AD-A257 232

7 Oct 92

Interim Report

Environmentally Compliant Thermoplastic Powder Coating

USAF Contract No. F09603-90-D-2215

Dr Douglas Neale
Mr Douglas Bruner
Mr David Butler

Science Applications International Corporation
1000 Corporate Pointe
Warner Robins Georgia 31088

SAIC Project No. 0100

Air Force Corrosion Program Office
WR-ALC/CNC
215 Page Rd, Suite 232
Robins AFB GA 31098-1662

CN-04

Distribution Statement A. Approved for public release; distribution is unlimited.

This interim report covers the evaluation of vendors and manufacturers of thermoplastic powder coating (TPC) equipment, materials, and technology. Assess the magnitude of the corrosion problems at several Air Force Bases in severely corrosive environment. Determine what potential equipment would benefit from the TPC system to replace the current solvent-borne coating systems used on munitions, munitions handling equipment, mobile communications and electronic support equipment and aerospace ground equipment (AGE). Evaluate the TPC flame sprayed application equipment and ethylene acrylic acid (EAA) and ethylene methacrylic acid (EMAA) copolymers thermoplastic powder.

Thermoplastic Powder Coating TPC Corrosion Protection
Flame Sprayed Application Equipment

112

Unclassified U U UL

ENVIRONMENTALLY COMPLIANT THERMOPLASTIC POWDER COATING

PHASE I INTERIM ENGINEERING REPORT
March 31, 1992

CONTRACT NO. F09603-90-D-2215
PROJECT NO. CN-04

A-1

ORIGINATING ACTIVITY: SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
1000 CORPORATE POINTE
WARNER ROBINS, GEORGIA 31088

REPORT SECURITY CLASSIFICATION: Unclassified

REPORT TITLE: ENVIRONMENTALLY COMPLIANT THERMOPLASTIC POWDER COATING ENGINEERING REPORT

TYPE OF REPORT: Interim Engineering Report (Phase I)

AUTHORS: Dr. Douglas Neale
Mr. Douglas Bruner
Mr. David Butler

REPORTING PERIOD: October 23, 1991 Through March 31, 1992

PUBLICATION DATE: March 31, 1992

PROJECT NUMBER: CN-04

ORIGINATOR'S REPORT NUMBER: 0100

SPECIAL NOTE: "The investigation reported in this document was requested by the Air Force Corrosion Office, CNC, Warner Robins Air Logistics Center of Robins Air Force Base, Georgia, 31098-5320, under Contract No. F09603-90-D-2215. It is published as a technical progress report only and does not necessarily represent recommendations or conclusions of the requesting agency, either at the time of publication or at the end of contract".

ENVIRONMENTALLY COMPLIANT THERMOPLASTIC POWDER COATING ENGINEERING EVALUATION REPORT PHASE I

Phase I of the Environmentally Compliant Thermoplastic Powder Coating Engineering Evaluation Study, Contract # F09603-90-D-2215, began on 24 Oct. 1991 with a kickoff meeting at Warner Robins-ALC attended by SAIC and WR-ALC/CNC. The purpose of this meeting was to review the Statement of Work (SOW) and to establish a plan for the successful execution of this three-phase program. After a general program review was completed, Phase I tasks were discussed and defined. This document, the Phase I Interim Engineering Report, reports progress in the completion of these tasks.

Phase I is broken into four sub tasks:

SUB TASK 1

Sub Task 1 involved identifying, contacting, and screening vendors of thermoplastic powder coating (TPC) equipment, materials and technology. Also, personnel from the Air Logistics Centers at Ogden, San Antonio and Sacramento as well as Wright-Patterson ALC Headquarters were contacted to inform them of the project and to solicit their participation. The goal of the vendor search was to acquire current information about the existing level of technology and the capabilities of TPC application hardware. The search consisted of surveying the Thomas Register for companies involved in powder coatings technology, reviewing powder coating industry literature and contacting industry experts including the Powder Coatings Institute and Dr. Jan Gooch, a polymer chemist who has worked with TPC technology for over ten years. The Thomas Register search resulted in identifying and contacting 32 companies. These contacts revealed that most listings were TPC applicators that purchased equipment and powders from a few actual hardware manufacturers. Many contacts were involved in electrostatic deposition of powders or application of thermoset plastics, technologies not included for consideration in the current SOW.

The vendor survey revealed that currently three basic options exist for thermal spray application of thermoplastic powders. The least developed technique, in terms of field-ready hardware, uses an inert gas plasma for heating the polymer powder. This technique has successfully applied a wide range of thermoplastic and thermoset polymers in the laboratory; however, the hardware is complex and expensive ($60,000 for a basic unit). The two remaining technologies use a propane (home gas grill) or acetylene (cutting torch) flame to melt and flow the polymer coating. One of these techniques has evolved from the metal powder spray ("metallizing") industry which uses oxygen with acetylene or propane to achieve extremely hot flames suitable for melting metals. The other, simpler, method uses compressed air rather than oxygen. This system operates with a "cooler" flame that is less likely to thermally damage the plastic powder as it passes through the heating zone. All three of these TPC application techniques use compressed gas (air or nitrogen @ 100 psig) to entrain powder from a hopper and to propel the powder through hoses to the flame/plasma gun. Portable, rugged production TPC application systems are currently available for both flame spraying techniques.

The screening process yielded five vendors as the consensus leading U.S. manufacturers of TPC equipment. They are:

Canadian Flamecoat Systems/American Thermoplastics;
Calgary, Canada/Mesa, Arizona - (propane/air flame)

UTP Welding Technology; Houston, Texas - (propane/oxygen flame)

METCO (Perkin-Elmer); West bury, New York - (propane/oxygen flame)

Plastic Flamecoat Systems; Houston, Texas - (propane/air flame)

Applied Polymer Systems; Tampa, Florida - (Argon plasma)

Canadian Flamecoat/American Thermoplastics, UTP and METCO have worked closely with Dow Chemical to develop and optimize their systems using Dow "Envelon" ethylene acrylic acid (EAA) thermoplastic copolymers. Plastic Flamecoat has pursued a similar cooperative arrangement with DuPont "Nucrel" ethylene methacrylic acid (EMAA) copolymers. EAA and EMAA are closely related polymers yielding similar physical and chemical resistance properties. They may be used interchangeably with the four flame spray systems listed above. Applied Polymer Systems has sprayed a variety of thermoplastic and thermoset polymers from a variety of powder suppliers.

After completing the screening, SAIC visited the production facility of each manufacturer listed above to brief the project and to review that vendor's TPC application hardware. Each vendor was asked to complete the Vendor Evaluation Checklist (VEC) included as Attachment 1 to this document. Attachment 2 is a summary of the four flame-spray systems assembled from written responses to the VEC as well as from actual interviews and observations made during equipment demonstrations. Attachment 2 also includes a summary of the Dow and DuPont copolymers. It is apparent from the range of performance parameter values supplied by the vendors that further equipment evaluation by SAIC and WR-ALC/CNC planned in Phase II of this program will be necessary to accurately characterize the systems. As a backup to the direct SAIC vendor review, Dr. Jan Gooch of the Georgia Tech Research Institute (GTRI) was commissioned to assemble an independent overview report documenting the current state of TPC equipment and material technology. Dr. Gooch's findings augment and substantiate the SAIC conclusions. His report is included as Attachment 3.

SUB TASK 2

Sub Task 2 is the development of a Site Evaluation Plan (SEP). The plan is included as Attachment 4 to this report. The SEP was written to insure thorough and consistent evaluations of the potential U.S Air Force base field test sites for TPC hardware. The original test sites were selected by WR-ALC/CNC from their highly corrosive environments and range of climates. The originally selected installations were;

Andersen AFB, Guam

Kadena AB, Japan

Osan AB, Korea

Sacramento ALC, California

This SEP was designed to asses the magnitude of the corrosion problem at each base, to evaluate the extent to which TPC technology can ameliorate the problem, to determine base facility compatibility with TPC hardware and processes and to ascertain whether sufficient manpower and skill levels exist to successfully operate TPC application equipment. Specifically, SAIC was tasked to consider the potential for TPC to replace the current solvent-borne coating systems used on munitions, munitions handling equipment, mobile communications & electronic support equipment and aerospace ground equipment (AGE).

SUB TASK 3

The Site Evaluation Plan was implemented by visiting the four field locations listed in Sub Task 2. The evaluation trip was conducted 7 January - 7 February 1992 and included a vendor visit as well as additional briefings at the San Antonio ALC, Kelly AFB and PACAF Headquarters, Hickam AFB, Hawaii. Results of this trip are reported in detail in Attachments 5 and 6 to this report. In summary, it was determined that a severe corrosion problem exists for all equipment, hardware and structures exposed to weather at Andersen AFB. The problem is compounded by continuing reductions in manpower and budget. Any coating technique that can effectively extend corrosion protection will be welcomed by base maintenance personnel. TPC will be most effective if used to coat equipment during periodic depot maintenance (PDM) when complete removal of the original coatings and proper substrate preparation (sandblasting) can be accomplished. Immediate applications for TPC evaluation include non-powered AGE equipment, trailers, stands, bomb fins, training missiles, Rapid Assembly Munitions Systems (RAMS), munitions containers, antenna masts, and Civil Engineering Structures (exposed structural steel, bomb vault doors, revetment walls, storage tanks, pipelines, hand rails, etc.). Powered vehicles are also candidates if fuel/hydraulic systems can be stripped (e.g. at PDM). Similar applications were identified at all bases. Corrosion at Kadena, while still a problem, is less severe than at Andersen, partly because the environment is less corrosive and partly because a more comprehensive anti-corrosion program has been implemented. Osan's corrosion problem is less severe than Kadena and exists primarily as a result of salt and sand applied to the roads and other traffic areas during the winter to melt ice. SAIC has recommended that an alternate cold weather test site with a more severe corrosion environment be considered to replace Osan (e.g., Shemya, Alaska).

SAIC determined that sufficient personnel skill levels for successful TPC application exist at every base and that no mechanical compatibility problems are evident. Compressed air and propane are locally available at each base. Since these bases are remote on the supply pipeline, attention must be paid to insuring that powder and hardware replacement parts are available to the applicators.

Potential environmental problems were noted at two bases, Andersen and McClellan. Andersen has experienced local EPA restrictions on outdoors sandblasting. Vacuum blasting is allowed, however, and SAIC recommends that a portable sandblast unit be provided with each TPC field hardware set to meet EPA requirements and to encourage and facilitate the use of the application equipment. The environmental group at McClellan noted that nitrogen oxides are released as a result of the combustion process and that the base is restricted from adding new systems that release these pollutants. This problem is not viewed as critical at this point since the TPC test equipment is not a permanent installation and is a very small source of NO_X.

High levels of personnel interest and motivation were noted at all bases when TPC technology was briefed. In general, the communications groups did not show great interest in TPC with the exception of those at the Sacramento ALC (McClellan) and Kadena.

The site evaluations were documented with 35 mm color prints and video tapes which have been submitted to WR-ALC/CNC. Final test site selection will be completed in Phase II of this program.

SUB TASK 4

SAIC has ranked and selected the following TPC equipment vendors for further test and evaluation:

1. Canadian Flamecoat/American Thermoplastics (Dow)
2. Plastic Flamecoat Systems (DuPont)
3. UTP Welding Technology (Dow)

The major weighting factors for hardware selection were:

1. Design Maturity
2. Ease of operation
3. Ruggedness (maintainability)
4. Supportability (standard parts, vendor support network)
5. Cost
6. Polymer Compatibility

The systems selected represent a complete cross-section of current TPC flame spray technology suitable for general industrial applications. Oxygen/fuel and compressed air/fuel systems are included as well as two major polymer powder suppliers. Each vendor has been informed of their selection and lease arrangements are currently under negotiation. One complete TPC application unit from each vendor will be delivered to WR-ALC/CNC for evaluation tests. These tests will last approximately six months and will be conducted under Phase II of this program (April - September, 1992). These units will also be used to coat test panels for the laboratory coatings evaluation/comparison tests to be conducted at an independent lab under Phase II. The Test Plan for these lab tests is a Phase II deliverable item and is currently being written.

A complete briefing list is included as Attachment 7 to this report.

ATTACHMENT 1

Vendor Evaluation Checklist

VENDOR EVALUATION CHECKLIST (rev 11/27/91)

1. Obtain complete vendor literature describing process technology, hardware, performance data, field support and pricing.

2. Determine hardware specifications
   a. Power/fuel/utility requirements (water, air, electrical etc.)
      1. Fuel consumption
      2. Fuel type/grade
      3. Electric power consumption
      4. Voltage/current
      5. Utility interface hardware compatibility
   b. Maintenance/repair requirements
      1. MTBF
      2. Required service inspections, maintenance schedule
      3. Level of repair, field or depot
      4. Construction ruggedness
   c. Vendor-supplier technical product/field support
      1. Program description
      2. Technical data/hardware upgrades
      3. Detailed technical support manuals with assembly/parts breakdown (illustrated)
      4. Replacement parts, local compatibility
   d. System costs
      1. Original purchase
      2. Life cycle(including maintenance, repair)
      3. Operating ($/hr, $/sq ft, $/# coating - including setup/use/cleanup cycle, also utilities, powder, fuel)
      4. Replacement parts/components
   e. System description
      1. Size
      2. Weight
      3. Number of components
      4. Portability (air, ground; handling equipment required)
      5. Shipment cube
      6. Construction (materials, fastenings etc.)
   f. Delivery time
   g. Warranty
      1. Term
      2. Coverage

3. Determine process specifications/requirements
   a. Required surface preparation (cleaning, blasting, pretreatment, adhesion enhancers, corrosion inhibitors, preparation required for overcoating existing polyurethanes/enamels/laquers)
   b. Compatibility with existing coatings (as overcoat)

c. Application envelope (rate, ambient conditions, thickness, substrate type and condition, etc.). Define limitations (potential problem areas and/or lessons learned - vendor's experience)
d. Object piece size/configuration limitations
e. Substrate/thermoplastic material temperature requirements
f. TPC material suppliers/availability/cost
g. Coating pigmentation capability
h. Coating $/sq ft applied
i. Environmental effects (cleanup, application. storage, etc.)
j. Application equipment power/utility/fuel consumption
k. Coating removability (cold, hot, abrasives)
l. Coating repairability
m. Other system/process limitations, requirements
n. NDE/NDT of surface/substrate with TPC (what thickness, what nondestructive techniques/methods/equipment available)

4. Define and document other issues
   a. Safety compliance (OSHA, NIOSH, AFOSH)
   b. Environment/Bioenvironmental
   c. Present level of technology
   d. Vendor willingness to participate in technology R&D, test and evaluation
   e. Operator skill level, training required
   f. Alternate application techniques (hot air, plasma, etc.)
   g. Existing test data for coating effectivness (chemical, environmental, corrosion)
   h. TPC materials available
   i. Material property/performance data sheets (safety, physical properties, chemical resistance, corrosion protection, durabilitiy, environmental resistance, application parameters etc.)
   j. Conformance to attached MIL specs, standards and T.O.s
   k. Air Force special requirements/objections
   l. List of TPC equipment users/customers

ATTACHMENT 2

Vendor/Supplier Summaries

THERMOPLASTIC POWDER COATING (TPC) VENDOR SUMMARY
(rev. 3/23/92)

VENDOR: Canadian Flamecoat Systems Inc.
412, 602-11 Avenue S.W.
Calgary, Alberta, Canada T2R1J8
(403) 269-8530
Contact: Mr. Randy MacKenzie, Vice President

American Thermoplastics, Inc.
Dobson Executive Suites
2266 South Dobson Road, Box "5"
Mesa, Arizona 85202
(602) 820-0528
Contact: Mr. Randy Goesselin, President

GENERAL SYSTEM DESCRIPTION:

The CFS Falcon 2000 system is a transportable TPC flame spray unit capable of pallet-mounting. The CFS system uses propane gas and compressed air for combustion. The compressed air source transports thermoplastic powder from the storage hopper to the flamespray gun and provides combustion/cooling air to the gun. Manually operated regulators provide control of gas and air flow rates. An electic solenoid valve in the powder feed line is operated with a switch on the flamespray gun to provide on/off control. CFS recommends the use of Dow "Envelon" ethylene acrylic acid (EAA) copolymer thermoplastic powder with this unit. The CFS system is described below and on the attached schematic.

PHYSICAL DESCRIPTION:

Component Weights:
- Gun: .2 lb.
- Hoses (Air, Powder Transport, Propane; 25 ft.length): 10 lb.
- Powder Feeder System
  (Hopper, Mobile Stand, Powder Eductor, Regulators):68 lb.
- Propane Gas Supply (20 Lb. Capacity Bottle, Full): 40 lb.
- Full Hopper Powder Load: 25 lb.

Total System Weight (Excluding Pallet): 145 lb.

Enclosure Cube Dimensions: 6' X 6' X 6'

COVERAGE*:

Maximum Coverage Rate (10 mil thick @ 5-7 mil/single pass, 50% deposit efficiency): 150 sq ft/hr

Maximum Powder Consumption Rate (@ 10 mil thick, 50% deposit efficiency): 15 lb/hr

Applied Coating Weight @ 10 mil thick: 1 lb. per 20 sq. ft.

