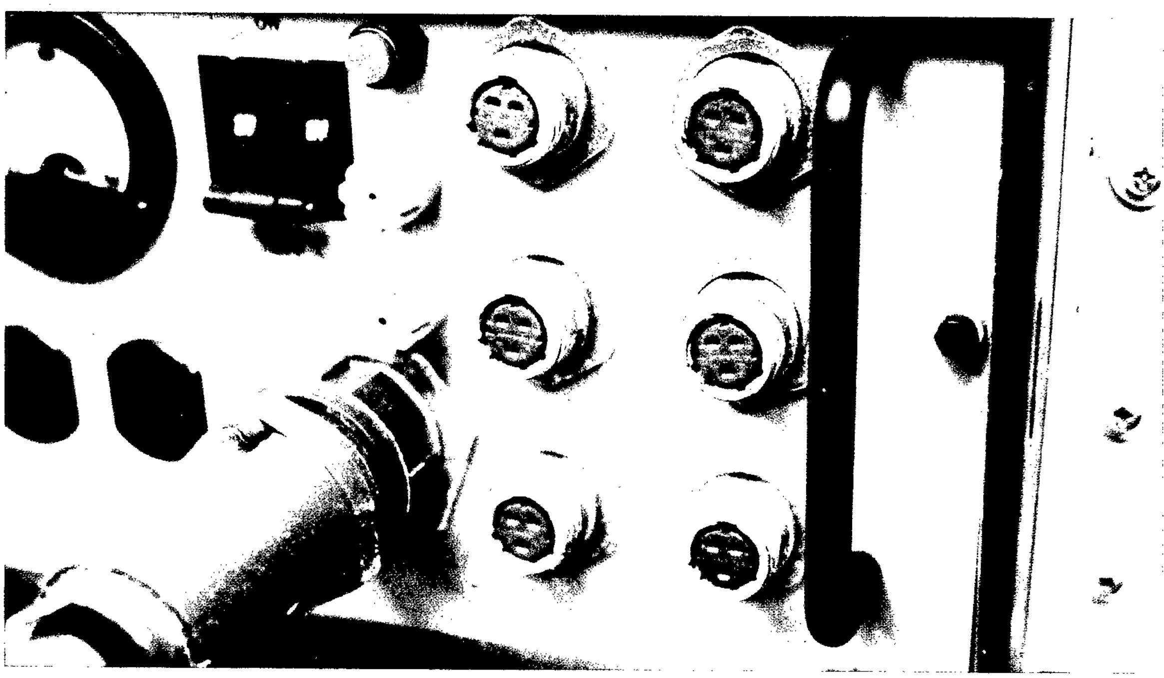
US Army

ManTech Journal

Corrosion Under Attack

Volume 10/Number 4/1985



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Contents

ABOUT THE COVER:

Differing types of corrosion/erosion are shown in the photographs on the cover of this issue. In the inset photo upper left, alligator cracks on the surface of pneumatic rubber tires are caused by ozone-stress cracking attack of the rubber. The inset photo in the center shows corrosion on the floor of an Army vehicle, caused by entrapped moisture and high humidity. The inset photo top right shows water entrapment in a rotor of an Army helicopter, which left unresolved would cause failure of the part and grounding of the aircraft. The lower photograph shows severe surface corrosion of cadmium electroplated steel hardware of communications equipment and of the steel support racks which developed during storage in an inadequately vented shelter. Every instance of these forms of visible deterioration can be prevented by design changes and/or maintenance procedures implemented during the Army's Corrosion Prevention and Control Program which currently is addressing this costly problem.

THE MANTECH JOURNAL is prepared quarterly for the U.S. Army under the sponsorship of the Deputy Chief of Staff for Production, AMC, by the Army's Materials Technology Laboratory, Watertown, Massachusetts, through the Metals and Ceramics Information Center, Battelle's Columbus Division, 505 King Avenue, Columbus, Ohio 43201-2693.

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Comments by the Editor

Raymond L. Farrow

New emphasis on reducing the impact of corrosion on Army materiel has been the highlight of 1985, and this issue of the U.S. Army ManTech Journal has been dedicated to reporting on the new thrusts implemented by the Army in this area. We are pleased that the Army has chosen the ManTech Journal as the instrument by which it is reporting on its new corrosion prevention and control effort. The thrust toward reducing the effect of corrosion on Army materiel can be related to the emphasis placed on producibility, maintainability, and cost control in the design phase during the past several years of the Army manufacturing technology program. By taking these factors into consideration early in the life cycle of the item, they were more effectively incorporated into the production phase. In a like manner, the early consideration in the design phase of the potential effects of corrosion on a particular item can extend the life cycle of that item and improve its maintainability cost.

The Army's corrosion prevention and control program received four-star emphasis when General Richard H. Thompson, Commanding General, U.S. Army Materiel Command, gave the keynote address at the 1985 Tri-Service Conference on Corrosion, which was hosted by the Army in Orlando in early December.

This issue of the Journal contains a series of articles that together present an excellent perspective of the corrosion prevention and control program. General Thompson's Guidance Statement on this program, which was issued in the summer of 1985, is reprinted in full starting on page 3. This document outlines in detail the items of the program that will be addressed, including design, management, maintenance, and training considerations and, also, the establishment of a Center of Excellence at the Materials Technology Laboratory to oversee the program and provide technical focus to the task.

A detailed discussion of the initiatives begun with the program to address Army corrosion and deterioration problems is presented starting on page 5. This article gives a full description of the past accomplishments of the program and outlines the goals that are to be achieved.

The new Center of Excellence on Corrosion Prevention and Control that has been established at the Army's Materials Technology Laboratory is featured in the article beginning on page 15. The timeliness of this initiative is best summed up by General Thompson's reference to our present-day capabilities of attacking corrosion as the best in history, based on current technologies.

For several years, information from the corrosion prevention and control program has been disseminated by the Materials Technology Laboratory through a semiannual publication, the Corrosion Digest (formerly MADPAC Digest). This publication and its accomplishments are discussed in the article beginning on page 20. The Digest plays an extremely important role in technology transfer of corrosion information.

Another product from the Army's current thrust toward solving its corrosion problems is the Corrosion Information and Analysis Task that has been instituted at Battelle's Metals and Ceramics Information Center, which is a DoD-sponsored information analysis center serving all three services. This task is fully described in an article starting on page 22. The task will lead to the establishment of a separate Corrosion Information Analysis Center; in the meantime, by using an already operational structure in the Metals and Ceramics Information Center, much time is saved; in fact, the task was immediately responsive to queries concerning certain corrosion problems.

The major subordinate command that may be faced with the most severe logistics in lessening its corrosion problems—and one that already has done much to reduce the effects of corrosion on its vast deployment of materiel—is the Tank-Automotive Command. The article beginning on page 26 presents a detailed discussion of some of the programs instituted by TACOM and also some of the related side requirements such as safety considerations and medical/sanitation controls.

