National Aeronautics and Space Administration (NASA)
Acquisition Pollution Prevention (AP2) Office

Potential Alternatives Report

For Validation of Alternative Low-Emission Surface Preparation/Depainting Technologies for Structural Steel

FINAL

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May 19, 2006

Prepared by
International Trade Bridge (ITB), Inc.
Beavercreek, OH 45432

Submitted by
NASA Acquisition and Pollution Prevention Office

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PREFACE

This report was prepared by International Trade Bridge, Inc. (ITB) through the National Aeronautics and Space Administration (NASA) Acquisition Pollution Prevention (AP2) Office under Contract Number NAS10-03029 Task Order No. 1. The structure, format, and depth of technical content of the report were determined by the NASA AP2 Office, Government contractors, and other Government technical representatives in response to the specific needs of this project.

The information contained in this report was leveraged from the following documents: Headquarters Air Force Materials Command Logistics Office's (HQ AFMC/LGP-EV) *System Safety Engineering Analysis (SSEA) for Hand-Held Paint-Stripping Lasers*, dated June 14, 2004, which was prepared by HQ AFMC System Safety Office (AFMC/SES) at Wright-Patterson Air Force Base (WPAFB), OH; and the Air Force Research Laboratory Materials and Manufacturing Directorate's (AFRL/MLQE) *Potential Alternative Report for Portable Handheld Laser Small Area Supplemental Coating Removal System*, dated February 2001, which was prepared by Science Applications International Corporation. Additional information was gathered from product data sheets and corporate information packets.

We wish to acknowledge the invaluable contributions provided by all the organizations involved in the creation of this document.

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EXECUTIVE SUMMARY

For this project, particulates and solvents used during the depainting process of steel structures were the identified hazardous material (HazMat) targeted for elimination or reduction.

This Potential Alternatives Report (PAR) provides technical analyses of identified alternatives to the current coating removal processes, criteria used to select alternatives for further analysis, and a list of those alternatives recommended for testing.

The initial coating removal alternatives list was compiled using literature searches and center participant recommendations. The involved project participants initially considered fifteen (15) alternatives. In late 2004, stakeholders down-selected the list and identified specific processes as potential alternatives to the current depainting methods. The selected alternatives were:

1. Plastic Blast Media
2. Hard Abrasive Media
3. Sponge Blast Media
4. Mechanical Removal with Vacuum Attachment
5. Liquid Nitrogen
6. Laser Coating Removal

Available information about these processes was used to analyze the technical merits and the potential environmental, safety, and occupational health (ESOH) impacts of these methods. Project participants used this information to select coating removal methods for testing in accordance with the Joint Test Plan, *Joint Test Protocol for Validation of Alternative Low-Emission Surface Preparation/Depainting Technologies for Structural Steel*, and the Field Test Plan, *Field Evaluation Test Plan for Validation of Alternative Low-Emission Surface Preparation/Depainting Technologies for Structural Steel*. Results of the testing will be documented in a Joint Test Report.

A preliminary cost benefit analysis will be performed to determine if implementation of alternative technologies is economically justified.

1. INTRODUCTION

Headquarters National Aeronautics and Space Administration (NASA) chartered the Acquisition Pollution Prevention (AP2) Office to coordinate agency activities affecting pollution prevention issues identified during system and component acquisition and sustainment processes. The primary objectives of the AP2 Office are to:

- Reduce or eliminate the use of HazMats or hazardous processes at manufacturing, remanufacturing, and sustainment locations.
- Avoid duplication of effort in actions required to reduce or eliminate HazMats through joint center cooperation and technology sharing.

As part of the AP2 program, the PAR details baseline processes, HazMats targeted for elimination and alternative replacement technologies. The preliminary ESOH analysis provides an initial qualitative assessment of viable alternatives, identifying conspicuous ESOH issues that may be a factor when selecting an alternative to the baseline process. A technology survey was performed to identify potential coating removal alternatives that meet specified requirements. The alternatives were identified through literature searches, electronic database and Internet searches, customized surveys, previous studies performed on coatings, and/or contacts.

After reviewing technical information documented in the PAR, government representatives, technical representatives from the affected facilities, and other stakeholders involved in the AP2 process will select the list of viable alternative coating removal methods for consideration and testing under the project's Joint Test Protocol and Field Test Plan. Test results will be reported in a JTR upon completion of testing. The selection rationale and conclusions are documented in the PAR.

A cost benefit analysis will be prepared to quantify the estimated capital and process costs of depainting technology alternatives and cost savings relative to the current depainting processes.

The conventional coating removal system typically uses abrasive blast media, which generates large quantities of hazardous waste subject to high disposal costs and scrutiny under environmental regulations. Others use chemicals that are high in volatile organic compounds (VOCs) and hazardous air pollutants (HAPs), which are targeted for reduction/elimination by environmental regulations. Information regarding the types of hazardous materials used in the current processes, as well as the affected programs, applications, and substrates are listed in Table 1-1.

This PAR focuses on the coating removal process for structural steel, as required by the project participants. The following subsections describe the coating removal process as it relates to applications used by the participants, including description of materials, process flow diagrams, amounts of materials used and hazardous waste generated.

Table 1-1 Target HazMat Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts/Substrates
Airborne Particulates and Contaminated Particulate Matter	Dry Abrasive Blasting	Maintenance of Test Stands, Ground Support Equipment, Shuttle Support Structures, Launch Pads, Towers and general structures.	SSPC-SP-5; SSPC-SP-10	Ground Support and Facilities Maintenance	A36 Carbon Steel; AL 6061

1.1 Background

Conventional coating removal systems typically use abrasive blast media, which generate large quantities of hazardous waste subject to high disposal costs and scrutiny under environmental regulations, or chemicals that are high in volatile organic compounds and hazardous air pollutants, which are targeted for reduction/elimination by environmental regulations. This project will focus on the use of abrasive blast media.

1.2 Objectives and Scope of Work

The primary objective of this effort is to demonstrate and validate alternatives to coating removal methods foe use on structural steel, although some aluminum panels well also be examined in the laboratory tests. Successful completion of this project will result in one or more coating removal methods qualified for use at NASA centers participating in this project.

One of the objectives of the Phase I effort is to develop a concise, focused PAR documenting the technical, production, and environmental information about the baseline coating removal processes. ESOH issues pertaining to the baseline and alternative methods will be discussed.

1.3 Coating Removal Methods Overview

Since regulations have become more restrictive concerning the release of chlorinated solvent emissions (National Emissions Standards for Hazardous Air Pollutants) and generation of hazardous waste (Resource Conservation and Recovery Act), research efforts have been focused on developing innovative alternative technologies (e.g., environmentally acceptable chemical strippers and light-based technologies) that would replace conventional coating removal processes (e.g., media blasting, chemical strippers) for large area coating removal.

2. BASELINE PROCESS

The baseline process information was gathered by discussions with center participants. The descriptions below are based on "typical" and generalized coating removal processes, and are not the exact processes used by any of the participants of the AP2 coating removal project.

In general terms, a coating removal system takes the protective layer off of components. For this project, the term protective layer should be interpreted as the organic coating. This protective layer takes many forms, primarily epoxy primer/polyurethane coating systems. Removal of the protective coatings can be done by chemical and/or mechanical means.

Mechanical coating removal involves flaking or chipping the coating off of the structure. This is done either by pelting them with a blast media or sanding the coating off with a pneumatic sander or sand paper. Blast media is composed of both synthetic (i.e., glass beads, steel shot, plastic media, aluminum oxide, and garnet) and natural (i.e., olivine, walnut hulls, and wheat starch) substances. Common to all media types is the fact that they are benign in their virgin state, but through the coating removal process, large quantities of hazardous waste are generated and must be disposed of. Hand sanding is a labor-intensive task requiring many hours of labor, resulting in worker exposure to adverse health affects, such as repetitive strain injury, exposure to chromated dusts from surface preparations, and inhalation of heavy metals from sanding substrate materials.

The participants have determined that the baseline process to which the alternatives shall be compared is Reade Advanced Materials' Black Beauty® Abrasive, a dry abrasive media.

Figure 2-1 shows a general process flow diagram for the baseline process including inputs (such as labor and materials) and outputs (such as emissions and waste).

2.1 Baseline Process Description

It must first be determined if the surface to be depainted is contaminated. If there is contamination, the surface is cleaned using either solvents or high pressure water wash and inspected again. Once the surface has been determined to be clean, the next step is masking of areas where the coating is not to be removed and protection of moving parts. If required, appropriate containment is placed around the area. Another inspection prior to the actual depainting is conducted to ensure the surface is clean and the proper protection is in place. After application, the surface is inspected to determine if it meets the required surface profile for recoating. If it does not meet the requirements, the depainting process is repeated.