NOMINAL UTILITY REQUIREMENTS*:

Fuel:
- Type: Propane
- Rate: 2.5 lb/hr (22 scfh)

Electrical:
- Type: 120 Vac, 60 Hz or 12 Vdc
- Rate: Less than 100 watts

Compressed Air: Information not available

NEW SYSTEM COST: $6,200.

TPC APPLICATION COST*: $8.00-$12.00/sq. ft.

Cost estimate based on Dow Chemical experience assuming powder @ $15/lb, 15 mil coating applied at 10 ft^2/lb, 40ft^2/hr on white metal blast substrate (two-man application team for blasting and coating @ $20./hr each).

MAINTENANCE/REPAIR COST*: Information not available.

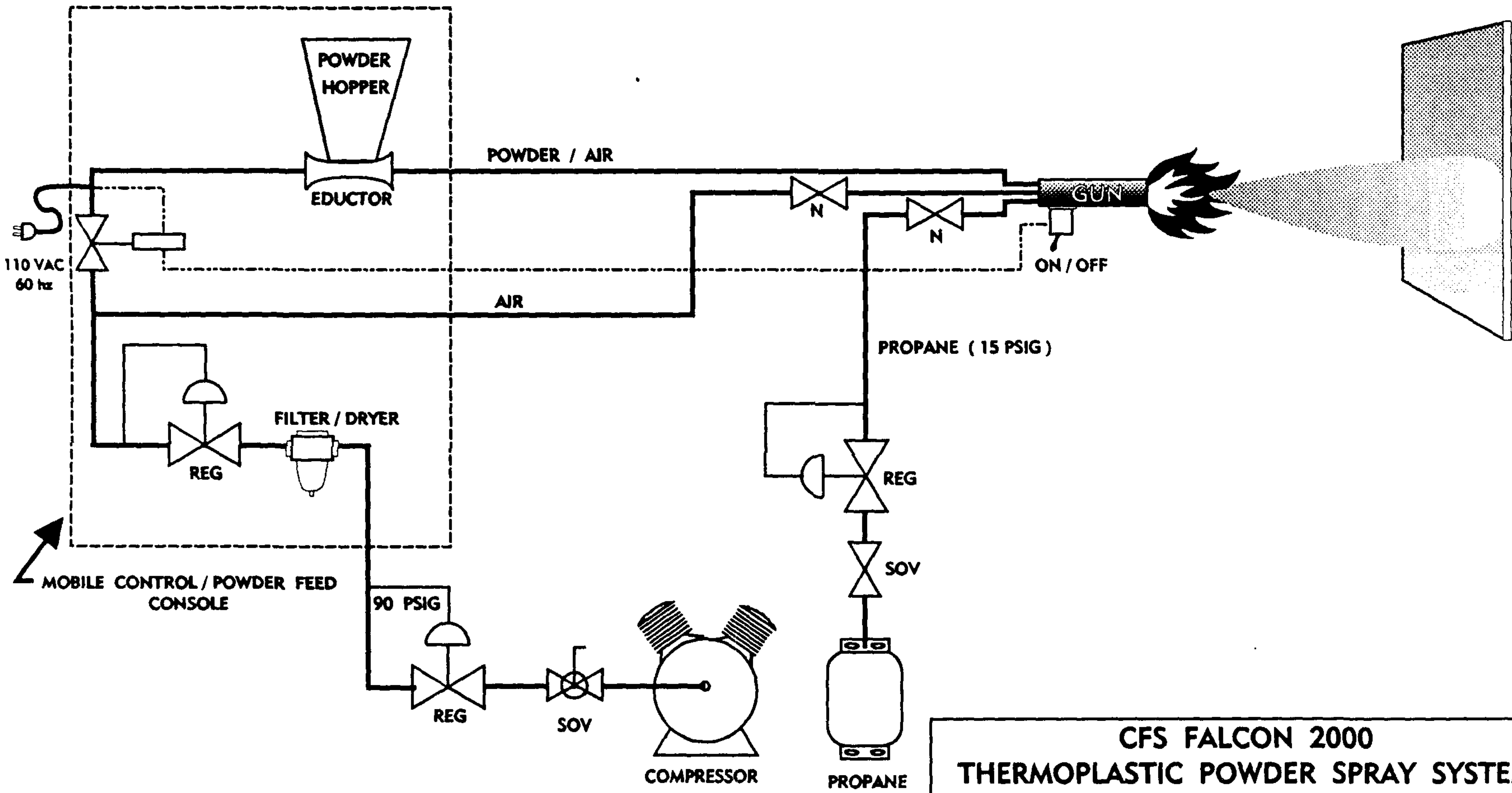
MTBF*: Information not available.

ESTIMATED LIFE CYCLE COST*: Information not available.

SETUP TIME: 10 min.

CLEANUP/BREAKDOWN TIME: 10 min.

* NOTE: Values given are preliminary estimates. Actual values for system performance parameters, application costs and operation/maintenance costs to be determined during system evaluation tests at WR-ALC.



CFS FALCON 2000
THERMOPLASTIC POWDER SPRAY SYSTEM
CANADIAN FLAMECOAT SYSTEMS, INC.
CALGARY, ALBERTA CANADA
AMERICAN THERMOPLASTICS, INC.
MESA, ARIZONA

THERMOPLASTIC POWDER COATING (TPC) VENDOR SUMMARY
(rev. 3/23/92)

VENDOR: Plastic Flamecoat Systems, Inc.
1613 Highway 3
League City, Texas 77573
(713) 332-8180
Contact: Mr. Jeff Loustaunau, V.P. Sales & Marketing

GENERAL SYSTEM DESCRIPTION:

The PFS system is a transportable TPC flame spray system potentially capable of pallet-mounting. The PFS system uses propane gas and compressed air for combustion. The compressed air source transports thermoplastic powder from the storage hopper and supplies combustion and cooling air to the flamespray gun. Gas regulators provide all required control. PFS recommends the use of DuPont "Nucrel" ethylene methacrylic acid (EMAA) copolymer thermoplastic powder with this unit. The PFS system is described below and on the attached schematic.

PHYSICAL DESCRIPTION:

Component Weights:

Gun: 1.5 - 2.0 lb. (Series 200 or Series 400)
Hoses (Air, Pilot, Powder, Propane; 25 ft.length): 6 lb.
Powder Feeder System
(Hopper, Mobile Stand, Powder Eductor, Regulators): 7 lb.
Propane Gas Supply (20 Lb. Capacity Bottle, Full): 40 lb.
Full Hopper Powder Load: 10 lb.

Total System Weight (Excluding Pallet): 65 lb.

Enclosure Cube Dimensions: 6' X 6' X 6'

COVERAGE*:

Maximum Application Rate @ 10 mil thick (5-7 mil/single pass):
350 sq. ft. per hr (Series 200)
500 sq. ft. per hr (Series 400)

Maximum Powder Consumption Rate (@ 10 mil thick, 50% deposit):
35 lb/hr (Series 200)
50 lb/hr (Series 400)

Note: PFS rule of thumb - 1 lb. powder consumed per 10 sq. ft. coated @ 10 mil (50% deposit efficiency)

Applied Coating Weight @ 10 mil thick: 1 lb. per 20 sq. ft.

NOMINAL UTILITY REQUIREMENTS*:

Fuel:
- Type: Propane
- Rate: 2.50 lb/hr (Series 200)
  3.75 lb/hr (Series 400)

Electrical:
- Type: None
- Rate: None

Compressed Air:
- Series 200: 6 scfm (nominal)
- Series 400: 15 scfm (nominal)

NEW SYSTEM COST:

Series 200 System (2" Gun): $5,400.

Series 400 Gun with Hoses: $1,200.

TPC APPLICATION COST*: $8.00-$12.00/sq. ft.

Cost estimate based on Dow Chemical experience assuming powder @ $15/lb, 15 mil coating applied at 10 ft^2/lb, 40ft^2/hr on white metal blast substrate (two-man application team for blasting and coating @ $20./hr each).

MAINTENANCE/REPAIR COST*: Information not available.

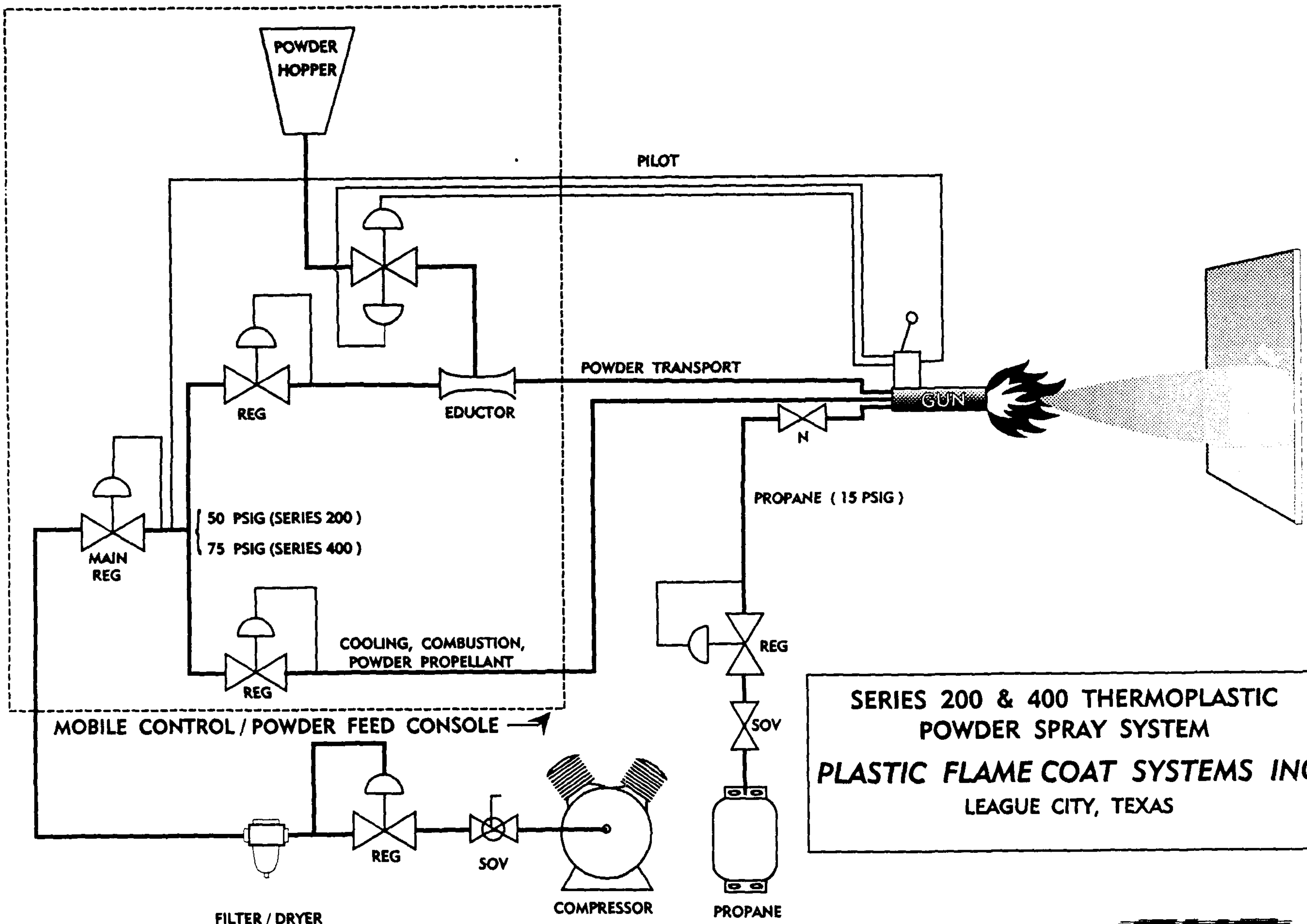
MTBF*: Information not Available.

ESTIMATED LIFE CYCLE COST*: Information not available.

SETUP TIME: 10 min.

CLEANUP/BREAKDOWN TIME: 10 min.

* NOTE: Values given are preliminary estimates. Actual values for system performance parameters, application costs and operation/maintenance costs to be determined during system evaluation tests at WR-ALC.



SERIES 200 & 400 THERMOPLASTIC POWDER SPRAY SYSTEM

PLASTIC FLAME COAT SYSTEMS INC.

LEAGUE CITY, TEXAS

THERMOPLASTIC POWDER COATING (TPC) VENDOR SUMMARY
(Rev. 3/23/92)

VENDOR: UTP Welding Technology
P.O. Box 721678
Houston, Texas 77272-1678
(713) 499-1212
Contact: Mr. Rocco Corvelli, V.P. Marketing

GENERAL SYSTEM DESCRIPTION:

The UTPlast F-311 FX Gun and Flame Spray System is a potentially pallet-mounted mobile electro-pneumatic thermoplastic powder spray application unit. The system uses either an acetylene/oxygen or propane/oxygen flame and a compressed air source to both fluidize the thermoplastic powder and to propel the powder through the flame. The powder fluidizer vessel enables the operator to dip-coat heated components as an option to the normal spraying application. UTP recommends the use of DOW "Envelon" ethylene acrylic acid (EAA) co-polymer thermoplastic powder with this unit. The UTP system is described below and on the attached schematic.

PHYSICAL DESCRIPTION:

Component Weights:

Gun: 2.5 lb.
Hoses (Oxygen, Propane,
Compressed Air; 20 ft. length): 15 lb.
Powder Feeder/Gas Control System
(Mobile Stand with Regulators and Gages,): 100 lb.
Propane Supply Bottle
(20 Lb Capacity Bottle, Full): 40 lb.
Oxygen Supply Bottle (Size 1A, Full): 150 lb.
Powder Fluidizer/Dip Vessel (Empty): 40 lb.
Nominal Powder Load: 30 lb. (approx. 1 hour supply at max. application rate, 50% deposit)
Maximum Powder Load: 75 lb. (volume = 13 gal. = 50 liters)

Total System Weight (excluding pallet): 375 lb.

Enclosure Cube Dimensions: 6' X 8' X 6'

COVERAGE* (@ 10 mil thick):

Maximum Rate (5-7 mil/pass): 300 sq.ft./hr.
Maximum Powder Consumption Rate (@ 50% deposit): 30 lb./hr.
Applied Coating Weight: 1 lb. per 20 sq. ft.

NOMINAL UTILITY REQUIREMENTS*:

Fuel:
- Type: Propane
- Rate: 3.25 scfh (approx. 50 hours/20 lb. Bottle)

Electrical:
- Type: 120 Vac., 60 Hz
- Rate: 500 Watts (estimated)

Compressed Air:
- Flowrates not known

Oxygen:
- 10.0 scfh (approx. 20 hours/1A bottle)

NEW SYSTEM COST*: $12,200.

TPC APPLICATION COST*: $8.00-$12.00/sq. ft.

Cost estimate based on Dow Chemical experience assuming powder @ $15/lb, 15 mil coating applied at 10 ft^2/lb, 40ft^2/hr on white metal blast substrate (two-man application team for blasting and coating @ $20./hr each).

MAINTENANCE/REPAIR COST*: Information not available

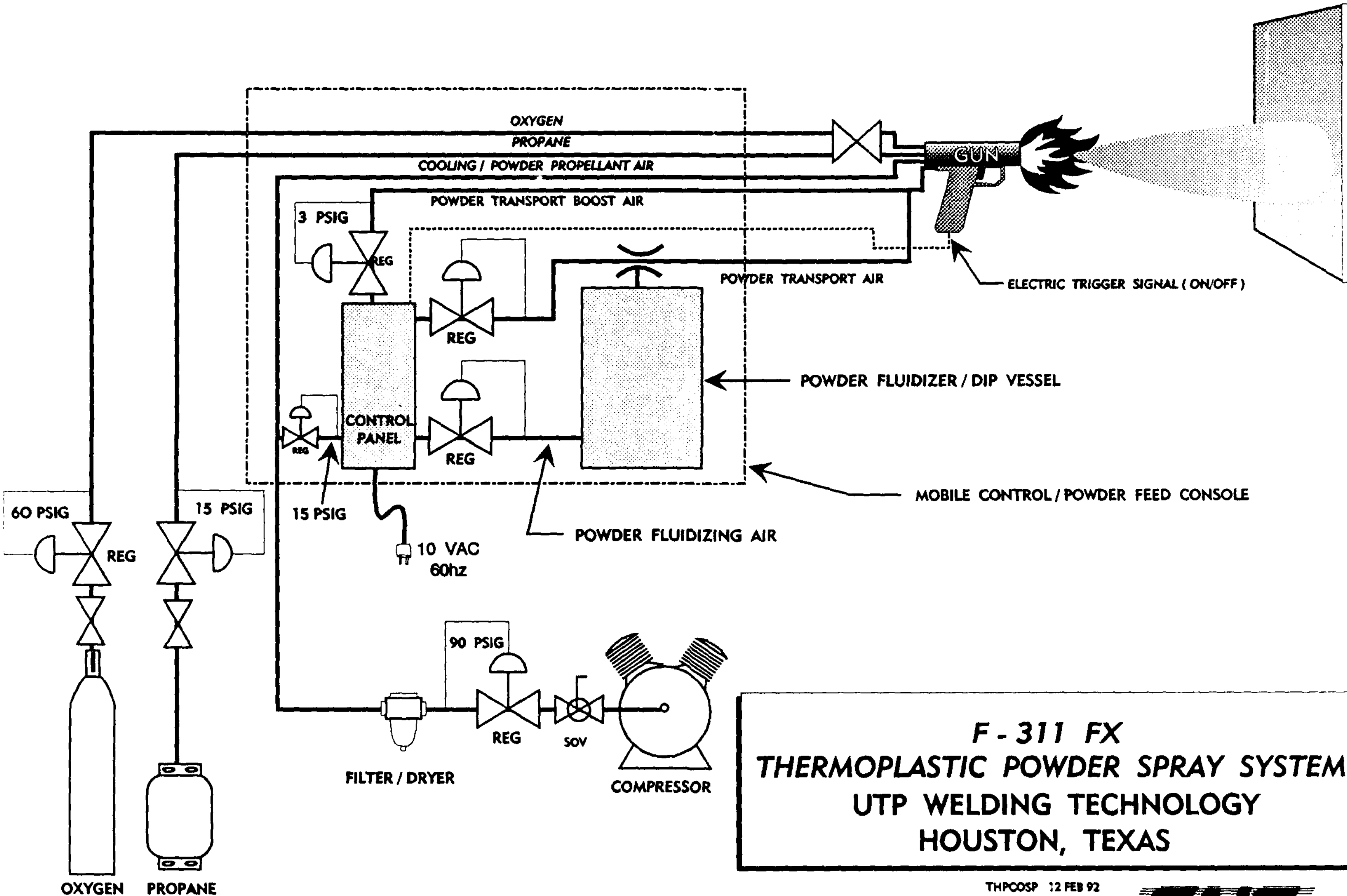
MTBF*: Information Not Available

ESTIMATED LIFE CYCLE COST*: Information Not Available

SETUP TIME: 15 min.