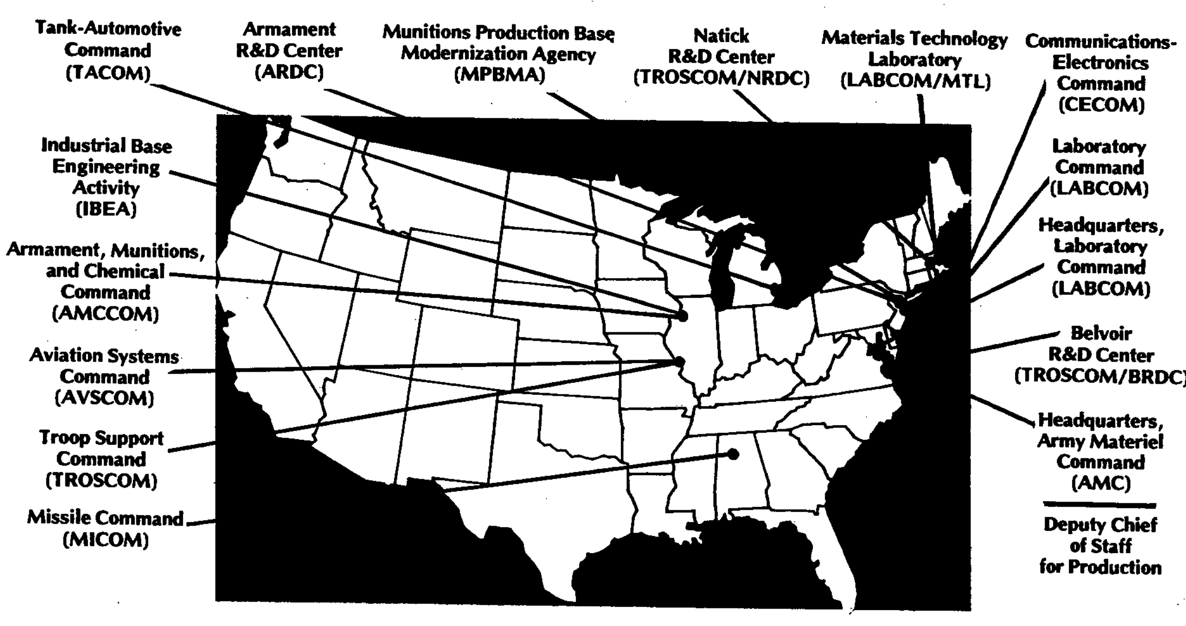
Steps taken by the Polymer Research Division of the U.S. Army Materials Technology Laboratory to determine the cause of deterioration of rubber gas masks are outlined in the special article on page 39. Further research is indicated from initial findings.

The organization that has been instrumental in creating an awareness of and in organizing a structured response to corrosion/deterioration is the National Association of Corrosion Engineers. This specialized group has expanded its activities from the oil industry to the military services and also other industry. An article describing it and its activities is presented on page 43.

The final article in this special issue of the U.S. Army ManTech Journal starts on page 48, which normally is the last page of each publication, and the article runs through page 55. The increased number of pages for this issue was necessary in order to present as complete a perspective as possible of the Army's corrosion/deterioration prevention program. This final article discusses in some detail an unusually effective new technique for removing old paint from delicate surfaces such as helicopter structures and accessory components, both metallic and nonmetallic.

We hope our readers will recognize some of the outstanding developments being achieved by the Army as described in this special issue of the Journal and we also hope that they will find new avenues of approach to old corrosion/deterioration problems through the information contained.

DARCOM Manufacturing Methods and Technology Community



The U.S. Army Materiel Command

Commander's Guidance Statement on Corrosion Prevention and Control

GENERAL RICHARD H. THOMPSON is Commander, U.S. Army Materiel Command. He has served in virtually every capacity as a staff officer in the Office of the Deputy Chief of Staff for Logistics—from Action Officer to Director, to Assistant Deputy Chief of Staff for Logistics, and finally, as the Department of the Army's Deputy Chief of Staff for Logistics. During more than 40 years of distinguished service, General Thompson has had a succession of challenging assignments in both command and staff positions. He commanded the 503d Supply and Transport Battalion of the 3d Armored Division in Germany; the U.S. Army Inventory Control Center in the Republic of Vietnam; the Defense Logistics Service Center and the Defense Property Disposal Service in Battle Creek, Michigan; and the U.S. Army Troop Support and Aviation Materiel Readiness Command in St. Louis, Missouri. His awards and decorations include the Distinguished Service Medal, the Legion of Merit with two Oak Leaf clusters, the Army Commendation Medal with two Oak Leaf clusters, and numerous campaign and service medals including the Brazilian Grand Master of the Order of Military Merit and the Spanish Great Cross of the Order of Military Merit. A native of New York City, General Thompson entered the Army in November, 1944, and advanced to the enlisted grade of Staff Sergeant before being commissioned a Second Lieutenant. His military education includes attendance at the Associate Infantry Company Officer Course, Quartermaster Officer Advanced Course, Air Command and Staff College, Armed Forces Staff College, and the National War College. His civilian education includes a Certificate in Business Administration from the City College of New York, a B.A. Degree in Social Science from the College of the Ozarks, and a M.S. Degree in Public Administration from George Washington University.

Corrosion Prevention and Control (CPC) is one of the fundamental considerations in assuring the sustained performance and readiness of Army systems and equipment. Active consideration both in the materiel development and deployment processes is required. An effective Army corrosion control program will be established in design, management, maintenance, training, and awareness.

Design. The latest state-of-the-art corrosion control technology must be incorporated into original equipment designs. The objective is to achieve a corrosion-free design by utilizing design practices that address selection of materials, coatings and surface treatments, system geometry, material limitations, environmental extremes, storage and ready conditions, packaging and preservation requirements, and rebuild and spare parts requirements. Design concepts will reflect realistic environments and resource availability.

Management. Major Subordinate Commands (MSCs)/Program Managers (PMs)/Commanders of the Arsenals, depots, and plant activities must manage the planning, programming, and budgeting for CPC and establish a structured program for periodic evaluation of corrosion prevention actions during development and acquisition of hardware. CPC must be incorporated into the Statement of Work (SOW) in development and acquisition contracts and tracked throughout the life cycle of the system. Contractor capability to carry out the contract requirements must be addressed in the source selection process. There must be strict compliance to all corrosion control requirements in contracts, in-house designs, manufacturing, and overhead operations. CPC design practices must be addressed at design and program reviews. Field reporting procedures will be established and utilization of feedback data planned to ensure a "closed loop" system among the user, the acquisition manager, and the contractor.

Maintenance. The corrosion control program must continue into field deployment. For each system, equipment maintenance manuals will contain corrosion inspection requirements and techniques for preventing and correcting corrosion. The manuals also will contain appropriate inspection, accept/reject criteria, and optimum repair levels.

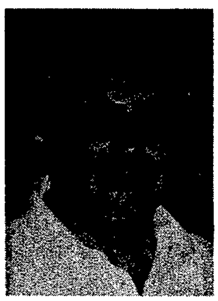
Training. Training of the designer, operator, and maintenance personnel is an essential ingredient in controlling corrosion. Therefore, the MSCs/PMs must make sure that corrosion training programs are established to provide personnel with knowledge of the causes of corrosion, the ability to detect/recognize corrosion, and the expertise to select preventive measures.

Center of Excellence. The Office of Technology Planning and Management and the Laboratory Command will make sure that emphasis is given to corrosion prevention and control research, developmemt, testing, and evaluation in assigned funding programs. A Center of Excellence for CPC technology will be established at the Materials Technology Laboratory (MTL—formerly AMMRC) to provide technical expertise, coordinate development of model CPC programs with the Major Subordinate Commands, promote CPC awareness and training efforts, and follow the budget closely to ensure fair treatment of CPC projects.

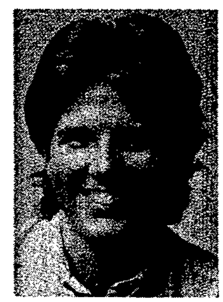
RICHARD H. THOMPSON
General, USA
Commanding

The CPC Mission

U.S. Army Corrosion/Deterioration Problems



MILTON LEVY is Chief, Corrosion Science Branch, at the U.S. Army Materials Technology Laboratory, where he also serves as Program Manager of the new Army Corrosion Prevention and Control Center of Excellence. He has been involved with corrosion science research at MTL (formerly AMMRC) since joining them in 1958. Prior to that he worked on R&D projects with the Ballistics Research Laboratory at Aberdeen Proving Grounds and also with the Coatings and Chemical Laboratory there. A member of the Metals Subcommittee of the Manufacturing Technology Advisory Group, he also is active in the American Chemical Society, The Electrochemical Society, and the National Association of Corrosion Engineers. Mr. Levy is author or coauthor of more than 40 technical papers on corrosion and has received numerous awards for his service to the Army, including the Research and Development Achievement Award. He received his B.S. and M.S. degrees in Physical Chemistry from Boston University.



PATRICIA A. M. FARRELL is a Chemist in the Surface Behavior (Corrosion Science) Branch at the U.S. Army Materials Technology Laboratory, where she acts as alternate Point of Contact for the new Army Corrosion Prevention and Control Center of Excellence. She has assisted in the establishment of the Corrosion Prevention and Control Program there since joining the Laboratory in 1982. Ms. Farrell is a member of the T9 Committee on Corrosion of Military Equipment of the National Association of Corrosion Engineers and has participated in the American Chemical Society. She has been active in high temperature oxidation of metals research at MTL and has coatuhored papers on her specialty of expertise during this time. She received her B.A. in Chemistry from Wheaton (Mass.) College and has conducted graduate studies in high temperature oxidation of metals at the Massachusetts Institute of Technology.