Figure 2-1 shows a general process flow diagram for the Baseline process.

2.2 Baseline Process Equipment

Current process equipment for depainting includes mobile compressors, air dryer, pressure pot, moisture control, hoses, vacuums, and containment.

PPE is also required, including a supplied air respirator, eye protection and hearing protection.

2.3 Baseline Material and Energy Usage

Actual amounts of energy and materials consumed during depainting operations will vary between locations and are dependent on a number of factors. Power for the mobile compressors may be provided by electricity, gas, or some other form of fuel. Air is also required.

2.4 Baseline Wastes and Emissions

Dry abrasives produce dust and requires proper containment and personal protection equipment. Proper containment is also required to capture all blast process contaminants (such as paint flakes, rust particles, dust and finer particles) generated by the process for proper disposal. Actual amounts of waste generated and emissions emitted during depainting operations will vary between locations and are dependent on a number of factors. Waste will include the coating removed and waste abrasive. Emissions will be comprised of particulate matter and may include hazardous materials or heavy metals depending on the type of coatings removed.

2.5 Environmental, Safety, and Occupational Health Status for the Baseline Process

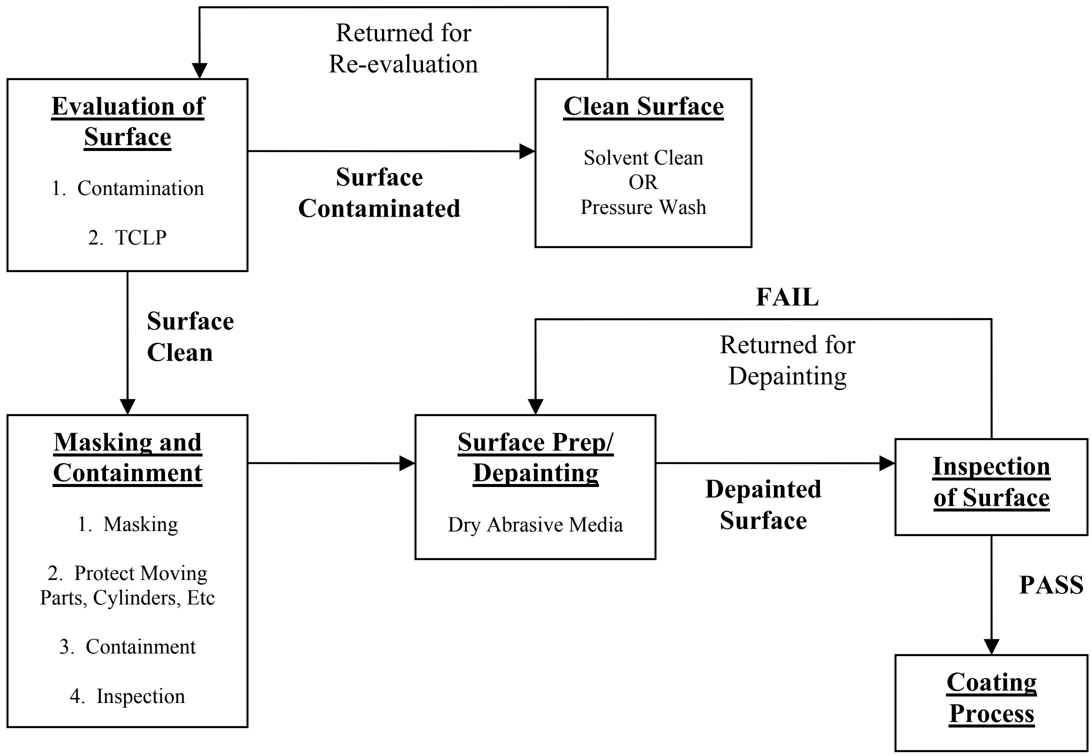
<u>Health and Safety Issues</u>

Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations. Proper precautions should be taken to ensure that personnel do not inhale dust/particulate matter. Therefore, appropriate PPE is required and includes a supplied air respirator, coveralls, eye protection and hearing protection.

<u>Environmental Issues</u>

Emissions of dust and particulate matter are of concern particularly if it contains contaminants such as lead or chrome. Therefore, proper containment is required to reduce emissions, but also to capture the material for proper disposal.

Figure 2-1 General Process Flow Diagram for Baseline Process



3. IDENTIFIED ALTERNATIVES AND PRELIMINARY SCREENING

To identify alternative technologies to the baseline process, a technology survey (herein referred to as the survey) was performed. The survey focused on those commercially available materials or processes which could replace those currently used. The survey identified 15 alternative materials or processes and potential vendors of these technologies. The results of the survey are summarized in this section.

3.1 Alternative Technology Selection

A wide variety of alternative technologies for the current coating removal processes were initially identified by the technology survey. These alternatives are:

- Plastic Blast Media
- Mineral Abrasives
  - Magnesium Sulfate Abrasive
  - Sodium Bicarbonate Abrasive
- Hard Abrasive Media
- Starch Media
- Dry Ice (CO_2) Blasting
- Sponge Blast Media.
- Ultra-High Pressure Water Jet
- Induction-based Removal
- Mechanical Removal with Vacuum Attachment
- Large Aircraft Robotic Paint Stripping (LARPS)
- Pinchlamp
- FLASHJET
- Liquid Nitrogen
- Laser Coating Removal

A summary of the advantages and limitations of the alternatives is shown in Table 3-1.

Table 3-1 Advantages and Limitations of Alternatives		
Alternative	**Advantages**	**Limitations**
Plastic Blast Media	• Safe for Substrates, Primers, Gel Coats, Circuit Boards • Non-toxic; Environmentally Safe • No Chemical Solvents • Consistent Specific Gravity • Long-lasting; Recyclable (up to 95% Recoverable)	• Slower strip rate • Airborne dust • Requires complex subsystems for media recovery and recycling • Quality of stripping is dependent on skill of the operator • May not remove corrosion products
Mineral Abrasive (Magnesium Sulfate)	• pH neutral, water soluble • Silica free • Consistent Specific Gravity • Can be used with water blasting systems • Safe to use around rotating equipment, bearings and sliding mechanisms	• Slower strip rate • Capital investment cost • Workers need to mask surface of substrate to prevent intrusion of blast media • High noise and dust (dry use of media) concerns
Mineral Abrasive (Sodium Bicarbonate)	• Can be used with or without water • Elimination of VOCs and HAPs associated with chemical strippers • Possible reduction of hazardous waste • Selective removal of layers • Prewashing and masking not required in most applications • Blast media usually less expensive than PMB, wheat starch and CO_2	• Slower strip rate • Capital investment cost • Workers need to mask surface of substrate to prevent intrusion of blast media • Sodium bicarbonate may convert to sodium carbonate, a corrosive, at temperatures of 140-160°F • High noise and dust (dry use of media) concerns

Table 3-1 Advantages and Limitations of Alternatives		
Alternative	**Advantages**	**Limitations**
Hard Abrasive Media	• Extensive work already done with this material • Reusable for a limited time • Produces an aggressive profile	• Requires complex subsystems for media recovery and recycling • Steel Shot/Grit material more expensive • Moisture issues with material • Static charge build-up • Airborne dust
Starch Media	• Plentiful resource that is biodegrable • Less waste • Able to selectively remove one or more layers • Does not cause fatigue to the substrate surface • Media is inexpensive and recyclable	• Typically used on delicate or composite substrates • Stripping rates slow to moderate • Requires complex subsystems for media recovery and recycling • Media can be moisture sensitive and may require air dryer for humidity control
Dry Ice (CO_2) Abrasive	• Reduces the amount of hazardous waste • Reduces time required for cleaning/stripping process • Leaves no residue on component surface • Effective in precision cleaning	• Capital investment cost • Slower strip rates • Non-automated system fatigues workers quickly • Potential hazard from compressed air or high velocity CO_2 pellets • Noise levels
Sponge Blast Media	• Sponge media is recyclable • Media absorbs and removes contaminants • Reduced dust generation • Less operator exposure to harmful materials • Easily transportable	• Foam media more expensive than sand blasting media • Large capital investment cost

