start investigating the use of induction methods for coating removal.
- **Review possible mechanical assist equipment for holding hand held laser in place – manual use of the hand held laser causes operator fatigue**

## VDOT's Laser Coating Removal Research – Next Steps

- Consider the use of an induction device in conjunction with the laser - The induction dis-bonder works by the principle of induction. Heat is generated in the steel substrate and the bonding is broken. The coating is then removed entirely without disintegrating and completely free from contaminating agents, i.e. blast media. This makes disposal and recycling of waste easier and more cost effective.