Editor's Note: The above authors also are responsible for the following two articles in this issue on the CPC Center of Excellence and the Corrosion Digest. They also were instrumental in gathering all of the information for the other articles in this issue as major Points of Contact for the Army CPC Program.

Consider what an average U.S. taxpayer could do with an additional $1,000 each year. That is a rough estimation of how much some 70 million such Americans lose through rust of their cars, appliances, plumbing, wiring, and other items.

As mentioned elsewhere in this issue, the upward spiralling cost of corrosion is increasing in importance during the present inflationary decade. In 1975, the National Bureau of Standards reported that the annual cost of corrosion to the U.S. approximated $70 billion, with $8 billion attributed to the Federal sector. Comparative costs to the Army have been estimated to exceed $2 billion per year. Some of these costs are avoidable and can be dramatically reduced through the judicious application of currently existing corrosion control technology. The U.S. Army Materiel Command (AMC) in 1979 promulgated a Materiel Deterioration Prevention and Control (MADPAC) Regulation (DARCOM-R-702-24) which prescribes policy, procedures, and responsibilities for the establishment and implementation of a program aimed specifically at the reduction of deterioration of Army materiel. The Program recently has been renamed from MADPAC to CPC—Corrosion Prevention and Control. This regulation applies to Headquarters, AMC, AMC Major Subordinate Commands (MSC's), program/project or product managers (PM's), depots and separate installations, and activities reporting directly to HQ, AMC. Responsibility for the program resides with the Director of Product Assurance, HQ, AMC. Coordination, program analysis activities, and other assigned management assistance are performed by the U.S. Army Materials Technology Laboratory (MTL).

Program implementation procedures require each MSC to establish a Deterioration Prevention Action Office (DPAO) responsible for administering the local CPC Program. Since each organization is expected to fund its own program, austere budgets may tend to limit the size and effort of the DPAO. However, it should be recognized that corrosion and deterioration of Army materiel represents a serious problem which impacts both the cost-effectiveness and combat readiness posture of the Army. As a minimum requirement, an action officer (AO or POC) should be designated for each DPAO. Similarly, each PM and depot is required to appoint a POC for liaison with the appropriate DPAO and AMMRC.

The efficacy of the CPC Program will be determined by field visits during command-wide CPC surveys and by review of the CPC semiannual summary reports. Each MSC DPAO is required by regulation to seek input from program managers, tenant activities, and other command elements pertaining to deterioration problems anticipated or encountered and corrective action required. Each reporting activity must prepare a CPC semiannual summary report for submission to MTL. Program managers and other operational elements not providing input to a subordinate command DPAO are also required to prepare a CPC semiannual summary report.

In May, 1981, MTL requested the first semiannual summary report submission for the period from January 1, 1981 to June 30, 1981. Format, frequency, and content of the summary report were detailed in the instructions provided. The functionality of these reports was also stressed (i.e., description of the materiel deterioration, solutions, lessons learned, and readiness and economic impact data). Follow-on requests for the periods from July 1, 1981 to December 31, 1981 and from January 1,

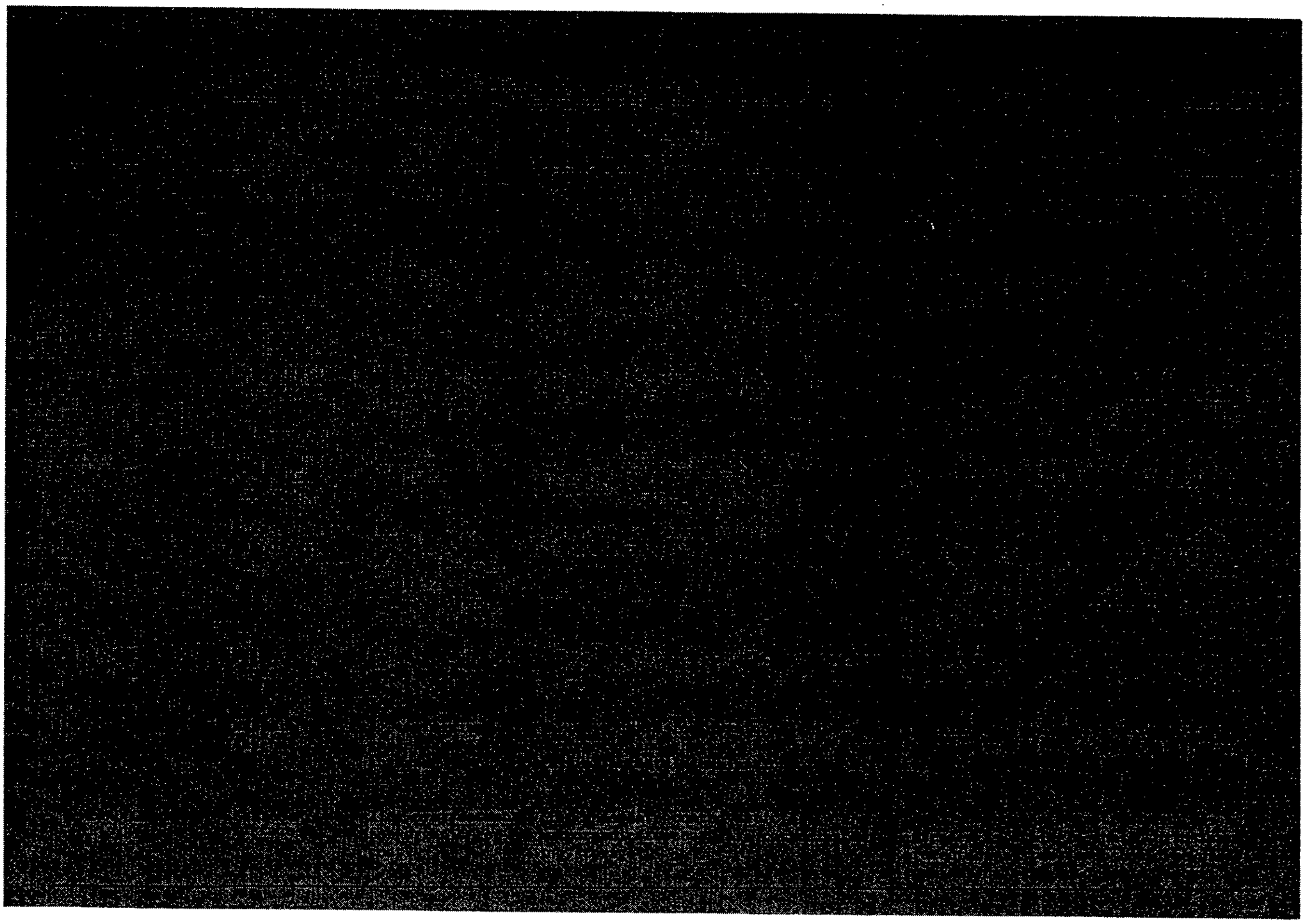


Table 1, cont.

(Cont) SUMMARY OF REPORTED MADPAC DETERIORATION PROBLEMS FOR PERIOD 1 JANUARY 1981 [illegible]

REPORTING STATION DATE	EQUIPMENT ITEM	MATERIAL/ COATING	PROBLEM	SOLUTION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 1, cont.

[illegible]

1982 to June 30, 1982 also were made. Some additional support and cooperation also will be required for the program to meet its objectives. A compendium (or collection) of all the reported problems was published in a review entitled "A Review of Army Deterioration Problems Reported Under the DARCOM MADPAC Program" for DoD distribution only.

To facilitate the review of the semiannual reports, a table similar in format to Table 1, summarizing the reported deterioration problems, was also developed. Table 1 represents a few pages of a more extensive review of the problems submitted to MTL from January, 1981 to June, 1982. The data were analyzed with respect to causes of corrosion, their solution, and cost savings when available. Further, several corrosion problems were selected from the table for detailed presentation, including photographs and economic and readiness impact data. Moreover, in several cases, MTL offered to carry out metallurgical analyses of corroded components to determine the cause of corrosion (see asterisks above).