Table 3-1 Advantages and Limitations of Alternatives		
Alternative	**Advantages**	**Limitations**
Ultra High Pressure Water Jet	• Does not generate dust or airborne contaminants • Reduces hazardous waste • Capable of selective stripping • Pre-washing and masking not required for most applications • Reduces process material costs significantly • Process water reclamation units capture removed paint and recirculate water • Requires no clean up after stripping	• Capital investment cost • May not remove corrosion • Coating debris sludge is potential hazardous waste • Wastewater disposal requirements • Water can penetrate and/or damage joints, seals, and bonded areas • Stripping rate varies with type of paint, coating condition and coating thickness
Induction-based Removal	• Does not generate dust or airborne contaminants • Reduces hazardous waste	• Slower strip rates • Capital investment cost
Mechanical Removal with Vacuum Attachments	• Eliminates airborne particulate matter • May eliminate need for the use of respirators • Unit is portable • Minimizes clean up time since waste is contained	• Slower strip rates • Capital investment cost • Quality of stripping is dependent on skill and experience level of the operator, therefore; operator training is critical to success and safety of operation
Large Aircraft Robotic Paint Stripping (LARPS)	• Decreases the amount of hazardous waste • Eliminates airborne particulate matter	• Not suitable for structures • Slower strip rates • Capital investment cost
Pinchlamp	• Decreases the amount of hazardous waste • Eliminates airborne particulate matter	• Not suitable for structures • Capital investment cost • Requires additional PPE for protection from laser

Table 3-1 Advantages and Limitations of Alternatives		
Alternative	**Advantages**	**Limitations**
FLASHJET	• Decreases the amount of hazardous waste • Eliminates airborne particulate matter • Quicker coating removal than conventional chemical or mechanical means • Operator friendly • Capable of selective stripping	• Not suitable for structures • Capital investment cost • High voltages associated with xenon lamp • Requires additional PPE for UV exposure and ear protection
Liquid Nitrogen	• Zero secondary waste • Chemically inert (minimal ventilation required) • Cryogenic process that is totally dry • Selective layer removal • Previous work performed for NASA with positive results	• Capital investment cost • Potential hazard from Liquid Nitrogen storage and use under pressure • Very high nozzle pressures • Size and weight of equipment • PPE required (protective gloves, aprons, face shields and footwear covers)
Laser Coating Removal	• Decreased hazardous waste and associated costs • Ability to selectively strip	• Capital investment cost • Portability • Safety concerns

3.2 Product Identification

After further evaluation, some alternatives were removed from further consideration. Table 3-2 lists those alternatives and gives reasons for their removal from the project.

Table 3-2 Alternatives Removed from Further Consideration

Technology	Reason for Removal
Mineral Abrasive (Magnesium Sulfate Abrasive)	• Previous work at Stennis Space Center has shown that while working on the upper levels of a tall structure, the sulfate may come out of solution adhering to lower levels of the structure and become very difficult to remove
Mineral Abrasive (Sodium Bicarbonate Abrasive)	• Slower strip rate • Capital investment cost • Sodium bicarbonate may convert to sodium carbonate, a corrosive, at temperatures of 140-160°F • High noise and dust (dry use of media) concerns
Starch Media	• Typically used on delicate or composite substrates, not suitable for structural steel • Requires complex subsystems for media recovery and recycling
Dry Ice (CO_2) Blasting	• Capital investment cost
Ultra-High Pressure Water Jet	• Capital investment cost • Coating debris sludge is potential hazardous waste • Wastewater disposal requirements
Induction-based Removal	• Capital investment cost • Concerns about commercial availability of equipment
Large Aircraft Robotic Paint Stripping (LARPS)	• Not suitable for large structures
Pinchlamp	• Not suitable for large structures
FLASHJET	• Not suitable for large structures

For the remaining alternatives, except the Mechanical Removal with Vacuum Attachments, only one (1) vendor was used to obtain material for testing according to the Joint Test Protocol to reduce project time and costs. Those vendors selected were either the sole source or had performed well in other government tests. Appendix A contains contact information on vendors of the baseline material and six (6) identified alternatives selected for testing.

4. PROCESS DESCRIPTIONS FOR VIABLE ALTERNATIVES

Of the original alternatives looked at, the six (6) viable alternatives identified below were selected for the coating removal project.

1. Plastic Blast Media
2. Hard Abrasive Media
3. Sponge Blast Media
4. Mechanical Removal with Vacuum Attachment
5. Liquid Nitrogen
6. Laser Coating Removal

These coating removal processes are attractive because of their ability to reduce particulate and dust emissions and reduce waste. All have the potential to reduce wastes and many are also recyclable thus further reducing environmental impact and costs. Each process is described in further detail in the following sections.

4.1 Plastic Blast Media

PBM is a clean, safe, easy-to-use and fast process for super-efficient coatings removal, deflashing, surface preparation, mold cleaning and nearly every other industrial cleaning application. It effectively removes coatings from steel, plastics, aluminum, fiberglass, brass and a variety of other materials in a wide range of industries. PMB replaces chemical stripping, sand blasting and other hard abrasive blast operations and also avoids damage to delicate substrates.

The PBM to be used for this project is Quickstrip®-A from US Technology Corporation. The effect this technology has on pollution prevention is that the stripping media, as well as paint chips, can be recycled resulting in zero waste.

4.1.1 Plastic Blast Media Process Description

It must first be determined if the surface to be depainted is contaminated. If there is contamination, the surface is cleaned using either solvents or high pressure water wash and inspected again. Cleaning the surface helps prevent contamination of the recycled media. Once the surface has been determined to be clean, the next step is masking of areas where the coating is not to be removed and protection of moving parts. Appropriate containment placed around the area is required in order to capture the media and debris for recycling. Another inspection prior to the actual depainting is conducted to ensure the surface is clean and the proper protection is in place.

The area is then depainted and the spent media and debris collected and placed into the classifier unit. The classifier separates debris from the media that can be recycled. After application, the surface is inspected to determine if it meets the required surface profile for recoating. If it does not meet the requirements, the depainting process is repeated.

Figure 4-1 shows a general process flow diagram for the PBM process.

4.1.2 Plastic Blast Media Process Equipment

PBM requires a Blast and Recovery Unit which is available in both pneumatic and electric versions and portable or skid mount. The unit can blast and vacuum simultaneously, eliminating dust clouds and poor visibility; or independently.

PPE is also required, including a supplied air respirator, eye protection and hearing protection.

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4.1.3 Plastic Blast Media Anticipated Material and Energy Usage

PBM can be recycled, thus reducing the amount of material required. According to the manufacturer, the PBM can be recycled approximately ten times with an estimated 14% of material consumed each cycle. A 6-10 millimeter (mil) thick coating can be removed at 2 square feet per minute (ft^2/min) at 40 pounds per square inch (lb/psi) and a media flow rate of 12 lb/min; based on that, it can be estimated that six (6) pounds of virgin material can remove 1 ft^2 and 50 lb of media being recycled can remove 54 ft^2.

Energy usage is dependent upon the Blast and Recovery Unit selected; however, 375 cfm at 100 psi is typical for most projects.

4.1.4 Plastic Blast Media Anticipated Wastes and Emissions

PBM does produce dust and requires proper containment and personal protection equipment. Proper containment is also required to capture all blast process contaminants (such as paint flakes, rust particles, dust and finer particles) generated by the process for recycling. Collected material is returned to U.S. Technology Recycling and is made into plastic products. US Technology Recycling qualifies as an exempt activity under federal and state rules; therefore participants in their recycle program are not generators of hazardous waste.

