

Equipment Acceptance Criteria for Laser Ablation Coating Removal and Induction Coating Removal on Steel
– (Structures Section)

Aug 3, 2022

1. Scope

The test methods listed herein are used to approve the use of laser ablation coating removal (LACR) and induction coating removal (ICR) equipment and their effects on steel substrates. LACR and ICR Equipment Manufacturers are required to verify their LACR or ICR equipment in accordance with this Test Method prior to use on any steel structure in the Commonwealth.

- 1.1. This standard may involve hazardous materials, operations, and equipment. This does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Apparatus

- 2.1. LACR or ICR device, including equipment for power, cooling, filtration, etc.
- 2.2. Coating thickness gage (Type 2)
- 2.3. Non-contact infrared temperature gun
- 2.4. Optical microscope
- 2.5. Uniaxial tensile test machine
- 2.6. Vickers hardness tester
- 2.7. Scanning electron microscope

3. Materials

- 3.1. Coating materials used in verification testing shall consist of one prime coat of Aluminum Epoxy Mastic conforming to System F (Approved List 21) followed by a white polyamide cured epoxy intermediate coating selected from System B (Approved List 13) unless otherwise directed by the Engineer. Both coatings selected shall be from the same coating manufacturer.
- 3.2. Steel plate used in verification testing shall conform to ASTM A36 unless otherwise directed by the Engineer. Steel plate used in verification testing shall be new steel, coated plate and shall measure ½ in x 24 in x 24 in.

4. Procedure

- 4.1. The LACR or ICR equipment manufacturer shall prepare coated steel for subsequent verification testing meeting the following conditions.
 - 4.1.1. ASTM A36 steel plate shall be in as received condition removing any oil and grease in accordance with SSPC-SP1 and the Coating Manufacturer's written instructions. Both sides of the ASTM A36 steel plate shall be coated.
 - 4.1.2. Before application of coatings, all surfaces to receive coatings shall be clean and dry. The coating shall be applied in a neat and orderly manner by brushing, roll or spraying as recommended by the coating manufacturer.
 - 4.1.3. Coatings shall be applied in a manner to provide a tight film of specified uniform thickness well bonded to the steel plate.

- 4.1.4. Coatings applied shall be fully cured in accordance with the coating manufacturer's written instructions prior to LACR or ICR removal.
 - 4.1.5. Dry Film Thickness (DFT): The equipment manufacturer shall measure the DFT of each coating applied using a Type 2 film thickness gage. The Type 2 gage shall be calibrated according to the frequency and procedure specified by the manufacturer and in accordance with ASTM D7091. Before taking measurements, a verification of combined accuracy shall be performed in accordance with SSPC PA-2, Appendix 8. The combined accuracy shall be within the manufacturer's tolerance of the gage and the tolerance of the standard shims used. If the gage does not meet the combined tolerance, it shall not be used. Another gage which passes accuracy testing shall be obtained for use in verifications of film thicknesses applied.
- 4.2. The LACR or ICR equipment manufacturer shall perform coating removal on the coated ASTM A36 steel plate while limiting and documenting temperature.
 - 4.2.1. Coating Removal. The equipment manufacturer shall use either LACR or ICR to remove the coating from the steel plate. Both sides of the steel plate shall be cleaned to bare metal and shall be free of dust and debris. The equipment parameters used to remove the coating from the steel shall be documented. For LACR, these parameters shall include laser power level, wavelength, mode (continuous wave, pulsed, or scanning pulse), and specifications relevant to the mode. For ICR, these parameters shall include induction current and induction frequency. Only the parameters documented for the coating removal on the test plates shall be allowed for project use (i.e., other settings for parameters with variable settings will not be permitted). Therefore equipment manufacturers shall test at the highest setting used for coating removal expected during field operations. The number of passes required to completely remove the coating shall also be documented. The coating along one edge of test plate, 1 in wide, to be used for hardness testing will not be removed to enable the required traverse.
 - 4.2.2. Temperature Testing. During coating removal, the equipment manufacturer shall demonstrate that using either LACR or ICR on structural steel does not elevate the temperature of the steel surface to 400°F or more at any time during the coating removal operation. This shall be verified using a calibrated non-contact infrared temperature gun. Immediately after each pass of LACR or ICR, the temperature shall be measured using the temperature gun to determine if the steel surface is exceeding 400°F. The temperature immediately after each pass of LACR or ICR shall be documented.
 - 4.2.3. Testing Documentation. The equipment manufacturer shall document the time in second/square feet and number of passes required to completely remove the coating, the temperature immediately after each pass, the time interval needed to allow a test plate to cool sufficiently before making a subsequent pass to limit the temperature to 400°F, and the time to clean both sides of each plate.
 - 4.3. The LACR or ICR equipment manufacturer shall contract with an independent laboratory to perform the verification tests described below to demonstrate that the proposed equipment and procedures will successfully remove coatings and non-visible contaminants and not adversely affect the steel properties.
 - 4.3.1. Microscopy to Verify Coating Removal Effectiveness. The independent laboratory shall examine cross sections of the cleaned steel plate under an optical or scanning electron microscope to verify how much of the coating has been removed. This shall be documented by reporting the remaining coating thickness. If no coating is remaining, this shall be reported. Representative images used to verify this shall be documented.
 - 4.3.2. Tensile Testing. The independent laboratory shall perform tensile testing in accordance with ASTM E8 using standard specimens. Perform at least six tensile tests on steel plate that has not been exposed to LACR or ICR. After coating removal, machine six standard samples out of steel plate subject to either LACR or ICR, and then conduct tensile tests on samples. All test results from these six samples shall meet the ASTM A36 mechanical requirements. Tension test results from all twelve samples shall be documented based on the ASTM E8 specifications.
 - 4.3.3. Fatigue Testing. The independent laboratory shall perform fatigue testing to establish that either the LACR or ICR process does not change the fatigue behavior of the structural steel. After the coating removal process, at least six fatigue samples shall be machined out of the steel plate. Fatigue samples