CLEANUP/BREAKDOWN TIME: 15 min.

* NOTE: Values given are preliminary estimates. Actual values for system performance parameters, application costs and operation/maintenance costs to be determined during system evaluation tests at WR-ALC



F - 311 FX
THERMOPLASTIC POWDER SPRAY SYSTEM
UTP WELDING TECHNOLOGY
HOUSTON, TEXAS

THPCOSP 12 FEB 92

SAIC™

THERMOPLASTIC POWDER COATING (TPC) VENDOR SUMMARY
(rev 3/23/92)

VENDOR: METCO (Division of Perkin Elmer)
1101 Prospect Avenue
Westbury, New York 11590
(516) 334-1300
Contact: Ms. Tuck Nerz, Materials Engineer

GENERAL SYSTEM DESCRIPTION:

The Metco 6P-II Thermoplastic Flame Spray System is a potentially pallet-mounted mobile thermoplastic powder spray application unit. The system uses nitrogen gas to fluidize and transport the thermoplastic powder to the gun and compressed air to cool the gun and propel the powder through an oxygen-propane flame. METCO has developed this process and hardware using Dow Chemical ethylene acrylic acid (EAA) "Envelon" co-polymers. The system is described below and on the attached schematic.

PHYSICAL DESCRIPTION:

Component Weights:
- Gun: 3 lb.
- Hoses (Oxygen, Nitrogen, Propane, Compressed Air; 20 ft.length): 10 lb.
- Flow Meters/Powder Feed System: 60 lb.
- Propane Supply Bottle (size FG, 939 cu.ft.): 174 lb.
- Oxygen Supply Bottle (size T, 337 cu.ft.): 172 lb.
- Nitrogen Supply Bottle (size T, 394 cu.ft.): 165 lb.
- Full Powder Load: 5 lb.
- **Total System Weight: 590 lb.**

Enclosure Cube Dimensions: 8' X 8' X 6'

COVERAGE*:

Maximum Application Rate
(@ 10 mil thick, 5-7 mil/pass): 435 sq.ft./hr.

Maximum Powder Consumption Rate
(@ 10 mil thick, 50% deposit efficiency):45 lb/hr

Deposited Coating Weight @ 10 mil thick: 1 lb./20 sq. ft.

NOMINAL UTILITY REQUIREMENTS*:

Fuel:
- Type: propane
- Rate: 40 scfh

Electrical:
- Type: 120 Vac., 60 hz
- Rate: 150 Watts each for 4MP feeder and 6PII contol box

Compressed Air:
- 684 scfh @ 100 psig

Nitrogen:
- Requirements not available

Oxygen:
- 78 scfh @ 18.6 psig

NEW SYSTEM COST:

Information not available

TPC APPLICATION COST*: $8.00-$12.00/sq. ft.

Cost estimate based on Dow Chemical experience assuming powder @ $15/lb, 15 mil coating applied at 10 ft^2/lb, 40ft^2/hr on white metal blast substrate (two-man application team for blasting and coating @ $20./hr each).

MAINTENANCE/REPAIR COST*: Information not available

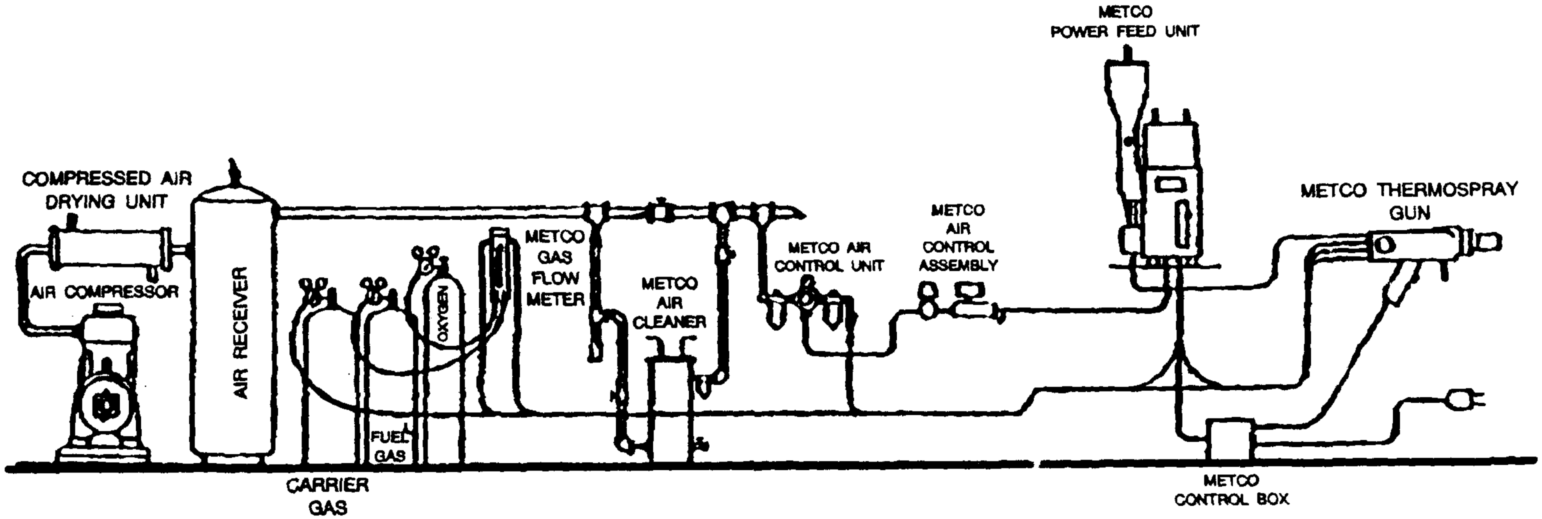
MTBF*: Information not available

ESTIMATED LIFE CYCLE COST*: Information not available

SETUP TIME: 15 min.

CLEANUP/BREAKDOWN TIME: 15 min.

* NOTE: Values given are preliminary estimates. Actual values for system performance parameters, application costs and operation/maintenance costs to be determined during system evaluation tests at WR-ALC



6P- II-H THERMOPLASTIC SPRAY POWDER SYSTEM

METCO PERKIN - ELMER

WESTBURY, NEW YORK

THERMOPLASTIC SPRAYED COATING MATERIAL/PROCESS SUMMARY
(Rev. 3/23/92)

MATERIAL: Dow Chemical Co. "Envelon" Thermal Coating Resin. Ethylene Acrylic Acid (EAA) Copolymer.

MATERIAL FORMAT: Dry Sieved Powder Packaged in Canisters/Bags/Drums

FUNCTIONAL COATING PERFORMANCE PROPERTIES:

Physical Properties - Flexible/Tough
Impact/Abuse Resistance - Excellent
Salt Fog Resistance - Excellent (greater than 10,000 hours)
Water Resistance - Excellent
Abrasion Resistance - Excellent
Weathering Resistance (UV, moisture, heat) - Excellent
Repairability - Very Good (Heat with application gun to flow and re-cover, add TPC material if required)
Adhesion - Excellent (3000 psi on properly prepared substrates)
Chemical Resistance - Resistant to attack by most acids and bases at ambient temperatures. Can be attacked by strong oxidizing acids at elevated temperatures. Variable resistance to immersion in organic solvents and fuels.

POWDER COST (Ready to Spray): $17.00/lb

SHELF LIFE: No Limitation (powder must be dry for proper application)

APPLICATION: Flame Spray or Dip

REQUIRED SURFACE PREHEAT FOR SPRAY APPLICATION:

150-175 deg. F (Typical - substrate preheat temperature may be material and/or thickness dependent)

POLYMER MELT TEMPERATURE:

Approx. 200 deg. F (300-350 deg F required for proper polymer flowout)

APPLIED COATING WEIGHT: 0.005 lb/mil/sq ft
(= 1 lb/20 sq ft @ 10 mil thick)

RECOMMENDED SURFACE PREP:

SSPC-SP 6-85 commercial blast cleaning (1-3 mil anchor pattern, "white metal") Surface should be dry and free of contaminants. No primer required.

APPLICATION THICKNESS: 5-7 mil per pass

REMOVAL (In Order of Preference):

Melt/Scrape (hot)
Hydroblast (high pressure water jet)
CO2 Blast (cold)

SERVICE TEMPERATURE RANGE: -40 to 160 Deg. F

MODIFICATION CAPABILITIES:

UV Stabilization: Yes

Pigmentation: Yes

Paint/Plate(overcoat): Yes

Matte Finish: Yes

ENVIRONMENTAL/BIOENVIRONMENTAL/SAFETY CONSIDERATIONS:

At ambient temperatures, resins are generally as inert toxicologically as any man-made product. Protective gloves and safety glasses are recommended for operators working with hot polymer. A paper dust mask should be worn by the operator while spraying. If polymer is heated to temperatures greater than 600 Deg. F, thermal decomposition may occur yielding fumes and smoke composed of acrylic acid, pyrolysis products (low molecular weight hydrocarbons) and products of incomplete combustion (carbon monoxide, organic acids, aldehydes and alcohols). Thermal decomposition is not a problem for the short flame residence times experienced in normal flame spraying operations. Care should be taken not to overheat deposited polymer (measured with an optical pyrometer). Spraying in an open or well ventilated area is recommended. The thermal spray process for applying 100% solids Envelon resins is VOC compliant. Envelon resins are not hazardous substances under the definitions of the OSHA "Hazardous Communication Standard" (29CFR1910.1200), the Federal Hazardous Substances Act (16CFR1500.3), the hazardous Material Transportation Act (49CFR172.101), the Resource Conservation and Recovery Act (40CFR261), and any state "Right-to-Know" law. FDA has cleared most types of Envelon for use in packaging all types of food. Since the material is inert, preferred disposal of scrap and collected overspray powder is achieved by collecting (sweeping) and depositing in a properly operated landfill. Incineration in a forced draft incinerator is an alternate disposal procedure. This method releases energy and exhaust products of carbon dioxide, metal oxides, water and trace

THERMOPLASTIC SPRAYED COATING MATERIAL/PROCESS SUMMARY
(Rev.3/23/92)

MATERIAL: Dupont Nucrel 535 High Performance Adhesive and Sealant Resin. Ethylene Methacrylic Acid (EMAA) Copolymer.

MATERIAL FORMAT: Dry Sieved Powder Packaged in Canisters, Bags or Drums

FUNCTIONAL COATING PERFORMANCE PROPERTIES:

Physical Properties: Flexible/Tough
Impact/Abuse Resistance: Excellent
Salt Fog Resistance: Excellent (greater than 10,000 hours)
Water resistance: Excellent
Abrasion Resistance: Excellent
Weathering Resistance (UV, moisture, heat): Excellent
Repairability: Very Good (heat with application gun to flow and re-cover, add TPC material if required)
Adhesion: Excellent (3000 psi on properly prepared substrates)
Chemical Resistance:
Resistant to attack by most acids and bases at ambient temperatures. Can be attacked by strong oxidizing acids at elevated Temperatures. Variable resistance to immersion in organic solvents and fuels.

POWDER COST (Ready to Spray): $8.00/lb (approximate)

SHELF LIFE: No Limitation (powder must be dry for proper application)

APPLICATION: Flame Spray or Dip

REQUIRED SURFACE PREHEAT FOR SPRAY APPLICATION:

150-175 deg. F. (typical - substrate preheat temperature may be material and/or thickness dependent)

POLYMER MELT TEMPERATURE:

Approx. 200 deg. F. (300-350 deg. F. required for proper flowout)

APPLIED COATING WEIGHT: 0.005 lb/mil/sq ft
(= 1 lb/20 sq ft @ 10 mil thick)

RECOMMENDED SURFACE PREP: SSPC-SP 6-85 Commercial Blast Cleaning (1-3 mil anchor pattern, "white metal"). Surface should be dry and free of contaminants. No primer required.

APPLICATION THICKNESS: 5-7 mil per pass

REMOVAL (In order of preference):

Melt/Scrape (Hot)
Hydroblast (High pressure water jet)
CO2 Blast (Cold)

SERVICE TEMPERATURE RANGE: -40 to 160 deg. F

MATERIAL MODIFICATION CAPABILITIES:

UV Stabilization: Yes

Pigmentation: Yes

Paint/Plate (overcoat): Yes

Matte Finish: Yes

ENVIRONMENTAL/BIOENVIRONMENTAL/SAFETY CONSIDERATIONS:

At ambient temperatures, resins are generally as inert toxicologically as any man-made product. Protective gloves and safety glasses are recommended for operators working with hot polymer. A paper dust mask should be worn by the operator while spraying. If polymer is heated to temperatures greater than 600 Deg. F, thermal decomposition may occur yielding fumes and smoke composed of methacrylic acid, pyrolysis products (low molecular weight hydrocarbons) and products of incomplete combustion (carbon monoxide, organic acids, aldehydes and alcohols). Thermal decomposition is not a problem for the short flame residence times experienced in normal flame spraying operations. Care should be taken not to overheat deposited polymer (measured with an optical pyrometer). Spraying in an open or well ventilated area is recommended. The thermal spray process for applying 100% solids Nucrel resins is VOC compliant. Nucrel resins are not hazardous substances under the definitions of the OSHA "Hazardous Communication Standard" (29CFR1910.1200),the Federal Hazardous Substances Act (16CFR1500.3), the hazardous Material Transportation Act (49CFR172.101), the Resource Conservation and Recovery Act (40CFR261), and any state "Right-to-Know" law. FDA has cleared most types of Nucrel for use in packaging all types of food. Since the material is inert, preferred disposal of scrap and collected overspray powder is collecting (sweeping) and depositing in a properly operated landfill. Incineration in a forced-draft incinerator is an alternate disposal procedure. This method releases energy and exhaust products of carbon dioxide, metal oxides, water and trace components.

ATTACHMENT 3

Survey Report

SURVEY OF THERMOPLASTIC POWDER COATINGS (TPC)
TASK 1

Prepared For

Science Applications International Corporation
2220 Northwest Parkway, Suite 200
Marietta, Georgia 30067

Contact: Dr. Douglas Neale
Tele: (404) 952-7002
Fax: (404) 952-6920

Prepared By

Dr. Jan W. Gooch
Polymers & Coatings Consultant
85 Chaumont Square NW
Atlanta, Georgia 30327

Tele: (404) 355-1467
Fax: (404) 894-6199

February 17, 1992

Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 General

The general scope of this subject including subsequent tasks assigned to Dr. Gooch is centered around identification of flame sprayed thermoplastic coatings to replace solvent-borne coatings. Conventional coatings used by the U. S. Air Force have been water- and solvent based, and the latter being the most widely used. Solvents produce volatile organic compounds (VOC) which are objectionable because environmental and health reasons.

2.0 STATEMENT OF WORK

<u>Task 1 - Conduct a Literature Search</u>

Conduct a literature search and assemble pertinent documents describing current technology for sprayed thermoplastic powder coatings including techniques, materials and applications hardware.

<u>Task 2 - Write a Summary of Findings</u>

Write a narrative summarizing and evaluating the technology documented in Part A. Include potential benefits, drawbacks and limitations of this technology for the U. S. Air Force in its corrosion prevention/protection programs (particularly for munitions handling equipment, mobile communications/electronics hardware an aerospace ground equipment). Discussion should include the requirements for application of thermoplastics on uncoated and previously coated (thermoplastic or conventional, damaged/undamaged) substrates at depot and field level facilities. Finally, the potential for near-term development of TPC technology hardware and materials should be assessed. Techniques that eliminate application of TPC with open flames are of particular interest.

<u>Task 3 - Assemble a List of Vendors/Suppliers</u>

Assemble a comprehensive listing of current active TPC vendors and material suppliers. Where possible, assess vendor/supplier viability and level of technology.