4.1.5 Environmental, Safety, and Occupational Health Status for the Plastic Blast Media Process

<u>Health and Safety Issues</u>

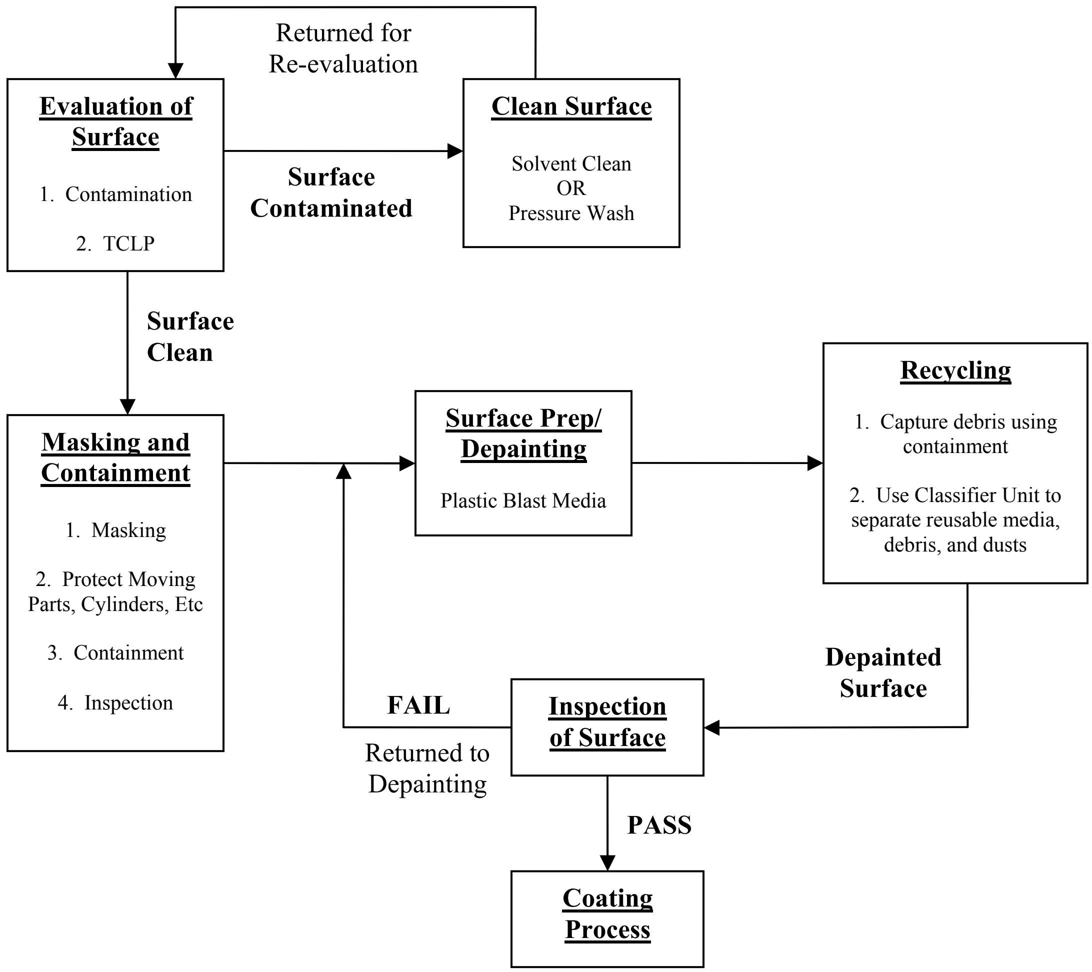
Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations. Proper precautions should be taken to ensure that personnel do not inhale dust/particulate matter. Therefore, appropriate PPE is required and includes a supplied air respirator, coveralls, eye protection and hearing protection.

<u>Environmental Issues</u>

Emissions of dust and particulate matter are of concern particularly if it contains contaminants such as lead or chrome. Therefore, proper containment is required to reduce emissions, but also to capture the material for recycling.

Quickstrip®-A from US Technology Corporation has the added advantage that all products of the process are collected and recycled by the company resulting in zero waste.

Figure 4-1 General Process Flow Diagram for Plastic Blast Media Process



4.2 Hard Abrasive Media

Hard abrasives typically remain intact upon impact with a surface. As such, force is directed into the substrate. Softer abrasives, such as glass beads and glass frit, shatter on impact, resulting in an exploding effect and diffused force. Harder abrasive media types are a good fit for substrates that require a more direct, aggressive cleaning action. Using hard abrasives on thin materials, however, may result in warping or other unwanted damage.

The hard abrasive to be used for this project is Steel-Magic® from US Technology Corporation. The effect this technology has on pollution prevention is that the stripping media, as well as paint chips, can be recycled resulting in zero waste.

4.2.1 Hard Abrasive Process Description

It must first be determined if the surface to be depainted is contaminated. If there is contamination, the surface is cleaned using either solvents or high pressure water wash and inspected again. Cleaning the surface helps prevent contamination of the recycled media. Once the surface has been determined to be clean, the next step is masking of areas where the coating is not to be removed and protection of moving parts. Appropriate containment placed around the area is required in order to capture the media and debris for recycling. Another inspection prior to the actual depainting is conducted to ensure the surface is clean and the proper protection is in place.

The area is then depainted and the spent media and debris collected and placed into the classifier unit. The classifier separates debris from the media that can be recycled. After application, the surface is inspected to determine if it meets the required surface profile for recoating. If it does not meet the requirements, the depainting process is repeated.

Figure 4-2 shows a general process flow diagram for Hard Abrasive Media.

4.2.2 Hard Abrasive Media Process Equipment

Hard Abrasive Media requires a Blast and Recovery Unit which is available in both pneumatic and electric versions and portable or skid mount. The unit can blast and vacuum simultaneously, eliminating dust clouds and poor visibility; or independently.

PPE is also required, including a supplied air respirator, eye protection and hearing protection.

4.2.3 Hard Abrasive Media Anticipated Material and Energy Usage

Hard Abrasive Media can be used at lower pressures (35-80 psi) and recycled, thus reducing the amount of material required; or used at higher pressures (100-120 psi) as a single shot.

4.2.4 Hard Abrasive Media Anticipated Wastes and Emissions

Hard Abrasive Media does produce dust and requires proper containment and personal protection equipment. Proper containment is also required to capture all blast process contaminants (such as paint flakes, rust particles, dust and finer particles) generated by the process for recycling. Collected material is returned to U.S. Technology Recycling and is made into plastic products. US Technology Recycling qualifies as an exempt activity under federal and state rules; therefore participants in their recycle program are not generators of hazardous waste.

4.2.5 Environmental, Safety, and Occupational Health Status for the Hard Abrasive Media Process

Health and Safety Issues

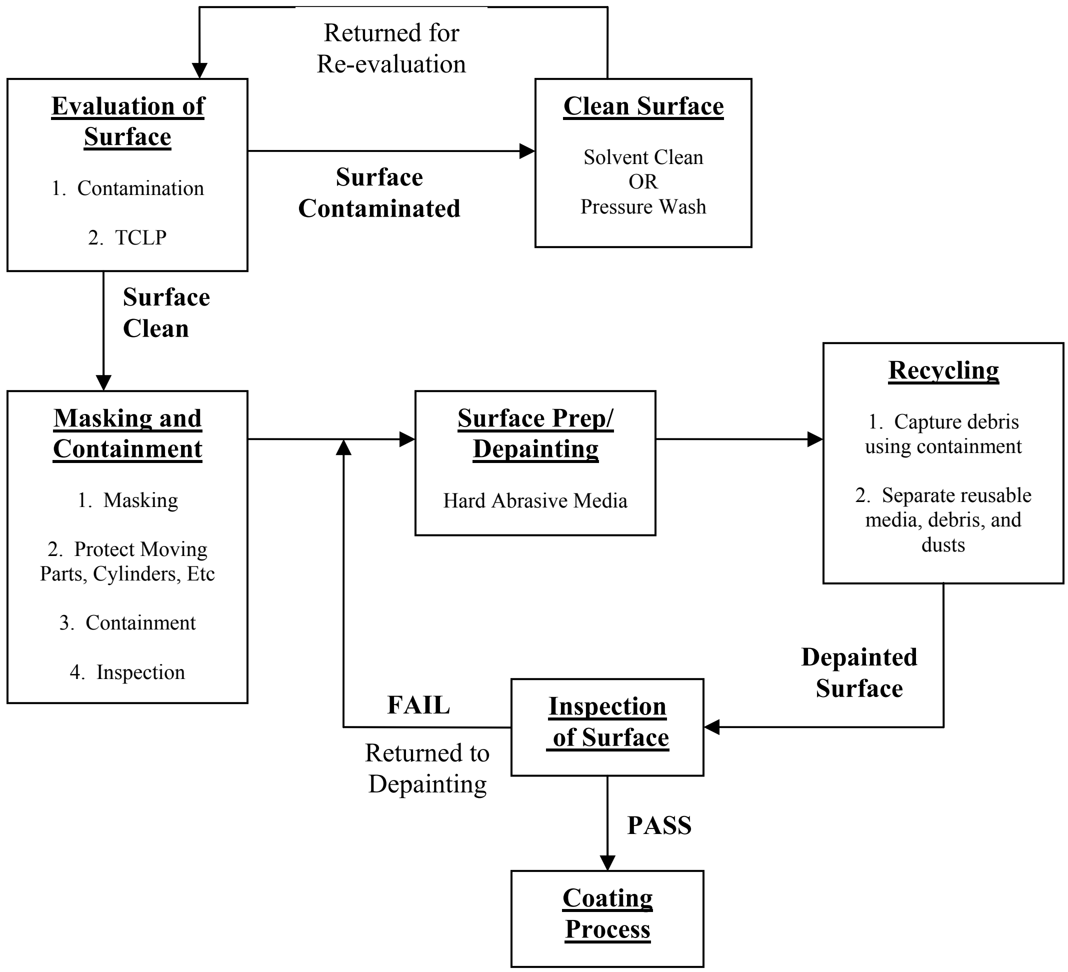
Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations. Proper precautions should be taken to ensure that personnel do not inhale dust/particulate matter. Therefore, appropriate PPE is required and includes a supplied air respirator, coveralls, eye protection and hearing protection.

Environmental Issues

Emissions of dust and particulate matter are of concern particularly if it contains contaminants such as lead or chrome. Therefore, proper containment is required to reduce emissions, but also to capture the material for recycling.

Steel-Magic® from US Technology Corporation has the added advantage that all products of the process are collected and recycled by the company resulting in zero waste.