SUMMARY OF DETERIORATION PROBLEMS

Table 1 provides a concise summary of some of the problems reported under the CPC Program, identifying the reporting station, the POC, the equipment item, material/coating involved, the problem, and solution if known. A concerted effort was made to identify the specific alloy and coating of concern. A cursory review of Table 1 shows that the reported corrosion problems are attributable to poor design, improper selection of materials/coatings, or inadequate/improper maintenance procedures; i.e., the procedures were either not carried out or improper products or treatments were substituted for those specified.

Design Configurations/Material Selection

Approximately one-half of the reported equipment deterioration problems can be attributed to either poor design or improper selection of materials.

The U.S. Army Aviation Systems Command, for example, reported several instances of "lake formation" in the tail rotor outboard retention plate and tail rotor blade assembly due to the lack of adequate drainage. Potential solutions include the addition of drain holes, where possible, or redesign of the parts. In another case, Tobyhanna AD reviewed the corrosion of steel brackets employed in air conditioning units due to dripping moisture condensation. The problem was resolved by nickel plating the steel brackets. Further, Fort Belvoir Research and Development Center cited engine fuel tank failures due to the separation of poorly soldered joints by fretting corrosion. The recommended solution was the substitution of mechanical locked joints for the lap joints presently used in conjunction with thicker terneplate.

Another problem describes galvanic corrosion due to the mating of a silver-containing gasket to an aluminum antenna lead of a missile antenna. The problem was solved by painting the mating portions of the antenna with silver paint. A number of MSC's reported problems with cadmium-plated steel parts. There appears to be a need to reexamine the effectiveness of cadmium plate as a function of thickness and environmental exposure. MTL has offered to carry out a metallurgical examination of failed cadmium-plated parts for AVSCOM.

An example of a failure of high-strength steel by stress corrosion cracking was cited by AVSCOM. Failures of some steel wing bolts occurred at mating surfaces of attachment fittings on the wings of certain fixed wing aircraft. As a consequence of this fact, new inspection procedures were implemented in conjunction with new bolt replacement at inspection time and the coating of these H11 bolts with an oil-based lubricant. Ultimately, a change of bolt material from H11 steel to Inconel 721 would be beneficial.

Numerous problems involving seal materials or sealants were presented by MICOM, TACOM, and TSARCOM. Solutions were achieved by simply changing the type of sealing or caulking material.

Maintenance Procedures

The remaining 50% of the reported problems involved maintenance procedures; either the procedures weren't carried out or unauthorized products or treatments were substituted. For example, Belvoir Research and Development Center reported that the zinc phosphate pretreatment for ferrous surfaces was not intended as a single-phase corrosion protection system and should be used in conjunction with follow-on organic topcoat. According to MICOM, the amount of corrosion observed on Shillelagh missiles could have been mitigated by proper monthly inspections and the employment of humidity indicators. Several problems were prime examples of the substitution of unauthorized products or treatments into the maintenance procedures. In contrast, several examples of improvements in maintenance procedures can be cited. The Corpus Christi AD is enhancing the condition of magnesium parts by improving field preservation techniques. Helicopter magnesium floor plates and a number of engine components are undergoing an interim repair procedure comprised of anodizing, priming, and painting. The long-range goal is to anodize and surface seal all Mg parts. TSARCOM reported that the extensive damage to brass and steel fixtures occurring in water purification sets will be avoided by separately shipping and storing the chemicals employed (calcium hypochlorite and ferric chloride).

Some of the problems presented provided no solution. For example, the surface corrosion observed on twenty-one steering arms of a personnel carrier is still being investigated.

In a number of cases, new techniques were introduced to combat materiel deterioration. Tannic acid-based rust transformers are being investigated by several MSC's and AMMRC as products which react with various oxides on steel surfaces to form a rust-inhibitive ferro-tannic complex capable of providing an excellent base for subsequent primer/paint application. CECOM is developing chemical vapor deposition of silicon nitride to coat glass fibers. An electrostatic discharge control program is being implemented by Belvoir R&D to prevent electrical component breakdown.

In order to display the materials/coatings most susceptible to corrosion, Tables 2 and 3 were derived from the summary of problems listed in Table 1. As expected, steel, aluminum, and magnesium alloy components were involved most frequently. Of the coatings, cadmium plating appeared to present the greatest problem. Problems involving alkyd paint referred to electronic components coated with forest green camouflage paints according to MIL-E-52798A or MIL-E-52835A and their failure to pass the MIL-STD-810C fungus test. This problem has been a source of continuing debate. However, a resolution is imminent through a cooperative effort between several MSC's. Although MIL-E-52798A does not require a fungus test, this formulation has failed to pass the MIL-STD-810C fungus test (supported moderate mold growth). Documented field contamination problems have been reported for this paint on military hardware (missiles and missile casings) which support the fungus test data. It appeared, therefore, that a fungus resistance requirement for MIL-E-52798A is valid for some military applications. It was recommended that the paint specification be amended to include a provision for an alternative class of paint containing a fungicide as an option to cover military applications where fungal resistance should be a requirement (Thirty-First Conference on Microbiological Deterioration of Military Material, 16-18 November 1982). However, it is up to the equipment developers to determine the need for fungus resistance, based on the importance of impace on the item and the risk to reliability of equipment functionality. Chemical agent resistant coat-

TABLE 2. MATERIALS INVOLVED IN DETERIORATION PROBLEMS

Metallic

Metal	Application: Base Metal	Application: Plating	Number of Occurrences
Aluminum	X		11
Cadmium		X	12
Copper	X	X	[illegible]
Copper/Beryllium	X		[illegible]
Brass (Cu-Zn)	X		[illegible]
Gold		X	[illegible]
Lead/Tin (Terneplate)		X	[illegible]
Magnesium	X		[illegible]
Nichrome	X		[illegible]
Nickel		X	[illegible]
Silver	X (?)	X	[illegible]
Steel	X	[illegible]	22
Titanium	X		[illegible]
Tool Steels (H11)	X		[illegible]
Zinc Chromate		X (Primer)	[illegible]
Zinc Phosphate		X (Coating)	[illegible]

Nonmetallic

Material	Application	Number of Occurrences
Acrylic Paint	Paint	[illegible]
Alkyd Paint	Paint	[illegible]
Amber [illegible]	Coating	[illegible]
[illegible]	Sealant	[illegible]
Black Oxide	Finish	[illegible]
Chromate	Conversion Coating	[illegible]
Coated Fabric	Collapsible Tank	[illegible]
Cork	[illegible]	[illegible]
Dow [illegible]	Coating	[illegible]
Epoxy	Potting [illegible]	[illegible]
Fluorosilicone Rubber	[illegible]	[illegible]
Glass Fiber [illegible]	Electronic Equipment	[illegible]
Lubricant	Storage/Recovery [illegible]	[illegible]
OSTRO/O-1 Solvent	Potting Compound	[illegible]
Petroleum	Preservative	[illegible]
Plastic	Connector	[illegible]
Polycarbonate	Missile Dome	[illegible]
Polychloroprene	Rubber Sheathing	[illegible]
Polyester Urethane	Collapsible Fuel Tank	[illegible]
Polysulfide	Sealant	[illegible]
Polyurethane	Paint	2

Table 3. Ranking of Materials Most Frequently Involved in Reported MADPAC (CPC) Problems

1. Steel Base Metal
2. Cadmium Plate
3. Aluminum Base Metal
4. Seals
5. Alkyd Paint
6. Magnesium Base Metal
7. Silver Base Metal and Plating

ings (CARC) polyurethane paints, MIL-C-46168A, will replace the alkyd forest green paints. Of all the paint formulations tested, these CARC coatings are the least susceptible to fungal attack and support sparse to no mold growth. It appears, therefore, that a fungicidal additive to CARC formulations is unnecessary.

Selected Deterioration Problems

Following is a listing by subordinate command of some problems and solutions in greater detail. They represent typical solutions implemented to mitigate deterioration and vary from the single remedy of adding drain holes in helicopter components to the relatively complex repair procedure involved in the refurbishment of multimetal water purification sets.