3.0 RESULTS

3.1 Results of Task 1

Dr. Gooch conducted a literature search of flame spray processes and equipment describing current technology for sprayed thermoplastic powder coatings including techniques, materials and application hardware.

3.2 Results of Task 2

General information on thermoplastic powder coatings

Flame sprayed TPC coatings

The flame-spray coating technique has been developed within the about last twelve years for application for application of thermoplastic powder coatings. Polyethylene, copolymers of ethylene and vinyl acetate, nylon and polyester powder coatings have been successfully applied by flame spraying. This technique permits powder coatings to be applied to practically any substrate, since the coated article does not undergo extensive additional heating to ensure film formation. In this way, substrates such as metal, wood, rubber and masonry can be successfully coated with powders if the coating itself has a proper adhesion to the substrate. The technique itself is relatively simple:

a. Powder coating is fluidized by compressed air and fed into the flame gun.

b. The powder is then injected at high velocity through a flame of propane. The residence time of the powder in the flame and its vicinity is short, but just enough to allow complete melting of the powder particles.

c. The molten particles in the form of high viscosity droplets deposit on the substrate forming high-build film upon solidification.

An example of a flame-spray gun disclosed in a patent of Oxacetylene Equi (S.U. Patent 1423176, 1985) is sketched in Figure 1. The gun has a body (1) with air (7), combustion gas (9) and powder material (5) supply channels. The outlet of the powder channel is axially positioned at the gun mouthpiece (3) with the channels for the combustion gas outlet situated at equal distances on the circumference concentric to the axial powder channel. The efficiency is increased by preventing the powder from burning in the flame since the concentric circumference diameter is 2.85-4.00 times the powder outlet channel diameter. The coating quality is increased when using liquified gas since the combustion gas outlet channel axis is at 6-9° to the powder channel axis, forming a diverging flame. The amounts of air and combustion gas are regulated by valves (8 and 10). The air passes through rough ejectors (11) creating a refraction in the channel (9). The air and liquified gas mix in chambers (12) forming a combustible mixture which flows to the mouthpiece nozzles (4). The powder particles entering the flame are heated and in a molten form are supplied onto the surface being coated.

Since the flame spray process does not involve oven heating it is very suitable for field application on workpieces which are large or permanently fixed and thus not able to fit inside an oven. It has been reported that objects such as bridges, pipelines, storage tanks and railcars are suitable surfaces to be coated by this technique. The nominal coating thicknesses reported are 3-5 mils and 6+ mils for most applications.

Plasma spraying of TPC coatings

The plasma spraying process of TPC coatings utilize argon gas passing through an electric arc between an anode and a cathode. The carrier gas loses one of its electrons and becomes a highly energetic, extremely hot and glowing plasma. As the plasma leaves the internally water cooled plasma generator in the gun, powdered thermoplastic formulations and inert gas are introduced into the stream in a precisely controlled manner. As the material is entrained in the high velocity and hot plasma stream, it becomes molten and is projected against the surface of the substrate at subsonic or supersonic speeds. When individual particles impact against the surface at high speeds, thermal and mechanical energies are transferred to the substrate, producing forces which favor bonding. The minimum reported film thickness is 2 mils.

The basic difference between the plasma and flame spraying technologies is that the former utilizes an electrical arc to heat an inert gas producing a hot and glowing stream of gas, and the latter a combustible gas producing a flame. The hot gas streams are necessary to heat the substrates and the TPC coatings to produce a film. The hot glowing gas from neither process is attractive due to fire hazards.

The equipment for this technology is bulky and the operator requires extensive training. The application of TPC coatings is recommended for depot level only.

Advantages/disadvantages of TPC coatings

A comparison to other generic powder coatings methods is contained in Table 1. Important advantages/disadvantages are discussed below with reference to Table 2.

Advantages:

a. The larger sizes of the substrates are not limited, but small objects are difficult to coat.

b. The key attribute of the plastic flamespray process versus electrostatic powder coatings is that coatings may be applied and repaired in the field.

c. There are no volatile organic compounds, 100% solids.

d. The flame sprayed thermoplastic powder coatings have excellent environmental weathering resistance.

e. Moderately skilled labor is required to operate the equipment.

f. TPC coatings do not have a drying, curing time or pot life, this presents a savings in time and extends shelf life.

g. TPC coatings can be recoated immediately since there is no drying or curing time.

h. TPC coatings can be applied with a single coat and usually require no primer coats.

i. The capital investment is low (about $7000).

j. The color is easy to change or modify since pigments can mixed in the powder feed in small batches; this is not convenient for electrostatic applied coatings since the batches are large and the dielectric properties are critical as noted in Table 1.

<u>Disadvantages:</u>

a. The open flame cannot be used near any volatile substance (e.g., fuel) or equipment containing such substances including aircraft and motorized ground vehicles. Even the electrically induced plasma spray developed by Applied Polymer Systems produces the same fire hazard.

b. Complicated shaped parts are difficult to coat.

c. The melting of a thermoplastic material in an open flame can degrade some polymers and produce hazardous gases. Degraded (burned) polymer particles provide a flaw within the film.

d. The surface temperature of metals substrates must be 150°F or greater to form a smooth film. Lower temperatures will cause a rough surface.

e. The film thicknesses of flame sprayed thermoplastic powder coatings are large (nominal 6 mils+) in comparison to solvent-borne and electrostatic deposited films. The MIL-C-83286B aliphatic urethane specifies a total dry film thickness of 2.6-3.2 mils. TPC coatings are compared to MIL-C-83286B in Table 2. The weight of the film is greater due to thicker film thickness which can be a factor for aircraft and equipment which must be airlifted. The densities (about 0.93 g/cm^3) of TPC and solvent-borne coatings are similar.

f. The glass transition temperature (cold embrittlement) of the thermoplastic coatings on aluminum panels was measured by the author and found to be higher (approx. 0°F) than vendor reported values (approx. -60°F). This could be a serious problem in colder climates since the impact resistance would be minimal.

g. The removal of these coatings cannot be accomplished using the standard paint removal chemicals. Typically, the coating is heated to its softening temperature (nominally 220°F) and scraped off the surface. The author discovered a cryogenic method of removing the material which includes cooling the coating below its glass transition temperature while abrading with plastic pellets. Abrasive cleaning with plastic media below the embrittlement temperature is a potential method of removing these TPC coatings.

h. The hardness of the flame spray thermoplastic coating is low, but the abrasion resistance is good. If a specification required a certain hardness, then the coating would not be suitable or the specification would have to be modified.

Munitions handling equipment

Generally, TPC coatings are not immediately useful for this application due to the high and unpredictable temperatures on metal surfaces. Also, the open flame is menacing. A hot inert gas system is recommended for this application where the temperature can be well controlled. The temperature range for munitions is -65°F to 165°F (reference General Purpose Bombs T. O. 11-A-15-1-1-57). Applied Polymer Systems has a potential solution to the temperature extremes which is deserving of investigation, but the surface temperature is still about 150°F. The reported (David Ellicks of WR-ALC) specification for painting general purpose bombs is MIL-C-83286B, the maximum DFT is 3.2 mils, requires quick drying, and the lowest controllable flame sprayed TPC coatings is 3-5 mils. Applied Polymer Systems, Inc. reported a minimum thickness of 2 mils using a carbon arc plasma sprayed TPC coating.

Mobile communications/electronics hardware

The final report entitled "Evaluation of Coating Systems for Air Force Vehicles and mobile Equipment" (referenced in section 7.0) was reviewed before making the following comments. The author refers the reader to the thorough investigation of surface preparation practices and coating materials discussed in this report. Some of the most widely used coating systems are urethanes (MIL-C-83286B); and alkyds (TT-E-489, TT-E-490, TT-E-527, TT-E-529 and others). Alkyds are particularly heat sensitive, and TPC coatings cannot be applied over either of these coatings since blistering would be expected.

Color formulating for TPC coatings is not reported to difficult, which is important since color schemes are already established. The film thickness requirement will be a problem, but modification to the coatings could conceivably solve this problem. Referring to T.O. 1-1-689 for avioncs and electronics equipment, the dry film thickness (DFT) is 3.2 mils of epoxy/urethane which is lower than typical flame spray thicknesses. The carbon arc plasma sprayed thermoplastic coatings technology from Applied Polymer System, Inc. equipment is reported to be capable of applying films of a minimum thickness of 2 mils. Other flame spray technologies could be used if the films thicknesses in the specification were increased.

Aerospace ground equipment

Unmotorized equipment is a candidate for coating with TPC materials. Referring to T.O. 35-1-3 for flightline tow carts, etc, the maxiumum DFT thickness is 3.2 mils of epoxy/urethane, and most flame sprayed films produce a minimum films thickness of 3-5 mils. If the specification was changed to increase film thicknesses, then flame spray TPC coatings could be used. The Applied Polymer Systems, Inc. technology reported a minimum film thickness of 2 mils.

Referring to T.O. 36-1-3 for trucks and others, the maximum DFT is 3.2 mils of alkyd enamel or epoxy/urethane. For mobile shelters there is not a directive for corrosion protection.

Referring to MIL-P-26915B for zinc dust pigmented primer coatings, and Federal Specificatioin TT-E-529 for semi-gloss alkyd coating, the total film thickness is about 3.2 mils.

In summary, whether alkyd enamels or epoxy/urethane coating systems are utilized on equipment, the coating thickness is never over 3.2 mils unless the equipment is recoated. All other requirements such salt spray resistance would have to be tested.

In addition, the chromaticity requirements (referring to MIL-C-46168D) could feasibly met be using TPC coatings.

Flameless TPC Coating System

At present, there is no commercially available flameless TPC coating systems, a proposal is enclosed to develop a prototype unit.

3.3 Results of Task 3

Vendors/Suppliers of TPC Coatings

Vendors

A list of vendors and suppliers of thermoplastic coatings equipment and materials are contained in Table 3. The total list of vendors/suppliers contacted are contained in Appendix A. The vendors/suppliers published information is supplied under separate cover.

Referring to Table 3, the flamespray equipment vendors are:

Applied Polymer Systems, Inc.
Canadian Flamecoat Co.
Plastic Flamecoat Systems, Inc.
UTP Welding Technology Co.

Actually, the technology from Applied Polymer Systems, Inc. is a electrically generated arc type plasma rather than a combustible gas flame like the others. The most active of the above vendors appears to be Canadian Flamecoat Co. and Plastic Flamecoat, Inc.

Applied Polymer Systems, Inc. has the only plasma spray system that has been reported to the author.

Suppliers

Suppliers of the TPC (ethylene-acrylic acid copolymers) coatings are Dow Chemical Co. and DuPont Polymers Co. These are the leading suppliers of TPC materials, and vendors purchase these materials and customize them for their specific uses. Non-ethylene-acrylic acid copolymer TPC coatings are supplied by Celanese Co., Atochem and others.

Coating and Recoating

Flamespray coating of metal surfaces such as steel requires a cleaned surface (SSPC-SP-10 near-white or SSPC-SP-5 white metal blast). Aluminum with protective chemical conversion coatings (MIL-C-5541) cannot be abrasively cleaned except with plastic media, and coatings on these surfaces are usually removed with chemical strippers. Aluminum without chemical conversion coatings must be cleaned with chemical strippers or abrasively using abrasive media which will not damage the surface since aluminum is softer than steel. The reader is referred to a report entitled "Evaluate and Document Lead Paint Abatement" referenced in section 7.0 for vacuum abrasive cleaning technologies and equipment. Flamespray coating of surfaces coated with conventional solvent- or water-borne coatings is not recommended because the heat may produce blistering. Recoating of previously flamespray coated surfaces is recommended after light abrasive cleaning to remove contamination. Repairs may be performed on damaged TPC coatings if the TPC coatings are identical in composition, excluding colors. Flamespray coating can be conducted in the field or at depot level.

<u>Near-term development of equipment</u>

Flamespray equipment is developed to provide field and depot level coatings, and the equipment usually sells for less than $7000. The electric arc plasma spray of TPC coatings is developed, but the equipment is larger and more expensive and sells for $70,000 with a technology license or a lease arrangement at about $1500/month.

4.0 CONCLUSIONS

The disadvantages of the TPC coatings have been discussed above. It is felt that the tremendous advantages that TPC coatings offer far out weigh the disadvantages. For some ferrous hardware items, TPC coatings are already a viable solution for corrosion prevention.

More information is required on the application rates and costs of the flame and plasma sprayed TPC coatings under controlled conditions. There has been a wide range of reported information for application rates and costs.

5.0 RECOMMENDATIONS

In order to make flame spray thermoplastic powder coatings usable for munitions handling equipment, the substrate temperature would have to be reduced below 150°F. The margin of error would still be too low due to the potential propane flame temperature of 1800°F+ (point temperature). A propane flame contains zones of temperature due to the oxidation process. It is recommended that this application be delayed until a low temperature method is perfected.

The coating thicknesses on mobile communications/electronics hardware and aerospace ground equipment would be difficult to control by the present flame sprayed thermoplastic coatings processes. To use the processes, it would be necessary to revise the specifications or modify the thermoplastic powder coatings. One method of controlling the coating thicknesses is to decrease the powder particle size and maintain a narrow particle distribution.

The inherent open flame of the flame spray thermoplastic coatings processes will not lend itself to areas where volatile materials (e.g., fuel) are present. In addition, equipment which possesses elastomeric seals, undercoatings will be damaged by the flame.

It is strongly recommended that a noncombustible hot-air or inert gas (e.g., nitrogen) be used as the spraying medium to eliminate a flame and reduce point temperature. It is recommended that the melt flow index of the powders be reduced to provide lower viscosity at lower temperature to provide lower application temperatures and thinner coatings. This will require an alteration in the composition of the powder coating materials. The higher melt viscosity index (less viscosity) powders would produce a softer coating, but a post-curing agent could be added to compensate for that property. This could be accomplished by crosslinking less than one percent of the total weight of the coating. Recoating or repairing of the coating would not be significantly impaired.

6.0 PROPOSAL FOR FLAMELESS SPRAYING OF POWDER COATINGS

The author proposes a flameless and safe method of spraying thermoplastic and thermoset powder coatings on metal substrates with causing any fire hazards even in the presence of fuel spills. The basic concept is explained as follows:

a. A electrically (nichrome element) heated steam of inert gas (nitrogen or argon) is generated in an enclosed insulated housing; an electrical generator must be considered for field use.

b. A steam of TPC particles enters a mixing nozzle with the gas stream at about 1500°F inducing a molten state within the particles.

c. The particles strike a substrate (100°F) and flow out to form a film.

d. The properties of the TPC coatings must be altered to provide a higher melt flow index (less viscosity) without altering the properties of the final coating.

A prototype flameless TPC coater will require one year of development.

7.0 REFERENCES

Military Specifications

MIL-P-23377 Solvent-	Primer Coatings: Epoxy, Chemical and Resistant
MIL-C-83286B	Coating Urethane, Aliphatic Isocyanate, for Aerospace Applications
MIL-C-85570B	Cleaning Compound, Aircraft, Exterior
MIL-P-83348A	Powders, Plasma Spray
MIL-P-53022	Primer, Epoxy Coating, Corrosion Inhibiting, Lead and Chromate Free
MIL-P-53030 and	Primer Coating, Epoxy, Water Reducible, Lead Chromate Free
MIL-C-46168	Coating, Aliphatic Polyurethane, Chemical Agent-Resistant
MIL-P-26915	Primer Coating, Zinc Dust Pigmented for Steel Surfaces
MIL-P-35582	Primer Coatings: Epoxy, Volatile Organic Compound (VOC) Compliant, Chemical and Solvent Resistant
MIL-M-38797	Manuals, Technical: Operation Instruction and Maintenance Instruction (For Various Types of Equipment)
MIL-M-38784	Manuals, Technical: General Requirements for Preparation Of
MIL-P-38790	Printing Production of Technical Manuals: General Requirements For
MIL-M-3910	Manuals, Technical: Illustrated Parts Breakdown: Preparation Of
MIL-STD-961C	Military Specification and Associated Documents, Preparation Of
MIL-STD-1388-1A	Logistics Support Analysis

Reports

Development of Environmental Protection Agency Compliant, Corrosion-Inhibiting, Aircraft Coating System, Georgia Tech Research Institute, Atlanta, Georgia, 5 February 1989.

Evaluate and Document Lead Paint Abatement, Government Contract No. DACA88-90-D-0006-0008, Georgia Tech Research Institute, 26 August 1991.

George, E. R., "Thermoplastic Powder Coatings," Proceedings of the Water-Borne & Higher Solids Coating Symposium, New Orleans, Louisiana, 6-8 February, 1991.

Evaluation of Powder Coatings, Contract No. TR515-536, Sheldon Toepke, McDonnell Aircraft Company, St. Louis, Missouri.

Evaluation of Coating Systems for Air Force Vehicles and Mobile Equipment, Contract No.0024-86-D-4306, ARINC Research Corporation, Annapolis, Maryland.

Personal Communications

Tor Aasrum of Jotun Corro-Coat, Larvik, Norway, 9 January 1992.

Ad Hofland of DSM Resins BV, Zwolle, The Netherlands, 6 January 1992.