Figure 4-2 General Process Flow Diagram for Hard Abrasive Media Process



4.3 Sponge Blast Media

Sponge blasting systems incorporate various grades of water-based urethane-foam cleaning media in order to clean and prepare surfaces. The foam cleaning media is absorptive and can be used either dry or wetted with various cleaning agents and surfactants to capture, absorb and remove a variety of surface contaminants such as oils, greases, lead compounds, chemicals, and radionuclides. Using the foam media wetted also provides for dust control without excess dampening of the surface being cleaned.

The Sponge Media to be used for this project is Sponge-Jet®. The effect this technology has on pollution prevention is that the stripping media can be recycled thus reducing waste and the amount of dust/emissions is greatly reduced due to "microencapsulation" or "microcontainment."

4.3.1 Sponge Blast Media Process Description

Sponge Blast Media is an open-cell, water reacted polyurethane sponge to which abrasives are chemically bonded during the production process. There are distinct sponge media types with different characteristics and blasting capabilities. The sponge media and abrasive should be determined based on substrate to be blasted and the coating system to be removed.

It must first be determined if the surface to be depainted is contaminated. If there is contamination, the surface is cleaned using either solvents or high pressure water wash and inspected again. Cleaning the surface helps prevent contamination of the recycled media. Once the surface has been determined to be clean, the next step is masking of areas where the coating is not to be removed and protection of moving parts. Appropriate containment placed around the area is required in order to capture the media and debris for recycling. Another inspection prior to the actual depainting is conducted to ensure the surface is clean and the proper protection is in place.

Ensure all areas not to be stripped are suitably protected. Cover/protect areas where the paint is to be left on. Proper containment should be ensured to protect other areas and workers and to capture the debris which will be separated and allow the used media recycled.

Add the sponge media to the Feed Unit and apply to the surface to be depainted. The debris shall be collected using the containment. This debris is then placed into the Classifier Unit which separates it into reusable media, large debris such as paint chips, and fine dusts. The paint chips and dusts are then disposed of as waste.

If it is required, the reusable media is placed in the Washer Unit to remove contaminants such as grease. The media may then be immediately reused in the Feed Unit.

Figure 4-3 shows a general process flow diagram for the Sponge Blast Media process.

4.3.2 Sponge Blast Media Process Equipment

The equipment consists of three transportable modules, which include the Feed Unit, the Classifier Unit and the Wash Unit (if required).

The Feed Unit is pneumatically powered for propelling the foam cleaning media. The unit is portable and is produced in several sizes (depending on the capacity required). A 100 hp unit is available for small to medium projects and has increased mobility; the typical unit for large operations is 400 hp. A hopper, mounted at the top of the unit, holds the foam media. The media is fed into a metering chamber that mixes the foam cleaning media with compressed air. By varying the feed unit air pressure and type of cleaning media used, sponge blasting can remove a range of coatings from soot on wallpaper to high-performance protective coatings on steel and concrete surfaces.

The Classifier Unit (which can be pneumatic or electric) is used to remove large debris and powdery residues from the foam media after each use. The pneumatic unit requires a minimum 100 cfm at 30 psi. The electric recyclers require a minimum 30 A, 115 V, single-phase, 60 Hz power source. The used media is collected and placed into an electrically powered sifter. The vibrating sifter classifies the used media with a stack of progressively finer screens. Large contaminants, such as paint flakes, rust particles, etc., are collected on the coarsest screens. The reusable foam media are collected on the corresponding screen size. The dust and finer particles fall through the sifter and are collected for disposal. After classifying, the reclaimed foam media can be reused immediately in the Feed Unit.

During degreasing applications, the foam media must be washed every three to five cycles. The washing of the foam media takes place in the Wash Unit, which is a portable centrifuge, closed-cycle device. The contaminated wash water is collected, filtered and reused within the Wash Unit.

PPE is also required, including a supplied air respirator, eye protection and hearing protection.

4.3.3 Sponge Blast Media Anticipated Material and Energy Usage

Sponge Blast Media can be recycled, thus reducing the amount of material required. According to the manufacturer, the abrasive media can be recycled approximately six times and the non-abrasive media can be recycled approximately 12 times. It is estimated that 12-13 fifty (50) pound bags, with the media being recycled, can remove 1000 ft^2 of a typical 9-12 mil thick three coating system (primer, intermediate, topcoat); or 4 lbs of virgin media can remove 1 square foot.

Energy usage is dependent upon the Feed Unit selected; however, large projects typically require the 400 hp model. The electric Classifier Unit requires a minimum 30 A, 115 V power source.

4.3.4 Sponge Blast Media Anticipated Wastes and Emissions

The system removes paint, surface coatings, and surface contaminants from a variety of surfaces. Waste streams produced from the system include blast process contaminants, such as paint flakes, rust particles; dust and finer particles. There can also be concentrated residue from the bottom of the wash unit if it is used.

Emissions from the Sponge Blast Media process are visibly reduced due to the nature of the sponge media. Sponge media particles flatten as they strike the surface, and then expose the abrasive where they cut into the coating and substrate (profiling if needed). As the sponge media rebounds, the porous urethane creates suction entrapping dust, paint, soot, corrosion, and other contaminants in a process known as "Microcontainment."

4.3.5 Environmental, Safety, and Occupational Health Status for the Sponge Blast Media Process

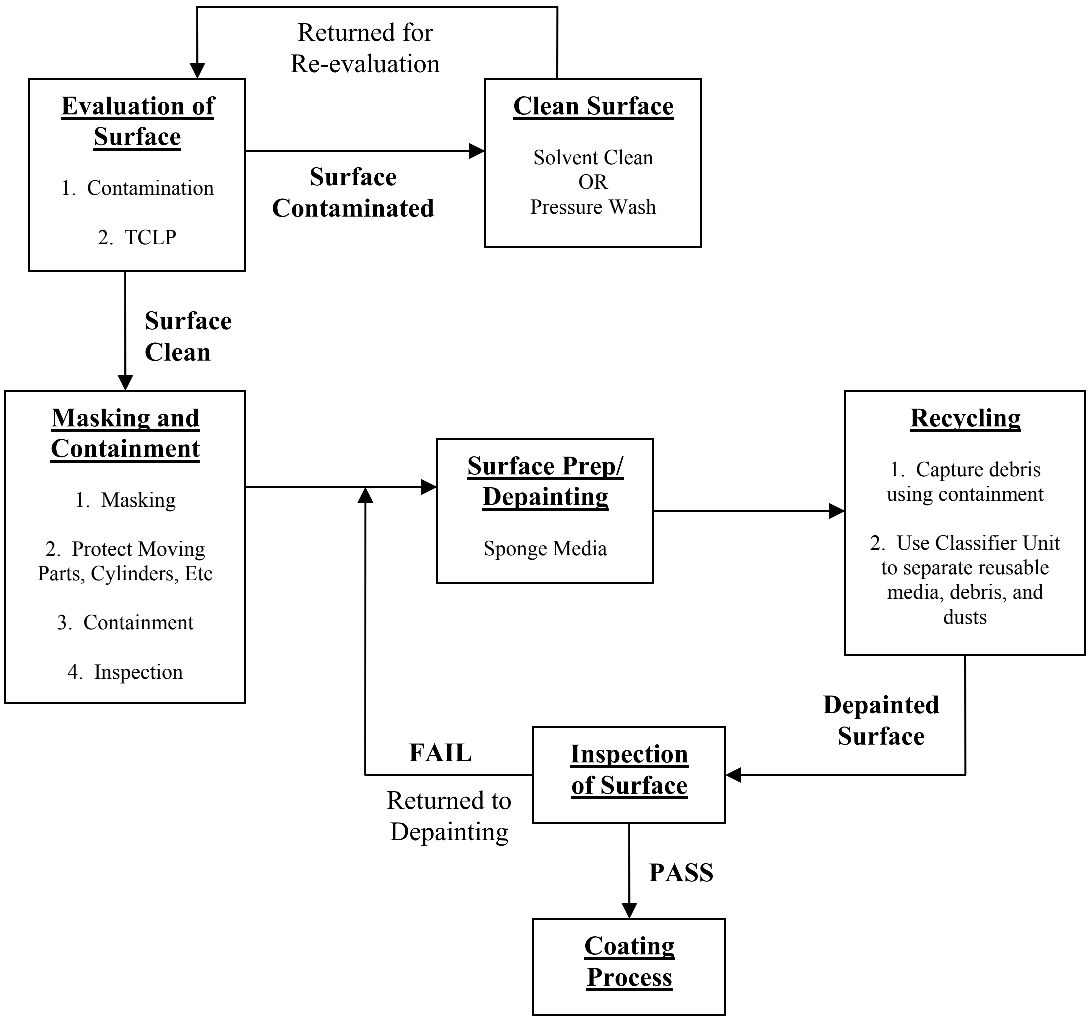
<u>Health and Safety Issues</u>

Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations. Proper precautions should be taken to ensure that personnel do not inhale dust/particulate matter. However, the "Microcontainment" effect of the sponge media visibly reduces the amount of dust produced by entrapping the particles. Appropriate PPE is still required to minimize personnel exposure and may include a supplied air respirator, coveralls, eye protection and hearing protection.