(1) REPORTING STATION: MICOM
POC: Larry Glasscock

PROBLEM: The radome in a missile side antenna debonded from the aluminum surface when subjected to humidity testing.

CAUSE: The radome was bonded to bare aluminum with FM-1000 adhesive. When exposed to moisture, aluminum oxide formed at the aluminum-adhesive interface causing debonding.

EFFECT: Antennas had to be replaced on several hundred new and fielded missiles causing delays in missile deployment.

COST: Chromating treatment cost approximately $2,000/antenna and required shipment back to the factory. Applying the Kapton tape cost $100/antenna and could be done in the field.

Solution; Initially, it was anticipated that chromating the aluminum surface would prevent the debonding. Though this method was effective, the time and cost required were found to be exorbitant. Subsequently, it was found that by replacing the FM-1000 with Kapton tape, great labor and cost savings could be achieved. The tape could be applied to the deployed missiles in the field by simply placing a wide swath over the groove. Newer missiles had narrower strips placed in the grooves by the manufacturer. So far, this remedy has been effective in keeping moisture out of the antenna slots.

(2) REPORTING STATION: ERADCOM
POC: John Goon

PROBLEM: A missile failed to pass the humidity tests due to corrosion on its electrical contacts.

CAUSE: In order that the plastic connector material be more flame retardant, a bromine was added to the plastics composition. When in contact with water, the bromine and the other compounds present reacted to form sodium bromide, which corroded the fill metal.

EFFECT: During the humidity test, several system outages developed. There are almost three dozen test point connectors for each of the 158 cards per system.

COST: No estimate given.

SOLUTION: After cleaning the connector area of all the salt residue, the connectors will be replaced with bromine-free plastic material, recoated, and tested.

(3) REPORTING STATION: TACOM
POC: Larry Main

PROBLEM: Machine gun mounting pins made of 1045 steel (Rc 22/40) with a black oxide finish have suffered surface corrosion on fielded tanks.

CAUSE: The pins are exposed to weather, abrasion, vibration, and high impact when loading and removing the machine gun on a continuing basis.

EFFECT: The surface corrosion can hamper inserting or removing the pins from the cradle, to the point of "freezing" the pins in placed. The pins are intended to provide a quick release for the machine gun.

COST: Minimal cost is involved in terms of man-hours and maintenance; nevertheless, readiness posture is affected.

SOLUTION: The material is being changed to a stainless steel, class 410; the black oxide finish will remain the same.

(4) REPORTING STATION: Tobyhanna Depot
POC: Gregory Estes

PROBLEM: Some of the elements of the Evaporator Heater of the air conditioning units show a high degree of deterioration.

CAUSE: Condensation drips onto the steel bracket which supports nichrome wire heater coils. This moisture causes the bracket to corrode.

EFFECT: If corrosion goes unattended, the bracket will fail to hold the coil, thus causing an operational failure.

COST: Potentially, a new heater (no price/unit available) will be needed for every air conditioner.

SOLUTION: Nickel plating the steel bracket appears to eliminate the corrosion.

(5) REPORTING STATION: Fort Belvoir R&D Center
POC: Sidney Levine

PROBLEM: Surface corrosion and cracking developed on fielded twelve-gallon engine fuel tanks.

CAUSE: The joints of the tank were soldered, not welded as specified. The thickness of the base steel and the weight of the terneplate were below the required levels. Condensation and flux residue also contributed to the corrosion that occurred.

EFFECT: The water distributors, which used the damaged tanks, became inoperative due to fuel leakage. There now exists a question as to the reliability of the remaining tanks.

COST: Cost of investigating and reconstructing the damaged tanks was nearly $6,000. To replace the remaining tanks (235) would cost $70,000.

SOLUTION: If joints are to be soldered rather than welded, it is recommended that locked joints replace the lap joints. The contractor is addressing the fabrication deficiencies.

(6) REPORTING STATION: TSARCOM/New Cumberland Depot
POC: Tom Eichenberger

PROBLEM: All the unpreserved brass and steel hardware inside the van body housing of the water purification units developed extensive corrosion.

CAUSE: The calcium hypochlorite and the ferric chloride salt compounds contained in the water purification sets caused corrosion of the metallic constituents in the presence of water.

EFFECT: Although the units are still functional, corrosion damage could ultimately affect the integrity of the unit structure as well as the water purification processing.

COST: The total cost to eliminate corrosion problems in the sets may run into many hundreds of thousands of dollars.

SOLUTION: The affected brass or steel lines and fittings were cleaned with a neutralizing agent and preserved. The chemicals are now shipped and stored separately.

(7) REPORTING STATION: AVSCOM
POC: Windel Baker

PROBLEM: Some helicopter electrical connectors having male plugs and female wire bundle quick disconnectors malfunctioned due to galvanic corrosion.

CAUSE: The quick disc connector and its housing are not encapsulated, thus permitting water intrusion. The electroless Ni-plated wire bundles are also in direct contact with Cd-plated plugs.

EFFECT: Because the assembly is open to the environment, water can seep in, creating conditions for a galvanic cell. In some aircraft, the problem is widespread enough to compromise their mission.

COST: Too costly to correct, due to the necessary change in the design drawings. Replacing the equipment as it becomes necessary will be less costly.

SOLUTION: Cd-plated wire bundles will replace the Ni-plated ones through attrition. The existing Ni-Cd contacts will remain until there is a failure.

Table 4

Problem Number	Equipment Item	Cost	Savings	Comment
16	Fire Finder	[illegible]	[illegible]	No Estimate Given
16	Hawk Side Antenna	[illegible]	$1,200/[illegible]	Used Kapton Tape [illegible]
17	Stinger Gripstock	$150,000	[illegible]	[illegible]
22	Machine Gun Mounting Pins	Minimal	[illegible]	[illegible]
26	Evaporator Heater	No Amount Supplied	[illegible]	[illegible]
27	Radio Mounts	[illegible]	[illegible]	[illegible]
30	Fuel Tanks	$70,000/Year	[illegible]	[illegible]
66	Water Purification Sets	Several Hundred Dollars	[illegible]	[illegible]
70	Message Center Connectors	Several [illegible]	[illegible]	[illegible]
72	Control Rods	Minimal	[illegible]	[illegible]
73	Electrical Connectors	[illegible]	[illegible]	[illegible]
74	Helicopter Recessed Floor Plate	[illegible]	[illegible]	[illegible]
75	Helicopter Transmission Sumps	[illegible]	[illegible]	[illegible]
76	Landing Gear Drag Beam	[illegible]	[illegible]	[illegible]
77	Blade Retention	[illegible]	[illegible]	[illegible]
78, 79	Nuts, Bolts, Jam Nut	Minimal	[illegible]	[illegible]
80, 81	[illegible]	[illegible]	[illegible]	[illegible]
82	Gear Box Housing	$2,000 to Replace	[illegible]	[illegible]

Economic Impact

Table 4 presents the limited economic impact data submitted by the reporting stations. The costs for refurbishing or replacing the parts listed varied considerably. Repair costs for machine gun mounting pins and helicopter control rods were submitted as "minimal", but the Army-wide cost to repair or replace fuel tanks and communications equipment could exceed several million dollars. A recent cost analysis addressed the overhaul of one helicopter for corrosion damage after 11 years of service in Hawaii. This aircraft was judged to be typical of aircraft received for overhaul. The following structural or airframe parts were lost to corrosion at a cost of $14,124 for parts and repair labor: caps, panels, floor plates, and attachments. Engine components that required repair included the compressor case, inlet housing, and transmission top case, costing $6,751. The total cost for the aircraft (not including paint stripping and repainting) was $20,785, which represents approximately 1% of the original cost of the aircraft. However, if this cost is extrapolated over the 3700 aircraft in the fleet, the costs of corrosion would amount to approximately $78 million.

MICOM and Tobyhanna AD reported significant cost savings by employing Kapton tape as a substitute for the chromating treatment used to prevent missile antenna debonding and eliminating unnecessary pretreatment steps in the processing of radio mounts.