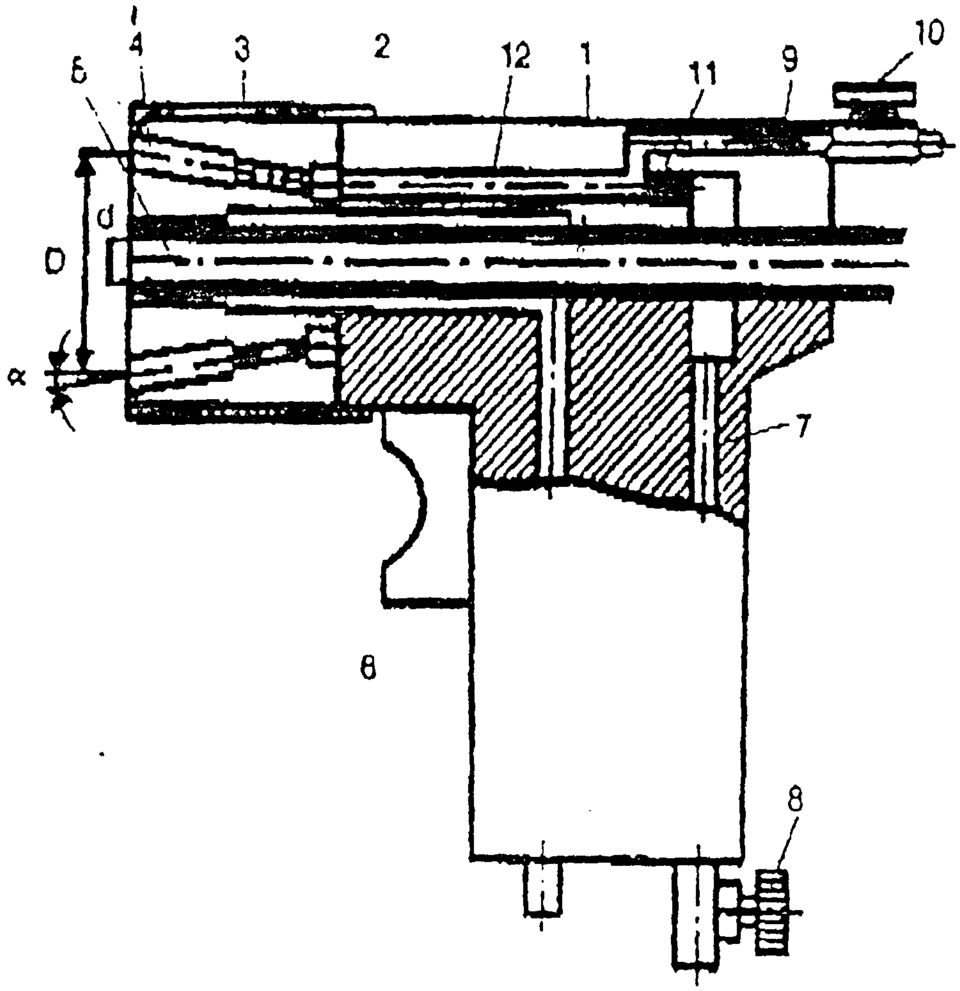


Figure 1. Schematic of Flame Spray Gun for Thermoplatic Powder Coatings.

Table 1. Characteristics of Different Powder Coating Application Techniques

Characteristic of Workpiece	Electrostatic Spray	Fluidized Bed and Electrostatic Fluidized Bed	Flame Spray
Size	Larger	Smaller	Not Limited
Substrate	Metallic, must be conductive	Any, not necessarily conductive	Any, not necessarily conductive
Temperature resistance	Relatively high	High	Moderate
Surface Temperature	50°F+ (oven cured at higher temp.)	160°F+	Nominal 150°F+
Aesthetic value	High	Low, not suitable for decorative purposes	Low, not suitable for decorative purposes
Coating thickness	Thinner films	Thick, high-build films with excellent uniformity	Thick, high-build films, uniformity dependent on operator
Type of coating	Thermoplastics and thermosets	Thermoplastics and thermosets	Thermoplastics only
Color selectivity	Difficult	Relatively difficult	Easy

Table 1. Characteristics of Different Powder Coating Application Techniques (Continued)

Characteristic of Workpiece	Electrostatic Spray	Fluidized Bed and Electrostatic Fluidized Bed	Flame Spray
Capital investments	Moderate to low approx. $50K	Low approx. $30K	Very low approx. $7K
Labor	Low, since it is highly automated	Moderate, depending on the automatization	Relatively high
Energy consumption	Only postheating	Preheating and often postheating	Low, a minimum temperature is necessary
Coating waste	Very little	Very little	Dependent on the workpiece geometry

Table 2. Evaluation of TPC Coatings for MIL-C-83286B Aliphatic Urethane Top Coat

Test[1]	Expected TPC Coating Test Results
Dry Film Thickness	2.6-3.2 mils is the specified DFT, and TPC coatings are difficult to control with that thickness range.
60° Gloss	The gloss varies with specification, but 93% gloss is typical for a gray aircraft coating. TPC coatings are usually about 80%.
Pencil Hardness	The pencil hardness of is nominally 2H and the TPC coating is about B. However, the elasticity in TPC coatings provides good abrasion resistance, and the hardness requirement may not be applicable.
Drying Time	TPC coatings have no drying time, advantage.
Pot Life	TPC coatings have no pot life and are stable, advantage.
Wet Tape Adhesion	TPC coatings have good adhesion in a one coat system, but needs testing.
Impact Flexibility	TPC coatings would have to be tested.
Heat Resistance Impact	TPC coatings would have to be tested.
Accelerated Weathering Impact	TPC coatings would have to be tested.
Lubricating Oil	TPC coatings would have to be tested.
Salt Spray	TPC coatings have good resistance from preliminary testing.

Table 2. Evaluation of TPC Coatings for MIL-C-83286B Aliphatic Urethane Top Coat (Continued)

Test[1]	Expected TPC Coating Test Results
Humidity Resistance	TPC coatings should have good resistance, but require complete testing.
Low Temperature Flexibility	TPC coatings of the ethylene-co-acrylic acid composition have not tested extensively, but -40°F to 160°F service ranges have been reported.
Hydrocarbon Resistance	TPC coatings would have to be tested.
Hydraulic Fluid Resistance	TPC coatings would have to be tested.
Skydrol 500 B Resistance	TPC coatings would have to be tested.
Distilled Water	TPC coatings have good resistance.

1. MIL-C-83286B/MIL-P-23377D system

Table 3. List of TPC Coatings Vendors/Suppliers

Vendor/Supplier	Location	Products	Application Method
Applied Polymer Systems, Inc.	4302 East 10th Ave. Tampa, Florida 33605 Tele: (813) 247-3065 Fax: (813) 247-5923	Thermoplastic Powders	Hyper-Spray Process
Canadian Flamecoat (American Thermoplastics)	#412, 602 11 Ave. SW Calgary, Alberta T2R 1J8 Tele: 403) 269-8530 Fax: (403) 265-8916	Falcon & Eagle System	Flamespray
Dow Chemical	400 West Sam Houston Pkwy. S Houston, Texas 77042-1299	Envelon	Flamespray
DuPont Polymers	Canby Mill Bldg. P. O. Box 80011 Barley Mill Plaza Wilmington, Delaware 19880-0011 Tele: (302) 772-6025	Nucrel	Flamespray
Plastic Flamecoat Systems, Inc.	1613 Highway 3 League City, TX 77573 Tele: (713) 332-8180 Fax: (713) 554-7434	EAA I EAA II EMAA Ionomer EMAA Poly M	Flamespray

Table 3. List of TPC Coatings Vendors/Suppliers (Continued)

Vendor/Supplier	Location	Products	Application Method
UTP Welding Technology	P. O. Box 721678 Houston, TX 77272-1678 Tele: 1-800-527-0791 Fax: (713) 499-4347	Flamespray Guns	Flamespray

APPENDIX A

LIST OF VENDORS/SUPPLIERS CONTACTED

List of Vendors/Suppliers Contacted

Vendor/Supplier	Location	Products	Application Method
Applied Polymer Systems, Inc.	4302 East 10th Ave. Tampa, Florida 33605 Tele: (813) 247-3065 Fax: (813) 247-5923	Thermoplastic Powders	Hyper-Spray Process
Bay State Abrasives	Bay State Abrasives 12 Union St. Westborough, MA 01581-0623 Tele: (617) 366-4431	PG-Series Plasmagun	
Canadian Flamecoat	#412, 602 11 Ave. SW Calgary, Alberta T2R 1J8 Tele: 403) 269-8530 Fax: (403) 265-8916	Falcon & Eagle System	Flamespray
Dow Chemical	400 West Sam Houston Pkwy. S Houston, Texas 77042-1299	Envelon	Flamespray
DSM Resins	Ceintuurbaan 5 8022 AW Zwolle The Netherlands Tele: 38-284911	Powder Coatings	Oven Cured (electrostatic sprayed)

List of Vendors/ Suppliers Contacted (Continued)

Vendor/Supplier	Location	Products	Application Method
DuPont Polymers	Canby Mill Bldg. P. O. Box 80011 Barley Mill Plaza Wilmington, Delaware 19880-0011 Tele: (302) 772-6025	Nucrel	Flamespray
Fourdel Industries	1080 Sandtown Road Marietta, Georgia 30060 Tele: (404) 499-1000	IR Ovens	Oven Cured (electrostatic sprayed)
GEMA Volstatic	P. O. Box 88220 Indianapolis, IN 46208 Tele: (317) 298-5001 Fax: (317) 298-5881	Powder Systems	Electrostatic Spray
General Plasma	12 Thompson Rd East Windsor, CT 06088 Tele: (203) 623-9901 Fax: (203) 623-4657	Services	Thermal Spraying (metallizing)
ISPA	2915 Wilmarco Ave. Baltimore, MD 21223 Tele: (30') 644-450C Fax: (301) 644-1766	Services	Thermal Spraying (metallizing)

List of Vendors/ Suppliers Contacted (Continued)

Vendor/Supplier	Location	Products	Application Method
Jotun Corro-Coat A/S	Hegdal N-3250 Larvik Norway Tele: 034-25-066 Fax: 034-25-713	Powder Coatings	Oven Cured (electrostatic sprayed)
Metco-P.E.	1101 Prospect Ave. Westbury, L.I. New York, N. Y. 11590 Tele:	6P-II Gun	Flamespray (metallizing)
Miller Thermal, Inc.	555 Communication Dr. Appleton, WI Tele: (414) 731-6884 Fax: (414) 734-2160	Powder Systems	Flamespray (metallizing)
Nordson Corporation	555 Jackson St. P. O. Box 151 Amherst, Ohio 44001-0151 Tele: (216) 988-9411 Fax: (216) 985-1417	Powder Systems	Electrostatic Sprayed

List of Vendors/ Suppliers Contacted (Continued)

Vendor/Supplier	Location	Products	Application Method
Plastic Flamecoat Systems, Inc.	1613 Highway 3 League City, TX 77573 Tele: (713) 332-8180 Fax: (713) 554-7434	EAA I EAA II EMAA Ionomer EMAA Poly M	Flamespray
Plasonics	112 Prestige Park Rd. East Hartford, CT 06108 Tele: (203) 528-2164	Services Nylon, stc.	Electrostatic Sprayed
Powder Coatings Institute	*(Memberships)*		
Stahlin Industries	8080 Grand St. Dexter, MI 48130 Tele: (313) 426-8800 Fax: (313) 426-5370	Powder Coatings	Electrostatic Sprayed
Sulzer Plasma Tech	1972 Meijer Dr. Troy, MI 48084-0310 Tele: (313) 288-1200 Fax: (313) 288-4162	Metal Powders	Plasma Spray
Swain Tech Coatings	35 Main Street Scottsville, New York 14546 Tele: (716) 889-2786 Fax: (716) 889-5218	Poly-Moly	Electrostatic Sprayed

List of Vendors/ Suppliers Contacted (Continued)

Vendor/Supplier	Location	Products	Application Method
UTP Welding Technology	P. O. Box 721678 Houston, TX 77272-1678 Tele: 1-800-527-0791 Fax: (713) 499-4347	Flamespray Guns	Flamespray
Vitek	251 Roosevelt Dr. P. O. Box 315 Derby, CT 06418 Tele: (203) 735-1813	Powder Coatings	Electrostatic Spray

ATTACHMENT 4

Site Evaluation Plan

SITE EVALUATION PLAN

FOR THE

ENVIRONMENTALLY COMPLAINT THERMOPLASTIC POWDER COATING

ENGINEERING EVALUATION STUDY

Contract No.: FO9603-90-D-2215

Delivery Order No.: 0003

Data Item No.: DI-S-3601A

Contract Data Requirements List No.: A002

December 20, 1991

Prepared For:

Mr. David Ellicks
WR-ALC/CNC
Warner Robins Air Logistics Center
Robins AFB, GA 31098-5320

Prepared By:

Mr. David Butler
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Approved By:

Mr. J.F. Hecker, SAIC
10260 Campus Point Dr.
Mail Stop 12
San Diego, CA 92121

SITE EVALUATION PLAN

Thermoplastic Powder Coatings (TPC) for Corrosion Prevention/Protection in United States Air Force Applications

1.0 Scope

The overall goal of this program is to determine the state of technology for sprayed thermoplastic powder coatings and to assess the capability of this technology to replace current solvent-borne coating systems for corrosion protection on selected U.S. Air Force hardware (munitions, munitions handling equipment, mobile communications-electronics equipment and aerospace ground equipment). Specifically, TPC is to be reviewed regarding its potential cost and technical effectiveness for depot level and field level repair/maintenance use. The performance of present and near-term advanced TPC application hardware, techniques and coating polymer systems will be documented and measured against Air Force specifications and requirements.

The purpose of the program Site Evaluation task is to determine how well current TPC technology matches Air Force requirements and capabilities. To that end, the Air Force Corrosion Program Office at Warner Robins ALC has selected Hickam AFB Hawaii, Kadena AB Japan, Osan AB Korea, and Andersen AFB Guam to characterize the range of requirements which TPC methods must satisfy. These locations include a representative cross-section of repair/maintenance capabilities, hardware applications, environmental exposure and other special considerations and limitations.

2.0 Evaluation Plan

Before visiting the selected Pacific Air Bases, SAIC personnel will visit and brief Air Force personnel at the Sacramento, San Antonio and Ogden ALCs. The purpose of these visits is to disseminate TPC technology information to these locations and to solicit Air Force assistance in focusing the site evaluations. A similar in-briefing will be held at HQ. PACAF at Hickam AFB Hawaii just prior to visits to the selected bases.

On-site, and initial technical exchange will be conducted among cognizant Air Force personnel and the SAIC site evaluation team. SAIC will present a TPC briefing to objectively outline the technology, existing hardware, available materials and potential benefits and shortcomings for Air Force applications. This presentation will be followed by an open discussion in which general and base-specific applications, requirements, capabilities and problems/limitations issues can be identified. At the conclusion of this interchange, a facilities tour plan will be drafted. Time for personal interviews with Air Force personnel responsible for base corrosion protection activities will be included in the tour plan. A stay of five working days has been scheduled at each base to insure a comprehensive evaluation.! A final briefing by the site evaluation team will be scheduled before leaving each base to discuss findings and conclusions with the personnel responsible for corrosion protection at that base.

During the site tour and interviews, the following activities will be conducted by SAIC to collect information and data relevant to evaluating TPC systems against the existing solvent-borne coating facilities:

2.1 Obtain publications and other descriptive material describing base mission, responsibilities and facilities from base public affairs office.

2.2 Determine base corrosion/abrasion environment (exposure to winds, salt, moisture, chemical, ultraviolet (UV), temperature, abrasion, others). Obtain historical data from base weather office.

2.3 Identify and characterize depot/field level coatings and repair/maintenance facilities.

* Existing coating/removal procedures/materials/equipment
* Coating/removal/substrate preparation capabilities
* Safety and environmental requirements and limitations
* Coating/removal workload (type and volume of hardware coated/stripped; types of coatings applied; first coat, overcoat, touch-up workload split).
  Available utilities (water, gas, electrical, etc.) and associated compatibility requirements
* Coating/removal/repair costs
* Equipment/modifications required to install TPC
* Photograph and video record relevant hardware and procedures

2.6 Evaluate base personnel resources (skill levels, numbers).

2.5 Determine base personnel technical training capabilities to include both the organic FTD

2.6 Document base logistics, support network for corrosion prevention activities(hardware and consumable replacement).

2.7 Evaluate document special problems, attitudes, limitations and intangibles.

At the conclusion of base tours, PACAF HQ will be out-briefed by SAIC to outline findings and preliminary conclusions regarding the potential of TPC to replace current solvent borne coatings and coating systems in the U.S. Air Force corrosion prevention program. A similar interim briefing will be held upon return to Robins AFB to inform and solicit additional direction from the Air Force Corrosion Program Office. Unless otherwise directed, SAIC will then conduct detailed analysis of the data and information collected. This analysis will document current TPC technology and its capacity for satisfying all applicable Air Force technical specifications, standards and requirements for use with mobile communications/electronics equipment, aerospace ground equipment, munitions and munitions handling equipment. Where TPC fails to meet specification, SAIC will identify, evaluate and recommend potential solutions to correct the shortfall. When the analysis is complete, a comprehensive briefing with specific recommendations for implementing TPC technology will be given by SAIC to the Air Force Corrosion Program Office.