shall meet the specifications for ASTM E8 standard specimens. These six samples shall be tested until a crack visually appears or the test is considered a runout. A runout shall be defined as a test that reaches 5 million cycles without any cracks present. Applied stress ranges used in the tests shall be at least 32 ksi and the maximum applied stress shall be less than or equal to 35 ksi. Minimum stress, stress range, and number of cycles to failure shall be documented for all six fatigue tests. Fatigue testing may be conducted in accordance with ASTM E466. Fatigue test analysis shall be conducted according to ASTM E739. A linear regression shall be performed on the six fatigue tests to determine a best fit line. The 97.5% confidence interval of this best fit line shall be better than or equivalent to the Category A fatigue curve in the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications. If all six fatigue tests are runouts, the fatigue testing shall be considered acceptable. Test data from the six fatigue tests and linear regression analysis shall be documented.

- 4.3.4. Hardness Testing. The independent laboratory shall demonstrate that using either LACR or ICR on structural steel does not change the Vickers hardness of the steel along a traverse starting at a cleaned surface and ending on an uncleaned surface. Vickers hardness tests shall be conducted according to ASTM E384. The Vickers hardness test result and location will be recorded at each point.
 - 4.3.5. Microstructure of Steel. The commercial laboratory shall demonstrate that using either LACR or ICR on structural steel does not result in a change to the steel's microstructure more than 1 μm in depth below the steel surface. This shall be demonstrated using a scanning electron microscope. The steel surface shall be examined on two pieces of steel, one uncoated piece not exposed to coating removal and one piece exposed to either LACR or ICR. The microstructure of the two pieces shall be examined to evaluate any differences between them.
5. Verification Report will include the following information
 - 5.1. Coating application and removal details
 - 5.1.1. Coating Removal Method: ICR or LACR equipment type, equipment parameter settings during coating removal (laser type, laser power and laser intensity for LACR; induction current and frequency for ICR), maximum power, and safety and energy control features.
 - 5.1.2. Base Plate. ASTM A36 steel plate mill test report.
 - 5.1.3. Coating Used. Coating type and manufacturer.
 - 5.1.4. Coating Thickness. Dry film thickness measurements before coating removal.
 - 5.1.5. Temperature Testing. The temperature after each pass of LACR or ICR over the surface of the steel during coating removal.
 - 5.2. Independent laboratory shall provide the following testing results
 - 5.2.1. Coating Removal. Optical or scanning electron microscope images to determine if the steel plate was cleaned to bare metal and is free of dust and debris. If coating remains after coating removal, its thickness shall be reported.
 - 5.2.2. Tensile Testing. Tension test results from all twelve samples based on ASTM E8 reporting specifications.
 - 5.2.3. Fatigue Testing. Test data and analysis from the six fatigue tests, including minimum applied stress, constant amplitude stress range, number of cycles to failure, and linear regression analysis.
 - 5.2.4. Hardness Testing. Vickers hardness results and test locations of traverse starting at a cleaned surface and ending on an uncleaned surface.
 - 5.2.5. Microstructure of Steel. Optical or scanning electron microscope images of the steel's microstructure up to 1 μm in depth below the steel surface of both uncleaned steel and cleaned steel after coating removal.