<u>Environmental Issues</u>

Emissions of dust and particulate matter are of concern particularly if it contains contaminants such as lead or chrome. Therefore, proper containment is required to reduce emissions, but also to capture the material for recycling. "Microcontainment" by the sponge media, however, visibly reduces the emissions. Recycling the media also reduces the amount of waste produced.

Figure 4-3 General Process Flow Diagram for Sponge Blast Media



4.4 Mechanical Removal with Vacuum Attachments

This method uses traditional paint removal technologies (needle guns, grinders, etc.) to remove the coating while incorporating point-of-generation "source capture" equipment specifically designed to collect airborne particles.

The systems to be used for this project are from DESCO Manufacturing and DCM Clean-Air Products, Inc. The effect this technology has on pollution prevention is that there is no secondary waste and the vacuum attachments can greatly reduce dust and emissions.

4.4.1 Mechanical Removal with Vacuum Attachments Process Description

The process varies slightly between manufacturers; some require decontamination of the surface while others do not. If decontamination is required, the surface is cleaned using either solvents or high pressure water wash and inspected again. Masking of surfaces is not necessary unless recommended by specifications. Required containment is minimal as the equipment captures dust and debris at the point of generation.

Using the selected tool, the area is depainted while the attached vacuum collects the dust and debris as it is generated. The area is examined to determine if it meets the specified surface preparation requirements; if not, the process is repeated. All of the collected dust and debris is disposed of in accordance with local, state and federal regulations.

Figure 4-4 shows a general process flow diagram for the Mechanical Removal with Vacuum Attachments coating removal process.

4.4.2 Mechanical Removal with Vacuum Attachments Process Equipment

Equipment varies from manufacturer to manufacturer but there are some basic requirements: the actual tool (such as needle gun, sander, or grinder) that removes the coating with a shroud or mechanism to capture the dust and a vacuum attachment to collect the dust.

PPE such as eye protection and hearing protection are recommended.

4.4.3 Mechanical Removal with Vacuum Attachments Anticipated Material and Energy Usage

Energy requirements typically include electric and/or air to power the hand tools and vacuum. Electrical requirements for the alternatives included an electric requirement of 120 V and air requirement of 120 CFM at 90 psi.

4.4.4 Mechanical Removal with Vacuum Attachments Anticipated Wastes and Emissions

The wastes associated with Mechanical Removal with Vacuum Attachments are minimal as there is no secondary waste only the coating and/or corrosion debris that is removed. Waste also may occasionally include the actual tools as they wear and break down and have to be replaced.

The amount of emissions is greatly reduced, typically 95-98%, by the use of the shroud and/or mechanisms used to capture the dust at the source.

4.4.5 Environmental, Safety, and Occupational Health Status for the Mechanical Removal with Vacuum Attachments Process

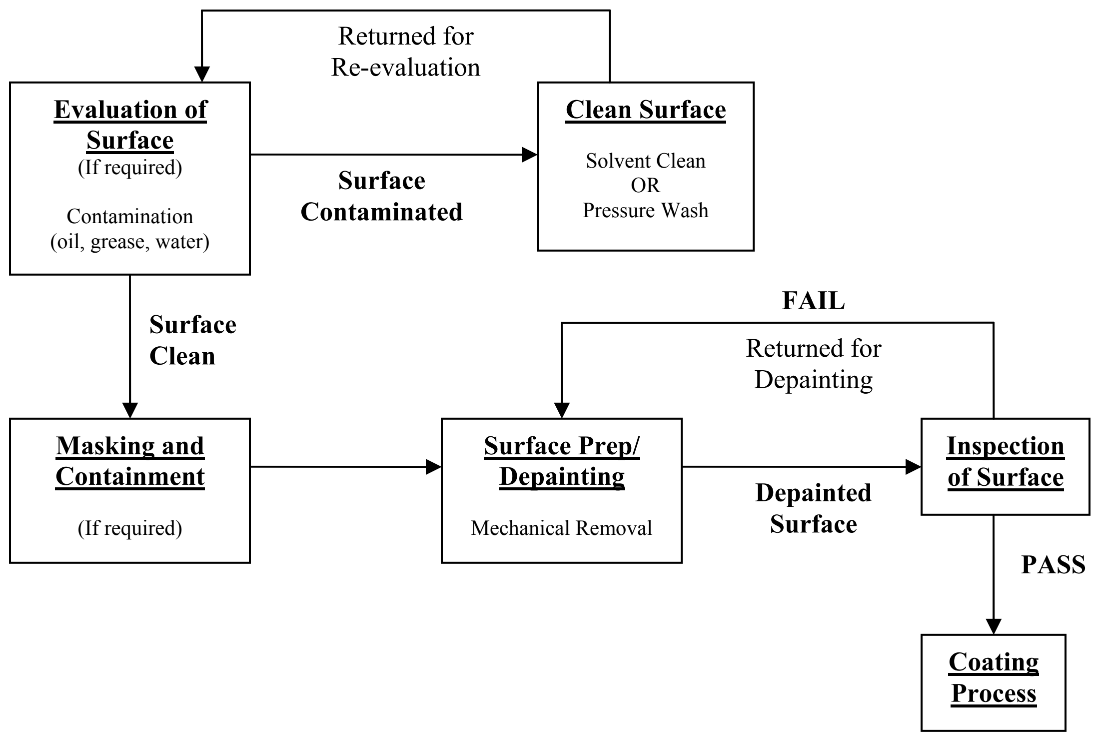
Health and Safety Issues

Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations and may be eliminated with the use of Mechanical Removal with Vacuum Attachments. In order for the vacuum system to be effective, the vacuum and blasting head must be kept in contact with the substrate being depainted. Therefore, training in the proper use of the equipment is essential. In addition, eye protection and hearing protection are recommended.

Environmental Issues

The environmental effects of the Mechanical Removal with Vacuum Attachments are minimal. The vacuum system captures dust and emissions that would otherwise have to be contained and captured for disposal. There are no secondary wastes produced from this technology, therefore only the coating/corrosion removed would require proper disposal.

Figure 4-4 General Process Flow Diagram for Mechanical Removal with Vacuum Attachments



4.5 Liquid Nitrogen Coating Removal

The use of liquid nitrogen (LN) as a cutting and cleaning media combines the advantages of water jet technology with the inherent advantages of cryogenics. Liquid nitrogen is an ideal choice because of its natural properties: dry, cold, chemical inertness, environmental benignity, and the fact that it rapidly converts back into an atmospheric gas. These properties make liquid nitrogen the ideal fluid for cutting materials, cleaning surfaces and removing coatings in environments where controlling contamination, chemical reactions, environmental hazards, secondary waste cleanup, heat and/or bacteria, or fulfilling regulatory oversights are critical.

LN is being used to cut, slice, trim and remove coatings using an ultra high-pressure stream of LN that has a density comparable to water without adding any moisture or particulates to the process. Various nozzle configurations are used to control the liquid nitrogen temperature and pressure and safely deal with the cryogenic extremes.

The effect this technology has on pollution prevention is that there is no secondary waste and it can greatly reduce dust and emissions.

The system to be used for this project is NitroJet® from NitroCision, LLC.

4.5.1 Liquid Nitrogen Removal Process Description

When operational, NitroJet® accepts liquid nitrogen (LN) as the feed stream. NitroJet® pressurizes the LN in two stages. The first stage pressurizes the sub-cooled LN to an intermediate pressure of between 15,000 and 20,000 psi with a temperature of about -250 degrees F.

The second pressurizing stage takes the discharge from the first stage and feeds it into dual hydraulic intensifiers that can boost the pressure up to the maximum operating pressure of 55,000 psi. The LN is discharged at a temperature of about -220 degrees F and is supercritical. In this condition the LN alone can cut, strip and abrade much like ultra high pressure water but without any residual liquid to be contaminated, collected or removed, because it is a dry process. Additionally, NitroJet® can have soluble or insoluble abrasives entrained in the liquid nitrogen stream for more aggressive cleaning, cutting or profiling.

The NitroJet uses programmable logic controllers (PLC) to coordinate the NitroJet's hydraulic system, the heat exchangers and pressure controls to provide maximum flexibility for any operational need. NitroJet® can be deployed manually or robotically and can be equipped with a vacuum capture system that allows for the capture of the material being cleaned or removed.