ATTACHMENT 5

Test Site Evaluation Report

MONTHLY STATUS REPORT

FOR THE

ENVIRONMENTALLY COMPLIANT THERMOPLASTIC POWDER COATING

ENGINEERING EVALUATION STUDY

Contract No.: FO9603-90-D-2215

Delivery Order No.: 0003

Data Item No.: DI-S-3601A

Contract Data Requirements List No.: A015

Report Period: January 21, 1992 through February 21, 1992

Prepared For:

Mr. David Ellicks
WR-ALC/CNC
Warner Robins Air Logistics Center
Robins AFB, GA 31098-5320

Prepared By:

Mr. David Butler
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Approved By:

Mr. J.F. Hecker, SAIC
10260 Campus Point Dr.
Mail Stop 12
San Diego, CA 92121

1.0 TECHNICAL ACCOMPLISHMENTS

1.1 During this reporting period, the SAIC team members visited the following organizations:

a. San Antonio Air Logistics Center, San Antonio, Texas
b. Canadian Flame Coat Systems, Calgary, Canada
c. Sacramento Air Logistics Center, Sacramento, California
d. HQ. PACAF, Hickam AFB, Hawaii
e. 633 Consolidated Aircraft Maintenance Sq. (CAMS) Andersen AFB, Guam
f. 18 Fighter Wing, Kadena Air Base, Japan
g. 400 Munitions Maintenance Sq. (MMS), Kadena AB, Japan
f. 51 Fighter Wing, Osan AB, Republic of Korea

1.2 The purpose of these visits was to gather information and brief field units on Thermoplastic Powder Coating (TPC) technology. Video and still photographs were taken at all sites to depict the corrosion problems at each location. A copy of these photographs and a video tape has been forwarded to the WR-ALC/CNC office. Government personnel at every site visited were very supportive of this process and were eager to test the TPC systems.

2.0 MEETINGS

2.1 On 15 Jan. 1992 Mr. Doug Bruner of SAIC briefed the following individuals on the TPC program.

Maj. Boomguard	HQ PACAF/ LGW
SMS Fralick	HQ PACAF/ LGWS
SMS King	HQ PACAF/ LGC
MSgt Becker	HQ PACAF/ LGM
MSgt Miller	HQ PACAF/ LGWS

This briefing was well received and many aspects of TPC technology were discussed. Particular concerns were voiced in the area of heat application to munitions, trailer decks, and other items where open flames may cause serious problems. The cost of the system and the powder was discussed and some attendees felt the cost was high. It was explained this is a one cc t system and life cycle costs could make this system more attractive than current systems. All attendees felt a new way to combat the corrosion problem was needed in the Pacific area. Prior to this meeting SAIC team members met with Brig. Gen Eichman the HQ PACAF LG. Members discussed the program with General Eichman and received favorable comments from him. No personnel from the Communications directorate attended this briefing. On 17 Jan. 1992, Mr. Butler of SAIC met with Col. Mike Mulikin, HQ PACAF/ LGW. Col. Mulikin was very supportive of this program and wants to keep abreast of technology developments and the test program SAIC will be conducting in the Pacific area.

2.2 On 21 Jan. 1992, SAIC team members briefed the 633 CAMS. Those in attendance were:

Maj. Jackson	633 CAMS/ CC
Capt. Edwards	633 CAMS/ LGMS
Capt. Rea	633 CAMS/ LGMW
CMSgt Tamiso	633 CAMS/ LGMS
SMSgt Denham	633 CAMS/ LGMW
SMSgt Mahon	633 CAMS/LGMMG
MSgt Lester	633 CAMS/ LGMW
MSgt Peter	633 CAMS/ LGMM
MSgt Salas	633 CAMS/ LGMMG
TSgt Mansey	633 CAMS/ LGMWC
SSgt Santiago	633 CAMS/ QA

Briefing was well received. Subsequent discussion brought out concerns for need to strip original coating and prepare substrate to white metal before application of TPC. Real concern is lack of manpower in all organizations and difficulties posed by any substantial re-conditioning program. Corrosion prevention programs are non-existent (Munitions has been written up for lack of an aggressive program). All current efforts involve spot cleaning and repainting with available primers and paints (zinc chromate and epoxy primers, enamel and polyurethane topcoats). There was a skeptical response to coating powered or hydraulically-outfitted platforms because of the manpower required to disassemble these units before blasting and coating with TPC. The group was still enthusiastic about the coating and discussed various components and platforms (trailers, bomb fins etc.) that might be tried. Almost all substrates involved in the munitions area are carbon steel. Transportation group does most of the reconditioning work on Munitions handling equipment. Guam EPA (which follows California EPA) has clamped down on open-air sand blasting (personnel silicosis hazard and collection of stripped coatings). Waivers for sand blasting have been obtained by Munitions because of its remote location. No permits for open-air sandblasting are being issued - only periodically renewable waivers for special cases. **Vacuum sandblasting units have been approved and it is strongly recommended that this project provide such units to the Test Sites along with the TPC hardware in order to insure that these systems are used** (vacuum sandblast equipment can be provided for $1000. - $2000. per unit). The sandblasting issue could easily cripple efforts to explore TPC applications. It appears that 40 ft. trailers and bomb buildup sheds (see video and still photos) are the most likely initial candidates in the munitions area. Also, some removable components might be candidates for coating. Questions were asked about coating hinges and fastener slots - tests should be conducted to identify problems in this area. Removal difficulty might be a problem, but little NDI is required for munitions handling equipment. It was suggested that a silver bullet might be incorporated in the polymer formulation to be activated when TPC coating removal is desired. This may be a research item for Dr. Gooch. Coating bombs was not well received; however, coating bomb fins is a good possibility (see video and photos of fins). Skill levels required for TPC coating are readily available at most sites on base. Propane gas is available locally, compressed air is available at all base sites (portable or installed). 120 Vac, 60 Hz. electric power is standard at Andersen. Metric and English tools are available. We were cautioned that Guam is remote and near the end of the supply pipeline so that care must be taken to insure sufficient supplies should be shipped well in advance. This will be true of TPC powder if it is introduced into the Air Force inventory. Right now commercial air freight shipping of hardware and supplies is the best way. There are no evident physical or attitude barriers to installing and using TPC equipment at Andersen. Lack of manpower is the only major obstacle to implementing TPC at this test site. SAIC found enthusiastic and motivated individuals at all locations during this visit and it is believed that equipment placed here will be used because of the substantial corrosion problem that exists. Constantly high humidity and temperature coupled with steady trade winds carrying salt mist creates the highly corrosive nature of Guam's environment.

The general briefing/discussion was followed by a guided video/photo review of the Munitions Branch materiel handling equipment, bomb buildup/preparation facilities, bomb renovation facility and bomb storage sites.

Wednesday, January 22:

SAIC team met with SMSgt. Mahan MSgt. Salas and MSgt Currie to review AGE equipment. Video and still photos were taken of portable lighting units, air conditioning units, portable compressed air units, heating, and jacking (hydraulic) units as well as various stands, trailers and miscellaneous support equipment to document existing severe corrosion problems. Corrosion is evident on new as well as recently painted (within 6 - 24 months) equipment. Andersen has received numerous pieces of equipment form Clark Air Base, RP. This equipment is in very poor condition from corrosion and from inundation with volcanic ash.

SAIC team met with Col. Canavan, 633 Air Base Wing LG, to brief the TPC test program and discuss its implementation at Andersen. Col. Canavan was interested, enthusiastic and supportive.

Thursday, January 23:

SAIC briefed MSgt. Petersen of the 633 Transportation Sq. who is responsible for most of the major repairs, overhauls and reconditioning (i.e., stripping/painting) of base vehicles/platforms. He confirmed manpower constraints and sandblasting restrictions. MSgt Petersen was enthusiastic and wants to utilize the TPC hardware assigned to Andersen. He assigned three members of his paint/coatings shop to conduct a tour of the transportation shop and the vehicles and trailers being serviced. This tour was video taped. Still photography was not conducted because many of the units had been previously photographed (40 ft. trailers, truck beds etc.). Transportation uses epoxy polyimide primers with polyurethane topcoats. Occasionally a clear (lacquer or polyurethane) overcoat is also applied. MSgt. Petersen will call Mr. Dave Ellicks at Warner Robins to voice his interest in the TPC project for Transportation's involvement.

Mr. Dave Butler contacted CMSgt Mallory of the Civil Engineering Sq. to arrange a briefing. Chief Mallory was not able to meet with the SAIC team, but he was aware of the TPC technology through discussions with other personnel at Andersen who had been briefed by the SAIC team. Mr. Butler further discussed the current program with Chief Mallory and received support for the use of the assigned equipment to coat various structures and components for which CE is responsible (e.g. igloo doors, structural steel buildings).

The SAIC team visited CMSgt. Lutz of the POL Section. Chief. Lutz was briefed and then conducted a tour of the badly corroded water tanker fleet, the fuel storage tanks and the fuels pipeline. All exhibit extensive corrosion. TPC is a good candidate for the exterior of base storage tanks and pipelines. Storage tanks are drained and purged before welding repairs and/or painting. Pipeline welding/repair is conducted with flowing fuel for cooling so TPC open flame technology poses no special difficulty.

SAIC team visited Maj. General Burr Commander of the 13th Air Force at Andersen. This was primarily a courtesy call by Dave Butler to his former Wing Commander. General Burr was briefed quickly on the current program. He is very aware of Andersen's corrosion problems and encourages this project.

Friday, January 24:

SAIC team reviews Andersen tour and writes preliminary report. Travel to Kadena Air Base, Okinawa, Japan. Note - Support from the Mobile Communications groups has not been forthcoming. Other than a strong showing at McClellan (Sacramento ALC) SAIC has not been able to generate much interest at the MAJCOM or base levels.

Saturday, January 25:

2.2 SAIC team (Butler, Neale) toured Kadena Air Base to become familiar with base layout and to identify specific visit sites (Munitions, AGE, Transportation, Civil Engineering, Communications). Informal contacts made with CMSgt Richard D'Amour (POC) , SMSgt David Osborne and MSgt Michael Lawhorne of the 400th Munitions Maintenance Squadron (MMS).

Monday, January 27:

SAIC team conducted general TPC briefing to the following members of the 400th MMS:

CMsgt Richard D'Amour	LGW
Tony H. Williams	LGWMR
TSgt Robert Killian	LGWF
Maj. J.H. Morgan	LQW
Lt. Col. Gene Hickman	CC
MSgt Charles A. Skinner	LGWM
Capt. Elias A. Zani, III	LGWM
Capt. Stephen G. Makar	LGQ
SSgt Gary Campbell	LGQSE
SSgt Steord B. Coleman	LGQSE
MSgt Clarence E. Brooker	LGWMR
SMSgt Dave Osborne	LGQSE

Briefing was well received. Lt. Col. Hickman asked several general questions and was enthusiastic about receiving TPC equipment and putting it to use in a number of applications. Sandblasting poses no local EPA problems. The 400th MMS operates metal shot blast and several portable vacuum sand blast units at their bomb renovation plant (see video and still photos). The 400th MMS also operates a new waterfall-type paint booth at the Air to Air missile shop. U.S. environmental and safety regulations are more severe than the Japanese counterparts. The 400th MMS sees immediate TPC applications for RAMs(rapid assembly munitions system), containers, conveyors, inert training missiles and munitions, some types of general purpose bomb fins, missile storage racks and stands MHU-110 and 141 trailers as well as for structural steel, metal doors and other exposed building metal. Epoxy, polyurethane, lacquer and enamel coatings are all used in the 400th MMS. Propane and compressed air (installed and portable) is readily available. 110 Vac, 60 Hz power is standard. English fittings predominate (metric not common). Manpower is tight, but available with skill levels more than adequate for TPC equipment operation. It was suggested that lab testing should include TPC coating over "used metal" that still has residual paint and/or rust to evaluate performance. Initial review and observations indicate that Kadena corrosion problem magnitude is somewhat less severe than for Andersen. Winter climate is milder with lower humidity and salt mist levels at Kadena. The general briefing/discussion was followed by a guided video/photo review of the 400th MMS automated bomb renovation facility and bomb storage sites. Technical data for the renovation facility was requested to determine maximum allowable bomb temperatures for the primer and topcoat drying stations. Data will be made available to SAIC team. Several portable vacuum sandblast units were observed under use for cleaning nose and aft fuse wells before bombs were loaded into the automated renovation facility.

Tuesday, January 28:

SAIC team briefed the 18th Maintenance Squadron (MS). The following were in attendance:

SMSgt Michael Rowan	MS (Fabrication)
Sgt Scott Tanos	CS (Communications)
MSgt Floyd "Buck" Brigham	MS (corrosion)
SMSgt Larry G. Ray	MEFG (AGE)

Reception enthusiastic. AGE has 1200 pieces of equipment to maintain (about half is non-powered). Each piece is stripped (sandblasted) every two years. Applying TPC on non powered units would entail no more work than is currently expended to strip, prime and paint (polyurethane) under the current procedures. SMSgt Ray suggested that TPC be evaluated against synthetic oils and hydraulic fluids and JP-4 fuel during lab tests. He also commented that a coating system that would double the normal recoating cycle time would have significant value. Supply concerns were noted. Propane and compressed air are readily available. AGE has its own sandblast and paint facility adjacent to the flight line. Metric and English capability is available. Manpower and skill levels are sufficient to allow substantial TPC evaluation. Sgt Tanos noted several applications for TPC in communication support trailers, antenna masts and support structures and for the base Giant Voice speaker support structures. Exposed metal on support buildings was also noted as a corrosion problem.

An afternoon tour of the AGE maintenance area was completed with MSgt Brigham; however, video and photography in the flight line area was aborted due to lack of authorization. Authorization was not obtained by the POC as required and the video tape was seized by the security police for review. If the tape is not returned by the time of departure, it will be mailed to D. Neale at the SAIC Marietta office.

A tour of several radar sites was completed with Sgt Tanos. Photos were taken of corrosion on a weather satellite communications control trailer and metal radome support building. Communications personnel noted some difficulty in obtaining the use of portable sandblast equipment from base sources. As is the case for Andersen Air Force Base, providing a dedicated sandblast unit with the TPC hardware may be desirable for Kadena.

The SAIC team toured the 400th MMS missile shop with MSgt Lawhorne. Still photos were taken of potential TPC applications including captive missile bodies; service, transportation and storage racks; and munitions trailers.

Air Force Personnel at all locations were realistic about potential limitations of this technology but were excited about receiving TPC equipment for field testing. Each unit identified specific applications within their areas of responsibility for evaluation of TPC performance.

Wednesday, January 29:

SAIC team returned to the 400th MMS bomb renovation facility to obtain further data on the IR drying ovens used to cure primers and topcoats. Additional video was taken to document bomb renovation. A visit to the munitions deactivation furnace facility (rotary kiln incinerator) followed. SAIC team then visited trailer maintenance shop and video taped a MHU-141 trailer being repainted with polyurethane olive drab semi-gloss. This site also housed some AGE equipment and various missile handling support equipment. A RAMS (Rapid Assembly Munitions System) site was visited and recorded. Finally, several outdoor missile component container sites were observed and video taped.

The SAIC team revisited a base satellite communication site to record additional TPC application candidates. Specifically, antenna support posts, cable trays and lightning rod supports were recorded as well as railings and other structural members associated with the communication building. SAIC was unable to record the **Giant Voice** speakers and support structure because of its proximity to the flight line and problems encountered the previous day with filming in a sensitive area.

SAIC obtained general Kadena Air Base information from Public Affairs and summary climate data from the base weather station.

SAIC team retrieved the video tape confiscated the previous day by base security. The tape was reviewed by the base Office of Special Investigation (OSI) and released when no sensitive material was noted.
30 Jan. 1992 team departed Naha, Okinawa for Osan Air Base Korea.

2.3 On 31 Jan. 1992 SAIC team (Butler, Neale) briefed the following form the 51st Maintenance Squadron:

SSgt Adam L. Adair	EMS
SMSgt H. L. Morris (POC)	MEW
CMSgt Thom Danihel	MEW
Capt Ed Robison	MEG
Col Cameron Stewart	MA
Lt. Col Meyer	AMA

Presentation was well received. SSgt Adair represented corrosion prevention interests and was enthusiastic about TPC applications. He asked many questions about the technology and suggested that F-16 and A-10 leading edges (wing and horizontal stabilizers) would be excellent candidates since removal is possible for remote flame spraying. These components are frequently sandblasted, primed and coated at the aircraft paint facility. Osan aircraft suffer severe erosion of leading edge coatings from rain and ice weather conditions. Also suggested were aircraft and ground antennas. Tests should be run on TPC coatings to evaluate electromagnetic performance (attenuation, band pass, etc.). Non-skid floor coatings in maintenance buildings was also discussed. Lt.Col Meyer stated that TPC coatings should be thoroughly tested against all solvents, fuels and fluids to which it would be exposed in the field. He was shown the MIL 83286 fluid immersion lab test requirements (SAIC suggests that some additional fluids may be added to the MIL Standard requirements, but that field exposure may be more realistic and offer a greater range of chemical resistance information). He also questioned TPC resistance to acid rain (current chemical resistance sheets show good resistance to concentrated sulfuric and nitric acids). It was agreed that non-powered AGE and munitions handling equipment would be excellent candidates at Osan. AGE equipment is stripped and painted every two years at Osan (same as at Kadena). Two part epoxy primers and polyurethane topcoats are standard at Osan with lacquer and enamel sprays from aerosol cans are used for field touch-up.

