

Atmospheric Plasma Coating Removal for Naval Engineering and Maintenance Applications

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ABSTRACT

For military forces, the need for vessels to be docked for maintenance significantly affects fleet availability and the readiness of that force. In shipbuilding and naval maintenance industries, coating removal is an essential but time-consuming process. Grinders, needle guns, or hand tools (such as wire brushes and chisels) are often required for small-scale removals, and each comes with drawbacks such as hazards to operator health, slow removal rate, and damage to substrates. There is a significant need for a new tool that will accelerate small scale coating removal operations without these negative effects. Atmospheric Plasma Solutions Inc. (APS) has developed a single-person-carriable system that uses cold atmospheric air plasma to rapidly remove organic based coatings without altering the surface profile of underlying substrates. This paper details the results of laboratory and in-field testing of this

system and highlights its adoption benefits to productivity, worker safety, corrosion control, and fleet readiness.

Key words: Non-Profiling Coating Removal, Cold Plasma Technology, Non-Destructive Weld Inspection, Asset Lifetime Extension, Surface Preparation

INTRODUCTION

A vessel docked for maintenance is a vessel out of service. For military forces, this significantly affects the readiness of that force, its ability to respond quickly and appropriately to a developing situation. It is for this reason that the United States Navy continues to search for and invest in innovations that improve maintenance turn-around times as well as innovations that keep vessels in service for longer periods of time. In large-scale construction and manufacturing industries such as shipbuilding and naval maintenance, coating removal is an essential but time-consuming process required for constructing and maintaining vessels and other structures. Although some new technologies have emerged in recent decades, the technologies of abrasive blasting, grinding, and needle-gunning remain the dominant coating removal methods employed today. Grinders, needle guns, or hand tools (such as wire brushes and chisels) are often required for small-scale removal, and each comes with their own drawbacks such as hazards to operator health, slow removal rate, and damage to substrates. In the naval engineering industry, there is a significant need for a tool that will accelerate small scale coating removal operations without negatively impacting the health of the operator or the underlying substrate. The joint effort detailed in this report was undertaken to evaluate the suitability of the *PlasmaBlast*® PB7000-M—developed by Atmospheric Plasma Solutions Inc. (APS)—to fill this need in small-scale removal operations in an experienced Naval shipyard setting.

The Atmospheric Plasma Coating Removal (APCR) process uses a low pressure (90-100 psi) compressed air source and electricity (208- 240 or 440-480 volt) to produce a special form of atmospheric pressure air plasma. This atmospheric air plasma is highly chemically activated and oxidizes any organic components in paints and other coating materials. The APCR process converts a significant portion of the removed organic coating into water vapor and carbon dioxide, leaving behind a lower volume of solids of mostly inorganic pigments and fillers that can be safely collected with a suitable HEPA vacuum. Figure 1 shows the *PlasmaBlast*® 7000-M field deployable unit that houses plasma power supply, plasma pen that is connected by an air/power cable 20 feet or more in length and has an approximate weigh of 35 pounds. The plasma power supply applies a pulsed electric field to the internal electrodes of the pen. Air is introduced into the electrode region of the pen at high velocity. The plasma generated in the electrode region is directed through a nozzle, which concentrates the plasma flow into a beam. The plasma beam is scanned across a coated surface (manually or robotically) to remove the coating layer-by-layer, allowing for full or selective removal, in addition to cleaning and surface preparation. Because the plasma can flow around surface features, it is well suited to treat both flat and more complex surfaces. This APCR system has been used to demonstrate the extreme versatility of the technology across a wide range of substrates, coating types, and removal conditions.



Figure 1 - *PlasmaBlast*® 7000-M field deployable unit

The PlasmaBlast® 7000-M is an air-fed Atmospheric Plasma Coating Removal (APCR) device that has repeatedly proven to be effective at removing organic coatings commonly found in shipyard environments. The M model has been packaged and configured as a man-portable, single-beam air and power input-only tool. Comparative tests were performed to compare the PB7000-M to the commonly used needle gun scaler; in these tests, coating removal tool efficacy, substrate impact, and user experience were evaluated on controlled test samples and decommissioned submarine sections. Through the testing conducted with a naval shipbuilding partner, it was demonstrated that the PlasmaBlast® system significantly outperforms the needle-gunning process in removal rate as well as impact on the user and surfaces' substrates.

EXPERIMENTAL PROCEDURE / RESULTS

The purpose of this research was to compare APCR and needle gun on the removal of coatings from relevant substrates used in naval construction. Specific experimental tests were implemented to highlight the effects of using atmospheric plasma on coatings rate of removal, surface temperature and profile, and other use case scenarios.

Rate of coating removal testing

Rates of removal for APCR and needle gunning were evaluated by measuring the amount of time it took to remove the coating down to bare metal in the designated areas. In these tests, the APCR process was measured to remove coating **51% faster** than the needle-gunning process, with APCR having an average area removal rate of 2.52 ft²/hr and the needle gun process having an average of 1.66 ft²/hr. APCR consistently outperformed the needle gun process, as can be seen in the removal rate distribution in Figure 2. It is estimated that an optimal APCR could achieve a removal rate of 3.5 to 4 ft²/hr (for this specific coating).

Removal Method	Avg Area Removal Rate (ft ² /hr)	% Area Rate Improvement Compared to Needle Gun	Avg Volume Removal Rate (ft ² ·mils/hr)	% Volume Rate Improvement Compared to Needle Gun
Needle Gun	1.66	+/- 0%	42.6	+/- 0%
APCR	2.52	+ 51%	65.1	+ 52.6%

Table 1 – Rate of removal test comparing APCR with needle gun

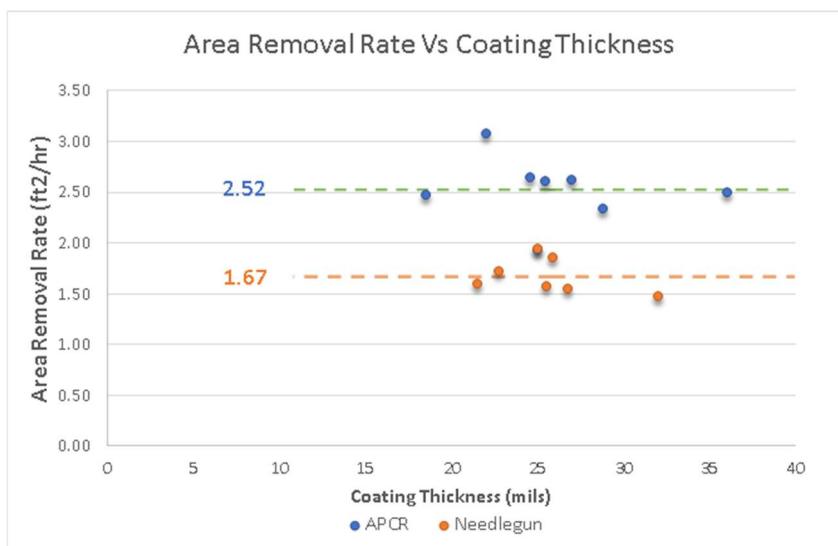


Figure 3 – Rate of removal for APCR versus needle gun.