Figure 4-5 shows a general process flow diagram for the NitroJet® process.

4.5.2 Liquid Nitrogen Removal Process Equipment

Virtually all components used in the NitroJet® system are commercially available and manufactured in the U.S. All high pressure piping, fittings, valves and pumps are pressure rated up to a maximum allowable working pressure of 55,000 psi and a design pressure of 60,000 psi. The current configuration of the system consists of a 4'x 9'x 5'skid weighing approximately 7200 lbs and is forklift deployable. It only requires a nitrogen supply and electrical power or portable generator for deployment. A compact unit is being designed that will enable the user to locate the pumping system in small remote areas such as payload bays or sensitive hangars where forklift access is impractical.

The major components of the system are:

- Electric powered hydraulic pump
- Hydraulic oil reservoir
- PLC control unit
- Liquid Nitrogen intermediate pressure pump
- Hydraulic control valves, coolers, and heat exchangers
- Cryogenic heat exchangers
- Hydraulic intensifiers

4.5.3 Liquid Nitrogen Removal Anticipated Material and Energy Usage

The NitroJet® system has a consumption rate of nitrogen on average of 3-4 gallons per minute (gpm), but is dependent on the tooling used. The Rotary Multi-Jet Head that is most commonly used to remove coatings discharges 2-3 gpm of nitrogen.

Recent system modifications have yielded a LN output of 5-8 gallons per minute. This doubling of the system flow rate provides for a higher energy release at the substrate surface producing a 55,000 psi configuration with approximately 2.5 times faster strip rate.

The power requirements are 480V, 3-phase, 150KVA (minimum) power source and 115V AC power source. Rotary nozzles also require a 100 psi source of dry compressed air.

4.5.4 Liquid Nitrogen Coating Removal Anticipated Wastes and Emissions

NitroJet® accomplishes the elimination of secondary waste by relying on liquid nitrogen's nature to rapidly transform from a supercritical fluid to a gas as it depressurizes. Once a gas, it simply dissipates into the atmosphere leaving nothing behind but the debris displaced in the cleaning process.

4.5.5 Environmental, Safety, and Occupational Health Status for the Liquid Nitrogen Process

<u>Health and Safety Issues</u>

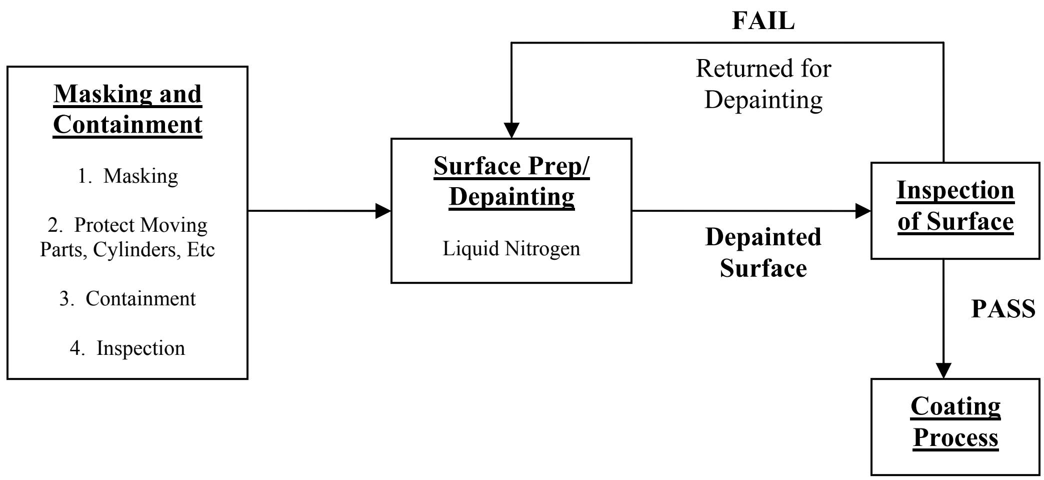
Airborne dust, which may contain contaminants from the coating such as lead or chrome, is the major safety and health concern with blasting operations. Proper precautions should be taken to ensure that personnel do not inhale dust/particulate matter.

Due to the extreme temperatures and pressures involved with liquid nitrogen, protective equipment includes temperature resistant protective gloves and aprons, protective face shields and footwear covers. There is also the possibility of the gaseous nitrogen displacing oxygen in an enclosed work space resulting in a condition called Oxygen Deficiency Hazard by the Occupational Health and Safety Administration which require respirators.

Environmental Issues

Emissions of dust and particulate matter are of concern particularly if it contains contaminants such as lead or chrome. Proper containment and capture is necessary to properly dispose of wastes. The use of liquid nitrogen, however, results in no secondary waste.

Figure 4-5 General Process Flow Diagram for Liquid Nitrogen Coating Removal



4.6 Laser Coating Removal

The paint stripping mechanism varies depending on the laser beam characteristics and delivery method. However, there are two basic laser paint stripping mechanisms:

Thermal Decomposition

Constant wave or continuous wave lasers vaporize thin layers of the coating system. This process uses thermal energy to remove layers of paint from the substrate surface. Constant wave lasers apply energy for a long period of time, heat up the material, and burn it off. Since it is easy to damage the substrate, constant wave lasers require extensive training, controls, and diagnostics to safely remove paint.

Ablation

Laser ablation can be achieved with pulsed lasers, which create bursts of high intensity energy. One advantage when compared to the constant wave laser paint stripping process is that the de-painting can occur at lower average temperatures. The ablation process is a mechanical process. A thin layer of coating is vaporized and converted into plasma which creates a shock wave. This shock wave removes the coating and creates a crack network in the remaining coating. There are different variations of the ablation mechanisms that can be observed depending on the laser beam characteristics. These characteristics include power, wavelength, pulse width, pulse frequency, beam profile, and operating parameters.

The effect this technology has on pollution prevention is that there is no secondary waste and it can greatly reduce dust and emissions.

The system to be used for this project is a CL 120Q Nd:YAG Class 4 Laser system with fiber optic cable from Clean-Lasersysteme GmbH with a HEPA vacuum and air filtration system.

4.6.1 Laser Coating Removal Process Description

For each different application that the laser technology would be used in, the laser unit would have to be programmed for the specific coatings, substrates, and possibly geometries of the components. After donning the appropriate PPE, the operator would activate the laser unit, target the area of the component to be depainted, and fire the laser. The operator would monitor the depaint process as it progresses.

Figure 4-6 shows a general process flow diagram for the Laser coating removal process.

4.6.2 Laser Coating Removal Process Equipment

The equipment used for laser removal of coating systems would be all-inclusive to the laser unit. No extraneous tools would be necessary.

The major components of the system are:

- Resonator
- Coupling optic
- Chiller control unit
- Central control unit
- Energy supply unit
- Chiller
- Operating panel

The operator would be outfitted with the appropriate PPE including eye protection, skin covering, and possibly ear protection.

4.6.3 Laser Coating Removal Anticipated Material and Energy Usage

The utility usage would vary depending on the consumption rate and utilization of the unit selected. The principle input needed for use of a laser unit would be electricity. The quantity of electricity used will depend on the specific unit employed and how much it is used.

4.6.4 Laser Coating Removal Anticipated Wastes and Emissions

The waste generated from using the laser unit to ablate coating systems will be primarily carbon dioxide and water. These and any other emissions can be collected at the headpiece or with a local exhaust system. Solid waste generated from the ablation of the coating system will be the paint chips ejected from the surface of the component. This mass would not exceed the quantity of coating that had been applied. If the laser unit is used in such a manner that the coating system is burned off (pyrolitic process), then the airborne emissions become abundant and potentially hazardous. The solid waste would be composed of ash and soot.

4.6.5 Environmental, Safety, and Occupational Health Status for the Laser Coating Removal Process

Health and Safety Issues

The current federal regulation governing the safe use of lasers is 21 Code of Federal Regulations (CFR) 1040.10 Chapter 1. The ANSI document 136.1-1993 is the guidance document for the Military Services and NASA laser safety standards. ANSI 136.1- 1993 contains detailed information on the classification of lasers as well as safe handling procedures and health effects from exposure. A brief summary of the information contained in ANSI 136.1-1993 is provided in the discussion of ESOH concerns that follows.

In addition, OSHA promulgated an instruction standard, PUB8-1.7, as a guideline for laser safety and hazard assessment. Some states and local governments have passed legislation concerning the use and safety of lasers. Ten states have passed comprehensive laser regulations. These states are Alaska, Arizona, Arkansas, Florida, Georgia, Illinois, Massachusetts, New York, Texas, and Washington.