All of the problems cited affect the readiness posture and/or the structural integrity of Army hardware. In several cases, catastrophic failure is possible. For example, failure of particular helicopter control rods could cause loss of the helicopter and personnel. It should be noted that only a minimal cost was involved in changing from a zinc chromate primer to an epoxy primer applied to the inside of the rod, as a means of eliminating the problem. One lighter amphibian air cushion vehicle was originally designed for fresh water deployment. Unfortunately, the military environment includes seawater which has caused corrosion of numerous components including the main gas turbine engine, fasteners, air conditioner, and auxiliary power unit. Many improvements involving substitution of more corrosion-resistant materials and coatings have been made, but many material problems remain to be solved.

Another important problem involved the metallographic examination of one gold-plated wave guide parametric amplifier which was done by AMMRC for Tobyhanna AD. The part was reported as damaged in use causing galvanic corrosion of the substrate. Metallographic examination was carried out for thickness of gold plating, plating uniformity, adhesion, and defects in the plating. The gold electroplate was fairly uniform in thickness (approximately 0.0001″) and exhibited good adhesion except in the vicinity of the soldered area (brass bellows soldered to a circular flange), where some cracks, spalls, and discontinuities were observed. These defects were probably due to contamination of the surface by soldering flux and dirt or dust particles before plating. It was recommended that a minimum thickness of 0.0002″ gold plate (twice the thickness measured) be applied over an interlayer of nickel of sufficient thickness to mitigate the potential for galvanic corrosion should the gold plate become damaged.

Materials, Designs, and Watertightness

A review of the Army's reported corrosion problems shows that some of the most important considerations are the materials to be used, designs incorporating dissimilar metals, and watertightness. Test programs may be necessary to validate a particular choice of material or design. However, in the final analysis, cost and performance are the overriding considerations and some compromises usually have to be made. The challenge is to obtain a system which is as corrosion-free as possible within these restraints. An important step in the acquisition of new weapon systems and maintenance of fielded systems exhibiting corrosion problems is the review of detail specifications by materials and process specialists to insure that the latest state-of-the-art in corrosion technology is employed.

The corrosion problems reported by the stations provide an excellent source of lessons-learned information. In fact, many of the problems reported herein were incorporated into a Tri-service lessons-learned document for the Joint Logistics Commanders Panel on Corrosion Prevention and Control.

Although there has been a steady improvement in the quality of the reports submitted, some stations have not submitted all of the required semiannual reports. In order to make future reviews more useful, it is essential that CPC POC's provide specific data on base metal, material, and coating compositions.

Recently, there has been an increasing number of stations reporting no problems. It is suggested that, in addition to QDR and EIR reports, sample data collection reports be reviewed for identification and cost accounting of equipment deterioration. This program (AR750-37) established a method for collecting maintenance data on specific equipment. Information may be used to establish a data base for analyzing maintenance/logistics/support/performance, operating and support costs, operational readiness, and mission capability.

From A Reactive to Proactive Approach

Center of Excellence Declares War on Corrosion

Milton Levy
Program Manager
U.S. Army Center of Excellence
Corrosion Prevention and Control

"Today's technologies offer the best hopes ever for waging a successful war on corrosion."—These were words spoken by General Richard H. Thompson, Commander, U.S. Army Materiel Command, during his keynote address at the Tri-Service Conference on Corrosion at Orlando, Florida, on December 3, 1985. General Thompson thus set the tone not only for the Conference but for the Army's new initiative to overcome the insidious destroyer of equipment that corrosion is.

One of six specific steps outlined by General Thompson to be taken to reduce the burden caused by materiel corrosion and deterioration was the establishment of a Center of Technical Excellence for Corrosion Control Technology. Other initiatives to be undertaken were:

- Corrosion-free equipment designs
- More effective maintenance
- Improved corrosion prevention control training
- Increased awareness about corrosion control
- Better program management of corrosion prevention control.

"Although we may never achieve a totally corrosion-free design, we certainly can concentrate more on designing with maintainability in mind." General Thompson commented.

Center's Mission Outlined

In accordance with Commander's Guidance Statement 94, the Army's Materials Technology Laboratory, formerly AMMRC, has been designated as the Army's Center of Excellence for Corrosion Prevention and Control (CPC). This mission assignment acknowledges the Laboratory's long-standing leadership within AMC in the technologies of metallic corrosion and organic structural materials deterioration, and carries with it a high-profile responsibility to reduce the $2 billion annual cost of corrosion.

The CPC Center of Excellence will serve as a central operations and information base; it will ensure crossfertilization of corrosion prevention technology and sharing of lessons learned; the Center will coordinate development of model CPC programs with AMC's major subordinate commands; promote CPC awareness and training efforts; guide the allotment of resources to effectively accomplish the objectives of the Corrosion Prevention and Control Program; and maintain very close ties with industry to ensure mutual exchanges of the latest CPC technology.

Also, with the growing potential for use of composite materials to lighten ground combat vehicles, the program has been expanded from the traditional focus on metals to include all organic materials.

Again, to quote General Thompson, "We feel this alignment will provide a better focus for strengthening the technology base, for facilitating technology transfer, and for ensuring the best possible return on our R&D investments."..."But the real key to winning this war is a greater focus on maintenance—practical maintenance, effective maintenance, preventive maintenance, maintenance awareness and training, and effective management of the information base which supports it."

"The challenge is enormous, but the potential return on our investment is huge—it involves BILLIONS OF DOLLARS!"

Losses Provide Motivation

In 1982, a National Bureau of Standards report estimated the total annual national cost of corrosion to be 142 billion dollars. Of that 142 billion, 21 billion dollars was considered an avoidable cost if current state-of-the-art corrosion prevention and control technology (or CPT) were used. It was these kinds of devastating losses that motivated the Army-hosted Tri-Service Corrosion Conference of 1978 to provide greater emphasis on corrosion prevention and control.

The first Joint Logistics Commanders' Panel for Corrosion Prevention and Control was commissioned in September, 1979. The Panel's mission was to provide emphasis for improvement of corrosion prevention and control efforts throughout the services and to promote awareness of the importance of corrosion prevention considerations during both weapon system development and during all other stages of a system's life cycle.

The Army alone estimates an annual loss of $2 billion due to corrosion and deterioration; this also adversely impacts its performance and readiness posture. Further, it was determined that poor design accounts for 15% of this figure, while 35% is attributed to improper selection of materials; inadequate and/or improper maintenance accounts for the remaining 50%.

Initiatives to Consider

What can be done about this problem? It is estimated that a 25% cost reduction can be achieved by using current state-of-the-art corrosion/deterioration control technology. In addition, an RDT&E is needed to develop new and improved corrosion/deterioration resistant materials and coatings.

Organization, Plan Established

At MTL, a Program Manager position for the Laboratory has been established within the Metals and Ceramics Laboratory, and facilities and staff are being augmented to handle the expanded mission. While continuing with current R&D functions, capabilities will be added in the areas of corrosion/deterioration awareness, training, maintenance, and design. The Center's current field reporting procedures will be expanded and improved to utilize feedback data in a closed loop among system designers, acquisition managers, contractors, and users. An important first step is under way with AVSCOM to develop a model MSC Corrosion Prevention and Control Program to cover the entire life cycle of Army materiel systems.

One specific helicopter just entering production will be the subject for review with design changes selected to lessen corrosion susceptibility but which will minimize disruption of production.

Results of this program will form the basis for design of additional corrosion prevention and control programs for other major subordinate commands.

New Thrust Created

The Materials Technology Laboratory is taking a new approach in its program to attack corrosion—from the reactive to the proactive (see Figure 1). Where they were originally concerned with solving field corrosion/deterioration problems, they now are placing a major emphasis on design to prevent corrosion and deterioration. In other words, "Stop it before it starts.".

As can be seen in Figure 2, their new approach to corrosion prevention is a multi-pronged approach attacking from all fronts. The proactive side involves materials selection, corrosion R&D, protection methods, concept design, lessons learned, training programs, and engineering development. The reactive side encompasses production, fielded systems, maintenance, and depot rebuilding.

Gearing Up

MTL is gearing up for the corrosion battle with both additional staff and funding. Staff will include a PM and Deputy PM, a secretary, an administrative assistant, a data base manager, a technical writer, a program and financial analyst, a field engineer, and a technical support staff of more than 200 scientists and engineers. Additional support staff will include a publicist, a facilitator, and a protocol officer.