Metric and English tool capability are available at Osan. 110 Vac, 60 Hz electric power is standard. Clear reading on propane availability was not obtained. All Air Force personnel queried were uncertain what propane supply situation exists. This base does experience supply shortages. Compressed air is available installed and at remote locations with mobile low pressure (150 psi) compressor units. Manpower with required TPC coating skills is available in limited numbers in the maintenance sq.. Local EPA standards for sandblasting and painting are not as strict as existing U.S. requirements observed by the Air Force.

The briefing was followed by a still-photo tour of the munitions storage, handling and maintenance facilities.

Monday, February 3:

Most base offices were closed for Lunar New Year celebration. SAIC completed general tour and observation of base facilities.

Tuesday, February 4:

SAIC visited AGE maintenance and briefed Sgt. Hajek on TPC technology. Sgt Hajek confirmed the two year re-painting schedule for AGE equipment. Video filming of AGE equipment indoors and out doors was completed. . Corrosion problems are not as severe at Osan as at Guam or Kadena. SAIC team then visited the maintenance squadron's aircraft and equipment paint facility with SSgt Adam Adair. Several pieces of prepped AGE equipment were recorded (partially sanded, not yet primed or painted). An F-16 and A-10 were also observed being re-painted. Special attention was given to the leading edges and antennas on these aircraft.

SAIC team was unable to arrange a briefing with communications personnel (continued low interest level from Com.). Osan has the similar but less severe civil engineering and transportation equipment corrosion problems than Guam or Kadena. It was noted that salt or some alternate de-icing compound is spread on base roadways during snow and freezing conditions adding to the corrosive environment. The base is not located immediately adjacent to a body of salt water and, at least during the period of observation, salt mist in the air is not evident. High moisture levels exist on the roads from melting snow. Civilian vehicles are generally coated with heavy films of road grit from the melting snow coupled with sand and salt applications. The same conditions exist for military vehicles which dictate frequent washings

Site review was completed by obtaining general base information from the Public Affairs Office and a climate summary from Base Weather (WX).

2.4 SAIC team members traveled to Hickam AFB Hawaii on Feb. 5 1992. On Feb. 6 1992 SAIC team members provided the HQ PACAF/LG. staff on the findings of this trip. Attendees were:

Lt. Col. Schulmeister	HQ PACAF/ LGMA
Maj. Boomguard	HQ PACAF/ LGWA
Maj. Worsham	HQ PACAF/ LGWS
SMSgt Fralick	HQ PACAF/ LGWS
SMSgt King	HQ PACAF/ LGC
MSgt Becker	HQ PACAF/ LGMC
MSgt Miller	HQ PACAF/ LGWS
Mr. George Fujimoto	HQ PACAF/ DEV
Mr. Brian Kang	HQ PACAF/ DEV

All attendees were interested and concerned about the corrosion problems identified in the PACAF theater. A separate briefing was given to Mr. Kang and Mr. Fujimoto in the HQ PACAF/ DE conference room. After viewing the flame spray video and receiving the briefing both gentlemen were very interested in the TPC process. They requested we contact Mr. Thomas Lenicki at the Engineering Services Center at Tyndall AFB Florida. They also requested we look at testing the following;

a. Aluminum Substrates
b. Weathered Galvanized Substrates
c. Dielectric Strength Measurements on TPC Materials (for use on gavanically protected systems)

3.0 PROJECT STATUS

The project is on schedule and within budget.

4.0 WORK PLANNED FOR THE NEXT REPORT PERIOD

Laboratory coating evaluation test plan to be developed and finalized.
Visit to additional TPC equipment vendor (Applied Polymer Systems Inc.).
Initiate sample preparation (TPC and standard USAF coating systems).
Schedule TPC hardware demonstrations at WR-ALC.

ATTACH ... 5

A W S CLIMATIC BRIEF	Station Name:	ANDERSEN AFB GUAM	Field Elev:	612 ft
	Latitude/Longitude:	N13 35 E144 56	Station MSC:	PGUA
September 1988	Hourly Obs POR:	Jan 78 to Dec 87	Call Sign:	912180
(see note)	Summary of Day POR:	May 48 to Dec 87		
	LST - GMT +10		Supersedes:	Jun 1988

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YOR
XTRM MAX TEMP °F	87	89	87	91	94	91	90	91	91	91	90	90	94	40
MEAN MAX TEMP °F	82	82	82	83	84	85	84	84	84	84	84	83	83	40
MEAN TEMP °F	79	79	79	80	81	81	81	80	80	81	81	80	80	40
MEAN MIN TEMP °F	75	75	75	76	77	77	77	76	76	77	77	76	76	40
XTRM MIN TEMP °F	66	69	69	69	66	69	70	70	71	71	69@	68	66	40
D/W TEMP ≥ 90°F	0	0	0	#	#	#	#	#	#	#	#	#	#	40
D/W TEMP ≥ 85°F	2	1	3	7	13	15	14	14	13	14	10	4	110	40
D/W TEMP ≤ 75°F	10	11	9	5	2	2	5	6	7	5	3	4	69	40
D/W TEMP ≤ 70°F	#	#	#	#	#	#	0	0	0	0	#	#	#	40
VAPOR PRESS "Hg	.74	.74	.76	.79	.85	.85	.85	.85	.85	.88	.88	.82	.82	10
MEAN DEWPOINT °F	70	70	71	72	74	74	74	74	74	75	75	73	73	10
99.95% WCPA Ft	850	850	800	800	850	850	900	950	950	1000	900	900	900	10
MEAN RH 07 LST %	79	79	79	79	80	82	84	85	83	84	83	83	82	10
MEAN RH 13 LST %	72	72	72	71	73	75	76	77	76	77	78	77	75	10
MAX 24HR PRECIP "	6.2	10.5	3.3	9.0	22.6	5.0	5.8	7.1	6.1	18.3	~~4.9~~	6.6	22.6	40
MAX PRECIP "	17.3	17.5	14.7	24.0	35.2	17.9	15.9	26.3	26.1	37.1	19.2	16.9	151.8	40
MEAN PRECIP "	5.0	4.7	3.7	4.0	5.8	5.6	9.8	13.0	13.3	13.1	8.8	6.0	92.8	40
MIN PRECIP "	1.1	.7	.3	.4	.8	.5	3.0	4.4	4.0	4.1	2.4	1.2	56.8	40
D/W PRECIP ≥ .01"	19	16	17	17	18	21	23	24	23	24	23	21	246	40
D/W PRECIP ≥ .5"	2	2	2	2	2	3	6	8	8	7	5	3	50	40
MAX 24HR SNFL "	0	0	0	0	0	0	0	0	0	0	0	0	0	40
MAX SNFL "	0	0	0	0	0	0	0	0	0	0	0	0	0	40
MEAN SNFL "	0	0	0	0	0	0	0	0	0	0	0	0	0	40
D/W SNFL ≥ .1"	0	0	0	0	0	0	0	0	0	0	0	0	0	40
D/W SNFL ≥ 1.5"	0	0	0	0	0	0	0	0	0	0	0	0	0	40
MEAN WND DRCTN	E	E	ENE	E	E	E	E	E	E	E	E	E	E	10
MEAN WND SPD Kts	8	9	9	8	7	7	6	6	6	7	8	9	8	10
MAX WND SPD** Kts	55	46	45	80	113	49	46	57	49	67	115@	~~64~~ 65	115@	28
MEAN CLD CVR 10th	7	7	6	6	6	7	8	9	8	8	7	7	7	10
D/W TSTORMS	#	#	#	#	1	1	4	4	5	4	2	#	21	40
D/W FOG VSBY <7mi	5	4	4	3	3	2	3	4	3	3	3	4	41	40

Legend: ANN - Annual. YOR - Years of record POR - Period of record
D/W - Mean number of days with... WCPA - "Worst case" (maximum) pressure altitude
@ - Based on less than full months # - Less than 0.5 day, 0.05 inch, or 0.5%, as applicable.
** - Instantaneous peak winds
* - Data not available $ - Percentage of calm winds ≥ mean direction

REMARKS: Typhoons/tropical storms observed (1954-1986):

	JAN	FEB	MAR	APR	MAY	JUN
Within 60NM	0/1	0/0	0/0	1/0	1/0	1/0
Within 120NM	0/1	0/0	0/1	3/1	1/1	2/7
Within 240NM	0/3	0/0	0/1	6/3	6/1	6/9

	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Within 60NM	0/1	0/3	3/5	1/6	6/3	1/1	14/21
Within 120NM	4/5	0/6	5/11	8/9	10/8	2/3	35/53
Within 240NM	7/14	11/19	15/19	23/24	17/17	6/5	96/115

NOTE: Updated in September 1988 to include new typhoon/tropical storm data.

CB DATED APRIL 1979 OBSOLETE

PREPARED BY: USAFETAC MARCH 1984	STATION NAME: KADENA AB JP LOCATION: N26 21 E127 46	PERIOD: JAN 46-NOV 83 ELEV: 146 FT	STN LTRS: WMO NO: 47931

AWS CLIMATIC BRIEF

MONTH	TEMP MEAN DAILY MAX	TEMP MEAN DAILY MIN	TEMP MEAN MONTHLY	TEMP EXTREME MAX	TEMP EXTREME MIN	PRECIP MONTHLY MEAN	PRECIP MONTHLY MAX	PRECIP MONTHLY MIN	PRECIP MAX 24 HRS	SNOWFALL MONTHLY MEAN	SNOWFALL MONTHLY MAX	SNOWFALL MAX 24 HRS	MEAN REL HUM (%) LST 07	MEAN REL HUM (%) LST 13	MEAN VAPOR PRESSURE (IN HG)	MEAN DEW PT (°F)	PRESSURE ALTITUDE (FT)	SFC WINDS PVLG DRCTN (16 PT)	SFC WINDS MEAN SPEED (KT)	SFC WINDS MAX SPEED (KT)	MEAN SKY COVER (tenths)	PRECIP (IN) ≥ 0.01	PRECIP (IN) ≥ 0.5	SNOWFALL (IN) ≥ 0.1	SNOWFALL (IN) ≥ 1.5	THUNDERSTORMS	FOG VSBY < 7/8 MI	TEMP MAX ≥ 90	TEMP MAX ≥ 85	TEMP ≤ 65
JAN	66	55	61	81	37	4.6	12.9	1.1	4.4	*	*	*	75	64	.38	51	300	N	7	45	7	15	3	0	0	*	2	0	0	30
FEB	66	56	61	83	37	4.6	9.8	1.3	5.1	*	*	*	74	67	.39	52	400	N	8	45	7	14	3	0	0	*	3	0	0	26
MAR	70	59	64	82	42	5.7	19.4	.9	6.5	0	0	0	80	70	.47	57	400	N	7	48	8	13	3	0	0	1	4	0	0	26
APR	75	64	70	87	46	6.6	19.1	.7	4.5	0	0	0	81	71	.58	63	900	E	7	40	8	13	4	0	0	2	5	0	*	13
MAY	83	70	75	91	53	9.9	26.8	.6	6.0	0	0	0	82	72	.69	68	350	E	7	39	8	14	6	0	0	3	4	*	4	5
JUN	86	75	80	93	62	12.0	30.7	.9	9.4	0	0	0	82	74	.82	73	600	SW	7	48	7	15	6	0	0	3	4	2	15	*
JUL	88	77	84	95§	70	8.1	19.5	.5	9.0	0	0	0	82	71	.90	76	700	WSW	7	68	7	12	4	0	0	3	2	8	28	0
AUG	88	78	83	95	69	10.1	27.3	2.2	11.0	0	0	0	82	71	.90	76	650	E	6	96	8	14	5	0	0	3	2	6	27	0
SEP	86	76	81	93	65	8.0	57.6	1.2	42.2	0	0	0	81	69	.82	73	700	ENE	6	74	7	13	3	0	0	2	1	3	22	*
OCT	81	70	76	90	53	6.9	35.0	.7	30.2	*	0	0	77	68	.67	67	600	ENE	7	158	7	12	3	0	0	*	2	*	*	3
NOV	75	65	70	86	52	6.3	16.8	.3	9.2	0	0	0	75	63	.52	60	380	ENE	8	89	7	12	3	0	0	*	2	0	*	15
DEC	66	59	65	81	42	3.1	11.2	.4	4.1	0	0	0	76	63	.42	55	300	N	7	42	7	14	3	0	0	*	2	0	0	26
ANN	77	67	72	95§	37	86.2	57.6	.3	42.2	*	*	*	79	68	.60	65	700	ENE	7	108	7	167	46	0	0	18	36	19	101	147
YRS	35	38	38	38	38	38	38	38	38	34	38	38	10	10	10	10	10	10	10	24	9	38	38	38	38	38	34	38	38	38

REMARKS:

RUSSWO FOR:
HOURLY OBS: DEC 73-NOV 83
SUMMARY OF DAY DATA: JAN 46-NOV 83

NUMBER OBSERVED WITHIN: (1900-1982) (A) Hurricanes (B) Tropical Storms	A/B	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	60NM	0/0	0/0	0/0	2/1	4/3	12/4	24/5	11/3	6/0	1/1	0/0	60/17
	120NM	1/1	0/0	0/1	7/3	8/10	35/11	47/17	34/6	18/5	6/3	0/0	156/59
	240NM	3/2	1/1	3/2	13/9	15/16	61/32	99/40	65/15	29/13	15/6	0/3	303/139

NOTE: * DATA NOT AVAILABLE   # AMTS < UNITS SHOWN IN HEADING   ** INSTANTANEOUS PEAK WINDS $ % CALM GRTR % PVLG DRCTN   § BASED ON < FULL MONTHS

CAV FREQ (%)	HRS LST	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
CEILING LESS THAN 3000 FT AND/OR VISIBILITY LESS THAN 3 MI	00-02	5	10	16	13	18	16	6	10	8	6	7	8	10
	03-05	5	10	17	16	21	17	7	11	8	6	5	6	11
	06-08	7	11	16	17	20	15	7	12	6	6	6	7	11
	09-11	7	12	15	18	18	15	8	12	6	7	7	6	11
	12-14	7	13	18	17	17	16	9	14	9	6	9	5	12
	15-17	8	12	17	14	17	16	9	12	8	7	11	7	12
	18-20	9	11	17	14	17	14	7	10	7	8	11	7	11
	21-23	6	9	16	12	16	13	6	9	8	7	10	6	10
	ALL HRS	7	11	16	15	18	15	7	11	8	7	8	6	11
CEILING LESS THAN 1500 FT AND/OR VISIBILITY LESS THAN 3 MI	00-02	1	2	4	6	21	7	3	2	2	1	3	2	4
	03-05	1	3	4	8	12	10	4	3	2	2	2	2	4
	06-08	2	3	5	11	11	7	4	4	2	2	2	2	5
	09-11	3	3	6	10	12	6	4	4	3	3	3	2	5
	12-14	3	4	7	8	9	5	3	5	4	4	3	2	5
	15-17	2	3	7	5	9	7	4	4	5	3	5	2	5
	18-20	2	4	7	8	10	7	3	2	3	3	4	2	4
	21-23	1	2	6	4	8	6	3	2	3	2	4	1	3
	ALL HRS	2	4	6	7	10	7	4	3	3	3	3	2	4
CEILING LESS THAN 1000 FT AND/OR VISIBILITY LESS THAN 2 MI	00-02	*	2	2	3	4	2	1	1	1	*	1	1	3
	03-05	1	2	2	3	5	4	2	1	1	*	1	*	2
	06-08	1	2	2	5	4	1	3	2	1	*	1	*	2
	09-11	1	2	3	4	5	2	2	2	1	1	1	1	2
	12-14	1	2	2	3	4	3	1	3	2	2	1	1	2
	15-17	2	2	2	3	3	3	2	3	2	2	1	1	2
	18-20	1	2	2	2	3	4	2	1	2	2	1	1	2
	21-23	*	1	1	1	2	3	1	1	1	1	1	*	1
	ALL HRS	1	2	2	3	4	3	2	2	1	1	1	1	2
CEILING LESS THAN 200 FT AND/OR VISIBILITY LESS THAN 1/2 MI	00-02	0	0	*	0	0	0	0	0	*	0	0	0	*
	03-05	0	0	0	*	*	0	*	0	0	0	0	0	*
	06-08	0	0	0	*	*	*	*	0	0	0	0	0	*
	09-11	0	*	*	0	0	0	*	*	*	0	0	0	*
	12-14	0	*	0	*	*	*	*	*	*	*	*	*	*
	15-17	*	0	0	0	0	0	0	*	*	0	0	0	*
	18-20	*	0	0	0	*	*	0	0	*	0	*	0	*
	21-23	0	0	0	0	0	*	*	0	*	*	*	*	*
	ALL HRS	*	*	*	*	*	*	*	*	*	*	*	*	*

CLIMATIC BRIEF | Station Name: OSAN AB KOREA | Elevation: 38 ft
Latitude/Longitude: N37 05 E127 02 | Station MSC: 471220
October 1987 | Hourly Obs POR: Apr 77 to Mar 87 | Call Sign: RKSO
Summary of Day POR: Jan 53 to Mar 87 | Supersedes: Jun 19

