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Laser Ablation for Surface Preparation of Ferrous Metals, Pulsed Laser

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Document History

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Foreword

This AMPP standard, designated AMPP SP21511-1, is intended to enable specifiers to develop project specification requirements and end users to achieve the required level of surface preparation or cleanliness using pulsed laser ablation (PLA). For the purpose of this standard, PLA employs pulsed, Q-switched laser technology.

PLA is a media-free, commercially available process that uses high-intensity directed energy in the form of a collimated, monochromatic, pulsed, focused, and scanned laser beam to remove coatings, oxides, contaminants, and hazardous materials (HAZMATs). This process is also referred to as laser ablation coating removal (LACR). PLA may be used to prepare coated or uncoated ferrous metal substrates before the application of a protective coating or lining, or it may be used in conjunction with other surface preparation methods. PLA offers environmental, health, and safety (EH&S) benefits as well as a level of precision that cannot be achieved with other surface preparation technologies. This standard is intended to be used by corrosion control professionals in civil infrastructure, defense, nuclear, petrochemical, automotive, aerospace, and other related industries. It is for use by coating specifiers, engineers, contractors, inspectors, and others who are responsible for defining a specific level of surface cleanliness or producing a post-blast treatment surface condition specified, using PLA technology.

PLA can remove 100% of existing coatings. However, it is most effective for applications requiring less than 95% of coating removal (by surface area of exposed substrate) when prescribed by appropriate Technical Authority guidance.

The primary functions of PLA cleaning applications are:

a) To remove material from the surface that can cause premature failure of the new coating system. Paragraph A1 of Appendix A (nonmandatory) provides additional information.
b) To enhance the adhesion of a new coating system.
c) To expose the surface profile of the substrate that is underneath the existing coating, rust, other corrosion products, or other contaminants and,
d) To reduce or remove nonvisible contamination that may be present on the substrate. Examples include thin films of oil and grease, and soluble ionic materials such as chlorides, ferrous salts, nitrates, and sulfates. PLA can reduce or completely remove water-soluble contaminants as well as fixed, non-smearable low-level radiological contamination

Rationale

PLA for surface preparation is a rapidly growing commercially available technology for cleaning metallic and other substrates. No industry standard existed before this standard to support decision-makers who are considering the use of laser ablation. As such, surface preparation professionals needed a standard to determine when, why, and how to use the technology safely and effectively.

Referenced Standards and Other Consensus Documents

Unless specifically dated, the latest edition, revision, or amendment of the documents listed in the table below shall apply.

AMPP/NACE/SSPC, www.ampp.org:	
AMPP Guide 21610	Pulsed Laser Ablation Technical Guide for Ferrous Metal Substrates
NACE SP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0178	Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC-SP 1	Solvent Cleaning
SSPC-SP 6/NACE No. 3	Commercial Blast Cleaning

SSPC-SP 7/NACE No. 4	Brush Off Blast Cleaning
SSPC-SP 10/NACE No. 2	Near-White Metal Blast Cleaning
SSPC-SP 17	Thorough Abrasive Blast Cleaning of Non-Ferrous Metals
SSPC-PA 2	Procedure for Determining Conformance to Dry Coating Thickness Requirements

ASTM International, www.astm.org:

ASTM/IEEE SI10	American National Standard for Metric Practice
ASTM G8	Standard Test Methods for Cathodic Disbonding of Pipeline Coatings
ASTM D522	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
ASTM D3359	Standard Test Methods for Rating Adhesion by Tape Test
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D6677	Standard Test Method for Evaluating Adhesion by Knife

American National Standards Institute (ANSI), www.ansi.org:

ANSI Z136.1	Safe Use of Lasers
ANSI Z136.6	Safe Use of Lasers Outdoors

Deutsches Institut für Normung (DIN), www.din.de/en:

DIN 12254	Screens for Laser Working Places – Safety Requirements and Testing

International Organization for Standardization (ISO), www.iso.org:

ISO 8502-3	Preparation of steel substrates before application of paints and related products—Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

International Electrotechnical Commission (IEC), www.iec.ch:

IEC 60825-1	Safety of Laser Products, Part 1: Equipment classification, and Requirements

National Fire Protection Association (NFPA), www.npfa.org:

NFPA 115	Standard for Laser Fire Protection

In AMPP standards, the terms shall and must are used to state requirements and are considered mandatory. The term should is used to state something that is recommended, but is not considered mandatory. The term may is used to state something considered optional.

Section 1: Scope

This standard describes the use of portable or stationary PLA consisting of pulsed, Q-switched laser technology for preparation of ferrous metal substrates (does not include stainless steel) as required for applying coatings or linings, welding, adhesive bonding, and other applications where PLA will provide the surface preparation or contaminant removal required. Appendix A (nonmandatory) provides additional detail in explanatory notes.

Continuous wave (CW) lasers and ultra-short pulsed lasers, with pulse duration measured in picoseconds, are not included in this standard.

AMPP Guide 21611 is a vital supporting document for this standard. Reviewing this Guide before planning to use PLA for a particular project is essential to understanding how to use PLA safely and effectively, and PLA should not be used or specified before the Guide is thoroughly reviewed and understood.

A visual guide, proposed nomenclature AMPP Guide 21711, titled "Guide and Reference Photographs for Steel Surface Non-Mechanical Cleaning by Pulsed Laser Ablation," is in development.

PLA may be used to treat and retain existing coatings for recoating, maintenance, or for complete coating removal. Laser ablation surface preparation includes certain laser technology attributes applied to various substrates. Four laser-substrate combinations will be addressed in separate standards as follows:

Substrate/Laser Type	Standard Designation
Ferrous Metals/Pulsed Laser	AMPP SP21511-1
Non-Ferrous Metals/Pulsed Laser	AMPP SP21511-2
Composite Substrates/Pulsed or CW Laser	AMPP SP21511-3
All Metals/CW Laser	AMPP SP21511-4

Section 2: Definitions

For the purposes of this standard, the following terms and definitions apply:

Ablation Cleaning (AC): Application of PLA to prepare a surface for follow-on surface treatments, cosmetic improvements, or decontamination. Typically used for the removal of surface contaminants and surface rust from bare substrates or other coated surfaces requiring cleaning similar to SSPC-SP 1, Solvent Cleaning.

Class 4 Laser: The most dangerous and highest laser classification, of classifications ranging from 1 to 4. Depending on the wavelength, at a power output above 500 milliwatts, beam exposure can result in severe eye injury from both direct and scattered beam reflections and may be harmful at large distances from the laser source. Class 4 lasers can injure the skin, cause thermal burns, present a significant fire hazard, and when used for ablation, these lasers create airborne contaminants that can be hazardous. The use of Class 4 lasers must comply with regulatory safety requirements, which vary according to where and how the laser is used.

End Effector: A hand-held manually operated device the laser operator uses to turn the laser beam on and off while focusing direct laser energy onto the work surface. Laser end effectors include designs for automated remote-controlled operation. See also *Laser Optic* below.

Focal Range: The plus or minus distance from the target surface within which effective laser ablation will occur using a focused laser beam with a specific focal length. The actual focal range for a particular PLA system is determined by the specified focal length of the end effector's aperture lens and the power output of the laser system. Typically, focal range increases relative to higher laser powers.