Large Savings From Successes

Recent examples of cost savings by implementation of corrosion/deterioration prevention and control programs show the magnitude of what can be accomplished. For instance, implementation of recommendations for just one Army helicopter saved $32.4 million, while avoidance of faulty stripline circuit production in an Army missile

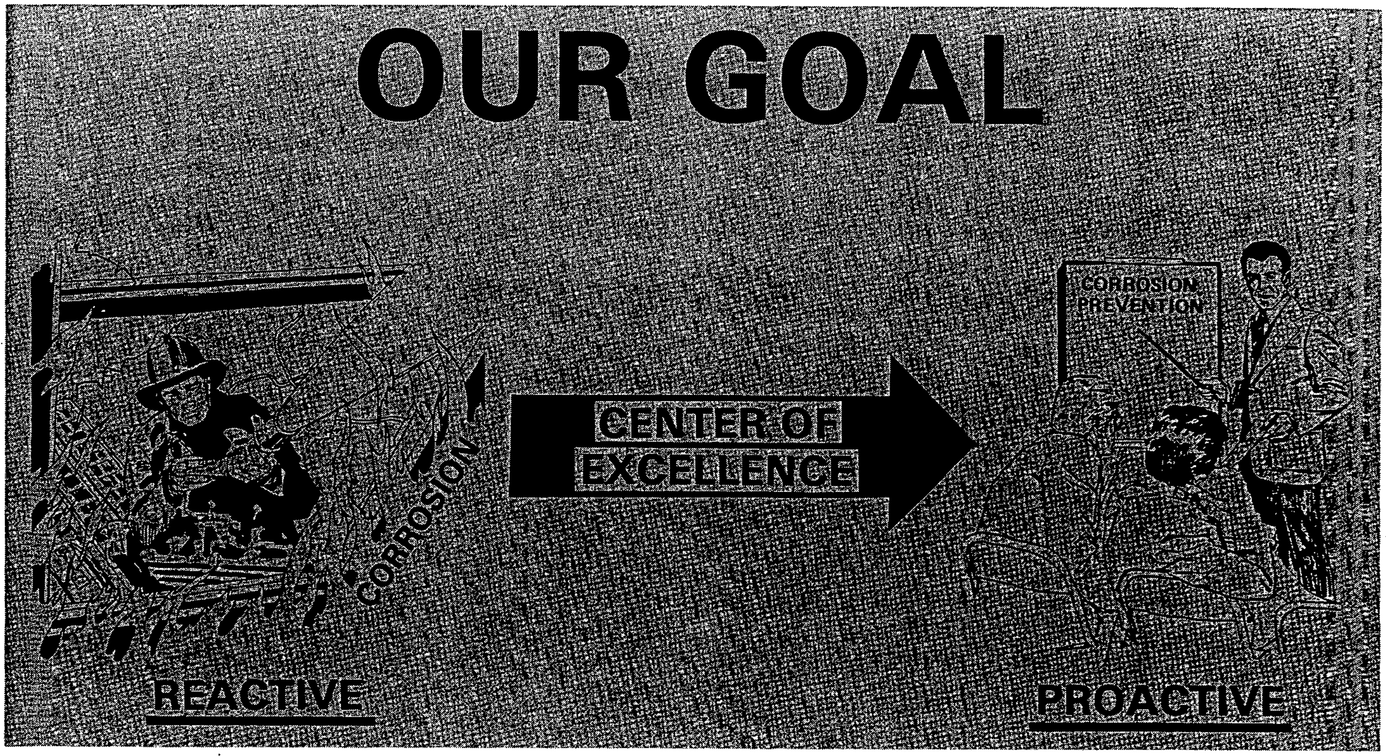


Figure 1

saved $4.0 million. All three branches of the service are cooperating to save even more. The savings from the first example of the helicopter illustrate the possibilities from this type of interservice cooperation.

Another example of excellent benefits realized from Tri-Service coordination was the conversion of an outstanding Navy technical manual on avionics corrosion prevention to a Tri-Service manual. Yet another instance of good interservice cooperation was the successful development of a portable neutron radiography machine. This machine now is being used for safe, rapid field inspection of large structures such as aircraft wings and composite materials that are not readable by conventional X-ray radiography. The Navy did much of the early work, while AMC developed the nonradioactive neutron generation source and built the first prototype inspection unit. The Air Force completed the testing and evaluation, and the Navy currently is pursuing subsequent generations of this unique nondestructive inspection device.

Continued interservice cooperation in the fight against corrosion is imperative, since maintenance budgets and new acquisition programs will be in direct competition with each other. This results from the fact that, with the largest national deficit in recent history, the defense budget is undergoing closer scrutiny than ever before.

Proposed Research

For FY 86, MTL has proposed R&D involving both metals and nonmetals:

Erosion/corrosion resistant coatings for gun tube liners—process development

Role of alloy chemistry on stress corrosion cracking (SCC) of aluminum alloys

Corrosion protection and control (formerly MADPAC)

Effects of fabrication—SCC of advanced aluminum alloys

Erosion/corrosion resistant coatings for gun tube liners—metals

Corrosion protection of advanced penetrator materials

Development of improved corrosion resistant treatment for magnesium

Development of corrosion resistant container materials for binary weapons

Interaction—DECON agents with metals and alloys

Hot corrosion protection for the advanced gas turbine alloys

Development of particulate erosion/corrosion resistant coatings—titanium, stainless steel for gas turbine compressors

SHS enhancement of material surfaces

Ultrastable polyphenylquinoxalines

Mechanical properties and solvent interactions of thermoplastic matrix composites for bridging & A/C