19.5

	LST	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
CIG/VSBY LESS THAN 3000/3	00-02	18	16	13	15	13	20	29	21	22	22	25	19	19
	03-05	23	20	23	23	24	43	50	38	38	37	31	26	31
	06-08	30	26	40	37	40	57	61	40	45	50	39	32	41
	09-11	43	31	30	19	19	27	37	17	17	27	32	35	28
	12-14	16	9	11	10	8	11	19	10	6	5	9	12	11
	15-17	8	7	9	9	6	9	13	9	5	4	5	10	8
	18-20	11	8	9	10	6	11	13	10	5	4	7	11	9
	21-23	13	12	10	12	9	13	17	11	8	2	14	14	12
	00-24	20	16	18	17	16	24	30	20	18	20	30	20	20
CIG/VSBY LESS THAN 1500/3	00-02	16	13	11	12	10	16	18	13	19	21	21	17	16
	03-05	21	17	19	20	22	38	39	31	32	35	27	23	27
	06-08	28	25	35	33	37	52	48	34	40	40	35	30	37
	09-11	41	29	25	15	13	19	21	10	14	26	29	33	23
	12-14	14	7	6	6	5	5	9	2	3	4	6	10	6
	15-17	5	9	6	5	4	5	7	4	2	3	3	7	5
	18-20	8	6	6	7	4	7	7	5	2	2	5	9	6
	21-23	11	9	7	8	5	9	10	6	5	6	10	11	8
	00-24	18	14	14	13	13	19	20	13	15	18	17	18	16
CIG/VSBY LESS THAN 1000/2	00-02	10	8	7	8	7	9	11	7	9	14	13	11	10
	03-05	15	12	10	14	13	24	23	19	24	28	19	16	18
	06-08	20	16	23	23	26	36	31	27	33	41	27	21	27
	09-11	29	17	14	9	9	10	11	5	9	18	20	21	14
	12-14	8	4	4	2	2	2	4	1	1	2	3	5	3
	15-17	3	3	3	3	2	2	3	2	1	1	1	4	2
	18-20	4	4	3	4	3	4	3	3	#	1	2	4	3
	21-23	6	6	3	5	4	6	4	3	2	3	6	7	5
	00-24	12	9	8	9	8	12	11	8	10	14	11	11	10
CIG/VSBY LESS THAN 200/¼	00-02	3	2	1	1	[illegible]	#	0	#	1	3	5	3	2
	03-05	4	3	4	2	2	3	2	3	7	12	9	5	5
	06-08	5	5	5	4	4	6	3	5	11	19	12	6	7
	09-11	5	4	2	1	#	#	#	#	1	5	6	2	2
	12-14	1	1	#	0	0	0	0	#	0	0	#	0	#
	15-17	#	#	#	#	0	0	0	#	0	0	#	#	#
	18-20	1	#	#	0	0	0	0	#	0	0	#	1	#
	21-23	1	1	#	0	0	0	0	0	#	#	1	2	#
	00-24	3	2	2	1	1	1	1	1	3	5	4	2	2

CLIMATIC BRIEF	Latitude/Longitude: N37 05 E127 02	Station MSC: 471220
October 1987	Hourly Obs POR: Apr 77 to Mar 87	Call Sign: RKSO
	Summary of Day POR: Jan 53 to Mar 87	Supersedes: Jun 1982

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YOR
XTRM MAX TEMP °F	56	64	71	84	89	96	97	98	91	83	72	55	98	34
MEAN MAX TEMP °F	34	38	49	63	73	79	84	86	78	67	53	39	62	34
MEAN MON TEMP °F	25	30	40	52	63	71	78	79	69	56	43	31	53	34
MEAN MIN TEMP °F	16	20	30	41	52	62	71	71	59	45	34	22	44	34
XTRM MIN TEMP °F	-16	-17	12	24	37	48	55	53	38	25	9	-9	-17	34
D/W TEMP ≥ 90°F	0	0	0	0	0	1	5	7	#	0	0	0	13	34
D/W TEMP ≥ 85°F	0	0	0	0	1	4	15	18	2	0	0	0	40	34
D/W TEMP ≤ 32°F	30	26	21	4	0	0	0	0	0	1	14	28	124	34
D/W TEMP ≤ 10°F	8	4	0	0	0	0	0	0	0	0	#	2	14	34
VPR PRESS ("Hg)	.08	.10	.15	.24	.38	.54	.71	.71	.50	.32	.19	.12	.28	10
MEAN DEWPOINT °F	14	18	28	39	51	61	69	69	59	47	33	22	43	10
99.95% PA Ft	200	300	350	450	500	600	600	650	450	300	300	200	650	10
MEAN RH 07 LST %	72	74	79	80	82	82	84	86	87	85	79	78	81	10
MEAN RH 13 LST %	57	54	51	48	53	59	68	67	61	55	56	59	57	10
24HR MAX PRECIP "	1.1	2.1	2.4	5.8	4.5	5.5	10.2	10.0	11.4	5.6	2.5	2.3	11.4	34
MAX MON PRECIP "	4.2	4.4	6.1	17.5	9.7	14.9	24.0	31.8	16.1	9.5	5.9	4.8	31.8	34
MEAN MON PRECIP "	1.1	1.1	2.1	4.2	3.5	4.8	12.5	9.7	6.0	2.2	1.8	1.1	50.1	34
MIN MON PRECIP "	.1	.1	.1	.3	.4	.2	4.7	1.5	.1	.1	.3	.2	.1	34
D/W PRECIP ≥ .01"	7	5	6	8	7	9	15	12	8	7	9	7	100	34
D/W PRECIP ≥ .5"	#	1	1	3	2	3	6	5	3	1	1	#	26	34
24HR MAX SNFL "	10	6	6	#	0	0	0	0	0	#	4	11	11	34
MAX MON SNFL "	31	10	9	#	0	0	0	0	0	#	5	19	31	34
MEAN MON SNFL "	7	3	1	#	0	0	0	0	0	#	1	3	15	34
D/W SNFL ≥ .1"	5	3	1	#	0	0	0	0	0	0	1	3	13	34
D/W SNFL ≥ 1.5"	2	1	#	0	0	0	0	0	0	0	#	1	4	34
MEAN WND DRCTN	$ENE	$W	$W	$W	$W	$W	$E	$E	$ENE	$ENE	$ENE	$ENE	$ENE	10
MEAN WND SPD Kts	3	4	4	4	4	3	3	3	3	3	3	3	4	10
MAX WND SPD** Kts	35	39	48	43	38	42	47	51	40	45@	42	44	51	24
MEAN CLD CVR 10th	5	5	5	6	6	7	9	8	5	5	6	3	6	5
D/W TSTORMS	0	#	#	1	1	1	4	3	1	1	1	#	13	34
D/W FOG VSBY <7mi	16	14	18	18	17	21	23	21	20	21	18	17	224	34

Legend: D/W = Mean number of days with... YOR = Years of record
@ - Based on less than full months # = Amount less than unit(s) given in heading
** - Instantaneous peak winds $ = Percentage of calm winds ≥ mean direction

REMARKS: Hurricanes/tropical storms observed (1900-1985):

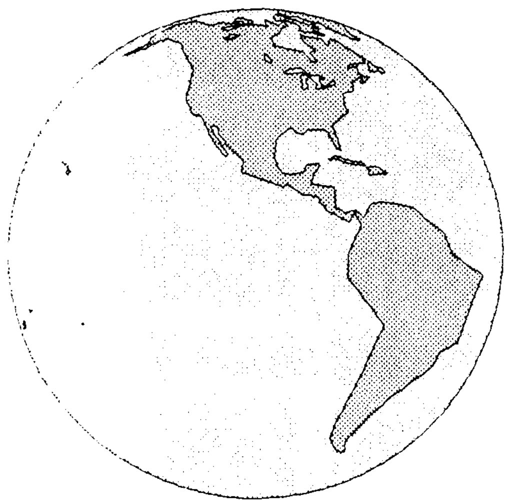
	MAY	JUN	JUL	AUG	SEP	ANNUAL
Within 60NM	0/0	0/1	1/3	1/1	0/0	2/5
Within 120NM	0/0	0/3	1/9	1/7	1/1	3/20
Within 240NM	0/1	0/5	10/19	8/22	7/3	25/50

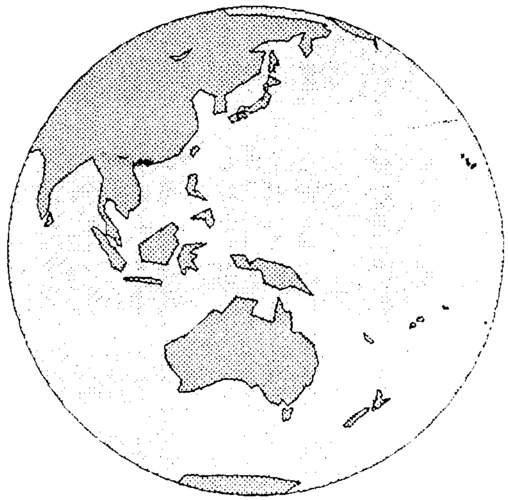
ATTACHMENT 6

Test Site Evaluation Briefing

Thermoplastic Powder Coating Engineering Evaluation Study

TPC FAR EAST TRIP REPORT
JAN-FEB 1992





SAIC

Evaluation Status

Immediate Tasks (March-August 1992)

- Develop Laboratory Test Plan (15 Mar 92)
- Test Specimen Preparation
  - Standard AF coatings (Georgia Tech Labs - 1 May 92)
  - TPC coatings (Vendors at Robins AFB Corrosion Labs - 1 May 92)
- Vendor Hardware Demos/Evaluations at Robins AFB
- Conduct Comparative Laboratory Tests
  - (Applied Testing Services and/or Georgia Tech Labs - 1 May 92)
- Select TPC Systems / Test Sites
- Procure TPC Hardware and Supplies

SAIC

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

US Air Force Bases Visited / Briefed / Evaluated

- Kelly AFB (San Antonio ALC) , Texas *
- McClellan AFB (Sacramento ALC) , California *
- Hickam AFB (HQ PACAF/LG) , Hawaii
- Andersen AFB (633 CAMS) , Guam
- Kadena AB (18th Fighter Wing/400th MMS) , Japan
- Osan AB (51st Fighter Wing) , Korea

* Also participated in 17 Dec 91 Teleconference along with Robins AFB (Warner Robins ALC), and Hill AFB (Ogden ALC).

SAIC

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

San Antonio ALC Visit Summary

- Two Visits (4 Dec 91 and 8 Jan 92)
- Briefing/Disscussion of TPC with corrosion and munitions support equipment personnel
- Communications, Environmental personnel not in attendance
- Interest in Technology was Fair to Good, Passive response

SAIC

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

Sacramento ALC Visit Summary

- Briefing/Discussion/TPC Demo/Debrief/Tour
- Equipment Support, Communications, Safety, Fire, Environment and Corrosion personnel in attendance.
- TPC Demo on COM Van sandwich panels - not successful
- Interest Level High, Response Positive in spite of demo
- Sacramento ALC desires test site status
- Environmental NO_2 Problem from combustion process

SAIC

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

HQ PACAF Visit Summary

- Inbriefing / TPC Technology discussion
- Interest Level, Response, and Support Excellent
- No Communications personnel in attendance
- Open Flame and Initial Cost were concerns
- Serious corrosion problem in the Pacific acknowledged with concensus to develop new technologies.
- Strong support from Brig Gen Eichman (LG) and Col Mulkin (LGW)
- Outbriefing / Discussion - Interest level remains High

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

Andersen AFB Visit Summary

- General Briefing/Discussion/Tours with Documentation
- Munitions, Age, Transportation, CE, and Fuels sites visited
- Personnel sparse, but skill levels sufficient and training available
- Comprehensive Anti-Corrosion Programs do not exist
- Concern for need to Strip Fuel/Hydraulic Systems before coating
- Concern for Open Flames, EPA Sandblasting Restrictions, and Supply Pipeline Restrictions

SAIC

Site Evaluation Briefing

Andersen AFB Visit Summary
(Continued)

- Severe corrosion problem exists
- TPC Canidates Identified
  - Trailers and Truck Beds
  - Non-Powered AGE
  - CE (Structural steel, Doors, Revetment Walls, Storage Tanks, Pipelines)
  - Bomb Fins
- No Showstoppers for installation of TPC hardware at Andersen
- High Interest Levels from Motivated Personnel were demonstrated

Thermoplastic Powder Coating Engineering Evaluation Study

Site Evaluation Briefing

Kadena AB Visit Summary

- General Briefing/Discussion/Tours with Documentation
- Munitions, Maintenance and Communications sites visited/documented
- Interest Level and Response Excellent
- Personnel Availability, Skill Levels and Training similar to Andersen
- Major AGE Maintenance program in place (1200 pieces, 2 year cycle)
- Concern for Open Flames, and Supply Pipeline Restrictions

Site Evaluation Briefing

Kadena AB Visit Summary
(Continued)

- No Local EPA Concerns
- Corrosion severity less than that at Andersen
- TPC Canidates Identified
  - Trailers and Stands
  - Non-Powered AGE
  - RAMS
  - Antenna Masts, Giant Voice
  - Munitions Containers
  - CE
- No Showstoppers; Kadena Personnel enthusiastic to receive TPC Equipment

Site Evaluation Briefing

Osan AB Visit Summary

- General Briefing/Discussion/Tours with Documentation
- Munitions and Maintenance sites visited/documented
- Interest Level and Motivation Fair to Good (1 year tour)
- Personnel Availability, Skill Levels and Training similar to Andersen
- AGE Anti-corrosion program similar to Kadena AB
- Concern for Supply Pipeline, Propane availability unknown

SAIC

Site Evaluation Briefing

Osan AB Visit Summary
(Continued)

- Corrosion severity less than that at Kadena AB
- TPC Candidates Identified
  - Stands
  - Non-Powered AGE
  - Munitions Handling equipment
  - Bomb Fins
  - Munitions Containers
  - F16 and A10 Leading Edges
- No Showstoppers, but may consider substitution of alternate cold weather site

Preliminary Vendor Evaluations

Canadian Flamecoat / American Thermoplastics

- Hardware simple, Mature, May need further Hardening for installation in Air Force inventory
- Suitable for industrial Mobile Field Application
- Low cost (Approx $7.K)
- Vendor Product Support Strong, International Network Under Development In Canada, USA, Europe
- Rank No. 1

Preliminary Vendor Evaluations

Plastic Flamecoat Systems

- Hardware simple, Less Mature than Canadian Flamecoat, will also require further hardening for installation into Air Force inventory.
- Suitable for industrial Mobile Field Application
- Low cost (Approx $7.K)
- Vendor Product Support Good, Less Mature Network than Canadian Flamecoat
- Rank No. 2

Preliminary Vendor Evaluations

UTP Welding Technologies

- Hardware Complex but Mature. current system will require extensive hardening for installation into Air Force inventory.
- Suitable for industrial Mobile Field Application
- Moderate cost (Approx $12K)
- Vendor Product Support Good, International Network
- Rank No. 3

SAIC

Thermoplastic Powder Coating Engineering Evaluation Study

Preliminary Vendor Evaluations

METCO - Perkin-Elmer

- Hardware Complex and Not Mature - Laboratory Models only
- Not Suitable for industrial Mobile Field Application
- Cost - Not determined by METCO
- Vendor Product Support Undetermined
- Rank - Cannot currently be considered as a viable candidate

SAIC.

Thermoplastic Powder Coating Engineering Evaluation Study

Preliminary Vendor Evaluations

Applied Polymer Systems

- Evaluation Pending - Currently scheduled for 2 Mar 92

ATTACHMENT 7

Briefings Summary

TPC BRIEFING SUMMARY

DATE	ORGANIZATION
10-9-91	WR-ALC/CNC
10-24-91	WR-ALC/CNC
12-2-91	UTP Welding Technology, Houston, Texas
12-3-91	Plastic Flamecoat System, Houston, Texas
12-4-91	San Antonio ALC, San Antonio, Texas
12-5-91	Ogden ALC, Hill AFB Utah
12-11-91	Teleconference: Ogden, San Antonio, McClellan, and Warner-Robins ALC's
1-8-92	San Antonio ALC
1-9-92	Canadian Flamecoat Systems, Calgary, Canada
1-13-92	Sacramento ALC
1-15-92	HQ. PACAF/LG, Hickam AFB, Hi.
1-17-92	HQ. PACAF/LGW, LGM, LGC, Hickam AFB, Hi.
1-21-92	633 CAMS/CC, MA Andersen AFB Guam
1-22-92	13 AF/ CC Andersen AFB Guam
1-22-92	633 Air Base Wing/LG Andersen AFB Guam
1-23-92	633 Cams/Trans, Fuels, CE, Andersen AFB Guam
1-27-92	400th MMS, Kadena AFB Japan
1-28-92	18th MS, Kadena AB Japan
1-31-92	51 MS Osan AB, Korea
2-4-92	51 MS (Muniitons,AGE) Osan AB. Korea
2-6-92	HQ. PACAF/LGW,LGM,LGC,DEF Hickam AFB Hi.
2-19-92	WR-ALC/CNC
2-19-92	WR-ALC/VEHICLES
3-2-92	Applied Polymer Systems, Tampa, Fla.
3-3-92	Air Force Civil Engineering Support Agency (AFCESA) Tyndall AFB Fla.
3-4-92	ASD/ENIS Eglin AFB Fla
3-17-92	World-Wide Corrosion Conference Robins AFB Ga.