When working with lasers, the greatest concern regards exposure of eyes and skin to laser radiation. Engineering controls designed into the laser system are the principle means of protection. A preferred method of protection from laser radiation is to enclose the laser equipment and beam path. In this manner, under normal working conditions, the possibility of exposure is greatly reduced. In addition, the requirement for PPE is reduced. If, however, the enclosure or engineering controls are inadequate, appropriate PPE must be used. PPE would include protective eyewear, such as goggles; face shield; or spectacles and protective clothing. Each type of eyewear must protect the wearer from both direct and diffusely scattered beams. As most eyewear is developed to resist a specific wavelength of laser output, with a tunable laser system additional safeguards, such as remote viewing, must be considered. Wearing opaque or tightly woven fabrics (i.e., laboratory jacket/coat) can protect the skin from most laser radiation. For lasers emitting ultraviolet radiation, sunscreen can also be effective.

An additional concern for the laser operator relates to the noise generated during the process. During the laser coating removal process, noise is generated from various sources including the vacuum for the effluent capture system, cross air flow, and coating removal from the substrate.

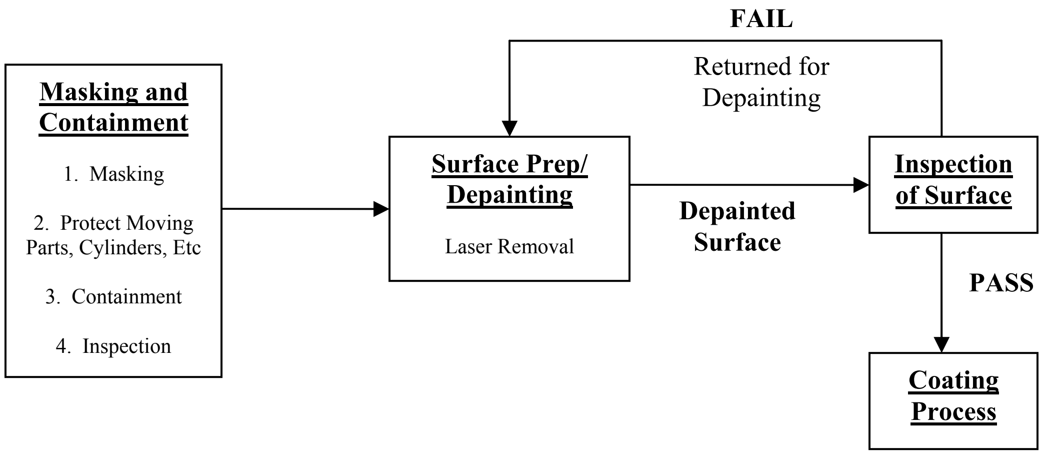
In addition to laser user safety, the safety of non-users must be considered. The best protection from lasers for non-users is avoidance. To this end, signs and labels are designated by the American National Standards Institute (ANSI) document ANSI 136.1 document. Besides the laser beam hazards, additional hazards, called non-beam hazards, may exist. These include electrical and fire hazards and laser generated air contaminants. These and other non-beam hazards can be reduced through engineering controls, training, and common sense. ANSI 136.1 should be referenced for more specific information. The maximum permissible exposure (MPE) is the amount of laser radiation exposure over a certain amount of time that does not cause hazardous effect. The MPE value and exposure duration vary depending upon the wavelength and power of the laser. For example, the exposure duration for a low power (Class 1) laser is 1000 seconds, whereas the exposure duration is less than or equal to 0.25 second for a high power (Class 4) laser. Knowledge of the MPE value for a specific laser is very important in avoiding injury. It should be noted that even at the MPE, exposure could cause discomfort. With increased exposure beyond the MPE, increased level of damage occurs.

As the eye and skin are primary targets of laser exposure, types of damage are briefly discussed in this paragraph. The most benign effect of exposure to the eye is minimal corneal lesions. These appear as white marks on the cornea and disappear within 48 hours without visible scarring. More damaging effects include loss of transparency of the cornea and surface irregularities when exposed to infrared laser radiation and corneal surface exfoliation and stromal haze with ultraviolet laser exposure. In addition to the corneal damage, retinal damage can also occur. This includes heating the central part of the retina, the macula, resulting in loss of central, clear vision. Whenever the retina is damaged, no matter how slightly, with laser radiation, the damage is permanent. In contrast, most corneal damage can heal or be corrected. When skin is exposed to visible and infrared laser radiation, the damage is usually reparable or reversible. As the power of the laser increases, damage shifts from reddening of the surface tissue, blistering, and charring to depigmentation, ulceration, and damage to the underlying organs. Exposure to ultraviolet laser radiation can be carcinogenic. Non-damaging exposure to ultraviolet radiation may still cause damage in the presence of photosensitizers.

Environmental Issues

Environmental concerns associated with the use of lasers in this application are due to the by-products and emissions generated when coatings are removed. Each type of coating has the potential to produce different types of waste emissions. Until the components of the emissions are identified, they should be characterized as hazardous. Any particulate waste generated should also be characterized as hazardous until properly identified as non-hazardous.

Figure 4-6 General Process Flow Diagram for Laser Coating Removal



5. SUMMARY

During the coating removal project, particulates in coating removal processes currently used by NASA were identified as hazardous materials of concern, and targeted for elimination or reduction. Fifteen (15) alternative materials/processes were identified as potential replacements for the current processes. These alternatives were identified through literature searches and direct vendor queries. The identified alternatives were:

- Plastic Blast Media
- Mineral Abrasives
  - Magnesium Sulfate Abrasive
  - Sodium Bicarbonate Abrasive
- Hard Abrasive Media
- Starch Media
- Dry Ice (CO_2) Blasting
- Sponge Blast Media.
- Ultra-High Pressure Water Jet
- Induction-based Removal
- Mechanical Removal with Vacuum Attachment
- Large Aircraft Robotic Paint Stripping (LARPS)
- Pinchlamp
- FLASHJET
- Liquid Nitrogen
- Laser Coating Removal

Manufacturers and distributors of the identified alternatives were contacted, and technical, environmental, safety, and occupational health information about the alternatives was gathered through a technology survey and compared with the baseline process.

It was decided in the stakeholder technical meetings that the goal of the AP2 effort was to identify a coating removal process as a replacement for the currently used coating removal processes used on structural steel. Initially, the search for replacement materials or processes included all the identified alternatives to allow for the consideration of all possible new technologies.

Of the 15 identified alternatives, nine were dropped from further consideration because they were not technically feasible, were not commercially available, or had been considered under numerous other studies. The following products were selected for demonstration:

1. Plastic Blast Media
2. Hard Abrasive Media
3. Sponge Media
4. Mechanical Removal with Vacuum Attachments
5. Liquid Nitrogen
6. Laser Coating Removal

APPENDIX A

Vendor Contact Information for Selected Alternatives

1. Baseline

Black Beauty®

www.reade.com

Reade Advanced Materials
P.O. Drawer 15039
Providence, RI 02915
Ph: 1-401-433-7000

Charles Reade
General Sales Manager

2. Plastic Blast Media

Quickstrip®-A

www.ustechnology.com

US Technology Corporation
1446 W. Tuscarawas Street
Canton, OH 44702
Ph: 800-634-9185

Clay James
Regional Sales Manager
Ph: 409-963-3408

3. Hard Abrasive Media

Steel Magic®

www.ustechnology.com

US Technology Corporation
1446 W. Tuscarawas Street
Canton, OH 44702
Ph: 800-634-9185

Clay James
Regional Sales Manager
Ph: 409-963-3408

4. Sponge Media

Sponge-Jet®

www.spongejet.com

Sponge-Jet, Inc.
235 Heritage Avenue, Suite 2
Portsmouth, NH 03801
Ph: 800-776-6435

Denis Crowther
CEO
High-Tech Enviro-Systems, Inc.
1327 SW 1st Avenue
Fort Lauderdale, FL 33315
Ph: 954-462-0023

5. Mechanical Removal with Vacuum Attachments

DESCO

www.Descomfg.com

DESCO Manufacturing
30081 Comercio
Rancho Santa Margarita, CA 92688
Ph: 949-858-7400

Rocky Ventittelli
Vice President
Ph: 619-463-1950

DCM

www.dcmcleanair.com

DCM Clean-Air™ Products, Inc.
9605 Camp Bowie West
Fort Worth, TX 76116
Ph: 800-624-4518

Ross W. Cole, Sr.
Senior Tech Representative
Pager: 800-306-8469

6. Liquid Nitrogen

NitroJet®

www.nitrocision.com

NitroCision, LLC
151 N. Ridge, Suite 260
Idaho Falls, ID 83402
Ph: 208-552-2354

Donald Noah
Manager, Project and Services
P.O. Box 1112
Titusville, FL 32781
Ph: 321-264-0783

7. Laser Coating Removal

Clean Lasersystem CL 120Q Nd:YAG Class 4 Laser

JET Lasersysteme GmbH
Huckelhoven, Germany