New approaches to fire resistant organic materials

Environmental durability of organic based materials

Predictive characterization techniques for composites

Effect of fabrication variables on composite materials

Erosion/corrosion investigation of surfaces with ballistic compressor

Near real time neutron radiography

Quantitative microstructural techniques for composites

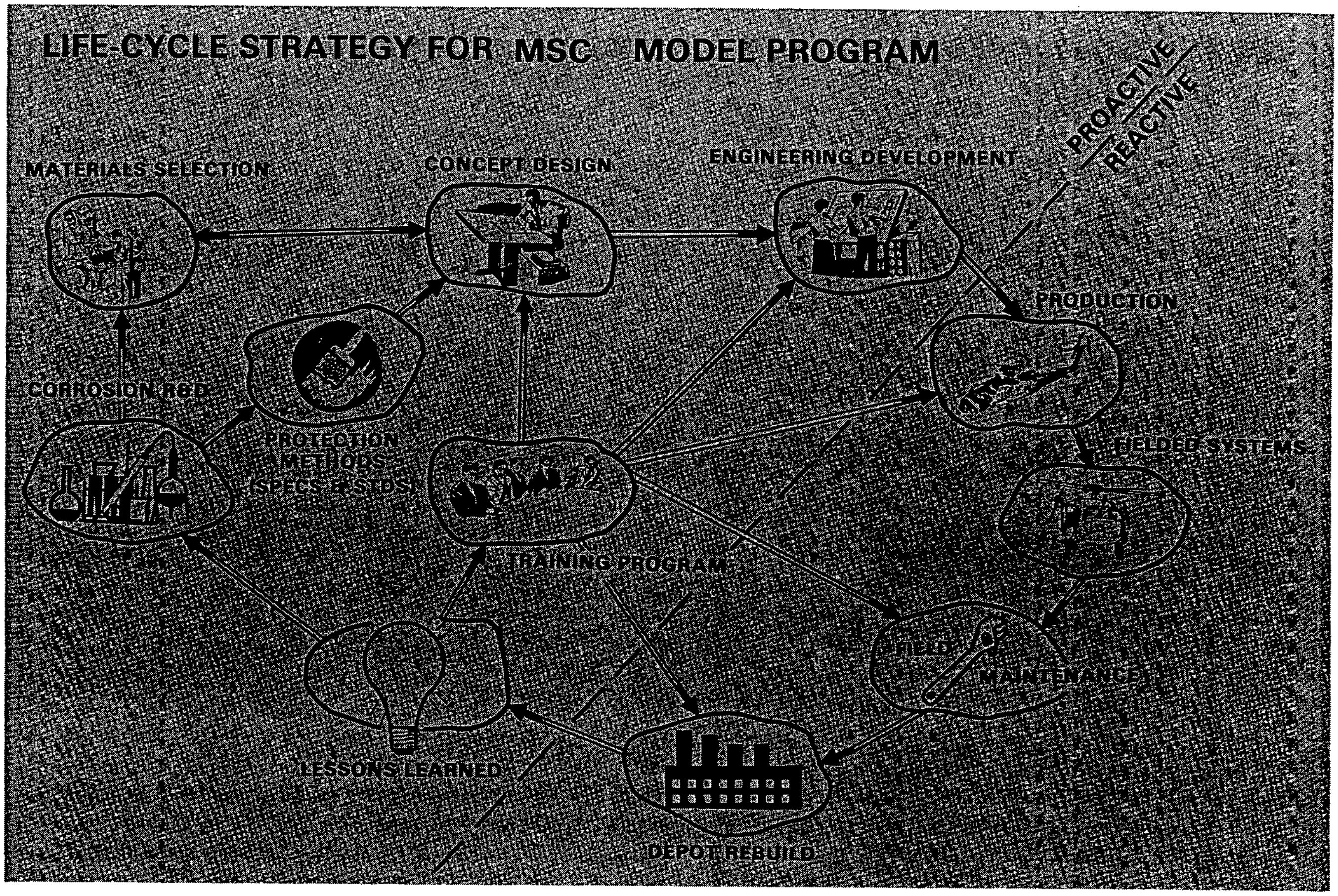


Figure 2

Old Method

- MSC identifies a corrosion problem
  - Factory
  - Field
  - Depot
- AMMRC provides
  - Technical expertise & assistance
  - Development of solution
  - Implementation assistance

New Method

- MTL assists in time phased inspections of materiel to identify corrosion problems
  - Helicopter selected for initial test case
- Helicopter selected for initial test case
  - Just starting production
  - Design changes incorporated with minimum disruption
- MTL provides
  - Technical expertise and assistance
  - Development of solution
  - Implementation assistance

Environmental durability of elastomers
Surface engineering by ion implantation
Chemical protection of structural composites
Permeation behavior of barrier & packaging materials

Areas of Expertise

MTL has expertise in both of the previously mentioned major areas. In metals, these include aqueous corrosion, electrochemical aspects, stress corrosion cracking, corrosion fatigue, high-temperature oxidation/sulfidation, chemical defense, erosion/corrosion, surface treatment, protective coatings, wear/abrasion, nondestructive testing, relability mechanics, and specifications and standards.

In the nonmetals area, the fields of MTL expertise include composites (UV radiation, humidity/temperature effects, and fatigue life), elastomers (chemical defense, ozone exposure, and wear/abrasion), polymers (change in optical properties, grazing/abrasion, oxygen deterioration, and stress effects), and ceramics (high-temperature degradation, erosion/wear, and fatigue).

In addition to in-house expertise, MTL has assembled scientific experts to serve as advisors from such institutions as MIT, Lehigh University, the University of Pittsburgh, and the University of Rhode Island.

Reduction of Corrosion Liability

The Army and AMC have instituted a number of measures which will contribute to the reduction of the Army's corrosion liability. One is in the area of innovative acquisition strategies where a major thrust to streamline the systems acquisition process has been established. The objective is to reduce acquisition time from the traditional 10 to 15 years down to 7 to 9 years for most systems.

A primary contributor to this thrust is a four-year development goal which emphasizes, among many things, use of performance oriented specifications and which places accountability for reliability and maintainability with the contractor. However, the Army is being very careful not to allow logistic supportability considerations to be sacrificed because of tighter cost or schedule constraints. Logistics R&D and RAM-D initiatives are being directed toward application of state-of-the-art research and technology in the system's design stage. To reduce both producibility and logistics costs, eleven high-cost Army systems have been targeted for a 50% reduction in RAM-D driven operating and support costs by FY91.

Further, contract warranty provisions for product reliability are paying good dividends. A very fine example was a recent experience with recurring cracks in the steel armor plates of sixty-seven tanks in the field. The Materials Technology Laboratory identified the cause as latent subsurface stress corrosion cracking, which was attributed to improper processing of the plate steel. The steel processing procedures were altered, the specification was revised to preclude similar problems in other applications, and the cracked steel plates were replaced (under the terms of the warranty) at no cost to the Army.

All of these measures are examples of shifting the accountability for systems support costs—to the designer, the contractor, materials experts, and the program manager. These actions should indirectly benefit efforts to reduce the staggering costs of corrosion.

O&S—A Significant Opportunity

Clearly, operating and support costs constitute, by far, the major portion of life cycle system costs. For example, cost analysis and projections for one Army tank indicate a cost breakdown of 3% for research and development, 30% for acquisition, and 67% for operation and support. O&S costs run as high as 75% for some systems. Thus, it is absolutely imperative to control O&S costs if one expects to reduce, or at least minimize, overall weapon system costs. And corrosion is a large part of our liability in the O&S costs.

Considering the fact that the Army's annual losses due to corrosion are estimated to total over $2 billion, prevention and control of corrosion constitutes an important part of this O&S cost reduction effort with which the new Center of Excellence at MTL is charged.

A Semiannual Army Summary

The Corrosion Digest

Patricia A.M. Farrell
Chemist, Corrosion Science Branch
U.S. Army Materials Technology Laboratory

The Corrosion Digest (originally MADPAC Digest) was developed by the U.S. Army Materials and Mechanics Research Center (now Materials Testing Laboratory) to provide a timely summary of semiannual Army deterioration problems; these were submitted by the Army Materiel Command's Major Subordinate Commands under the Materiel Deterioration Prevention and Control (MADPAC) Program, now called the Corrosion Prevention Control (CPC) Program. A computer program was written to present a summary of the report in a concise, readable fashion. The summaries are compiled, indexed, and disseminated throughout AMC as quickly as possible.

The first summary of semiannual reports was published in AMMRC SP84-1, entitled "A Review of Army Deterioration Problems Reported Under the DARCOM MADPAC Program", which reviewed and analyzed reports submitted between January 1, 1981 and June 30, 1982. This report was followed by the first MADPAC Digest, which covered the period from July 1, 1982 to December 30, 1982. The first digest contained a listing of Points of Contact and their Autovon numbers for further information about a specific problem. Also, a listing of Army Major Subordinate Commands (MSC's) reporting problems, no problems, or insufficient detailed information is provided in the first issue.

Succeeding Digests were published to summarize semiannual reports submitted between January 1, 1983 and the present. In addition, the Digest alerted the AMC community to upcoming events such as corrosion meetings, conferences, and new programs.

Changed Format

The second and third editions of the MADPAC (CPC) Digest covered the two reporting periods of 1983. A slightly different presentation in that document was due to a change in the computer system used to collate the input data. MTL currently is using the dBASE II data base software that accompanies the KAYPRO 10 computer. The reader of the second and third editions of the Digest also witnessed a substantial increase in the number of problems reported—an increase of as much as 50% over the first edition. This increase enhanced the ability of the CPC Program to serve as an exchange of corrosion information.

Digest Briefing Notes

The second and third edition of the digest alerted the CPC community to the following corrosion activities:

- The digest reported the development of a "strawman" Army Regulation on CPC. Since that time the draft AR has undergone several reviews through Headquarters, Department of the Army, the Army Major Comands, and the AMC Subordinate Commands. The draft AR now is at the prepublishing stage, and its publication is anticipated shortly.

- The MTL staff regularly participates in the activities of the National Association of Corrosion Engineers. The Annual NACE Convention is held in the March-April time frame. As was reported in the digest, the MTL staff hosted the T-9 Subcommittee Symposium on Corrosion of Military Equipment in March of 1985 in Boston. MTL will continue to work with NACE on training and other activities during the coming year.

- The 1985 Tri-Service Conference on Corrosion was rescheduled for December and held in Orlando, Florida. MTL (AMMRC) hosted the Conference this year.

Name Changed

With the fourth and fifth editions, the MADPAC Digest changed its name to the Corrosion Digest. This name change coincided with an increased emphasis everywhere in the Army aimed at combating corrosion throughout the life cycle of Army systems.

Directives and taskings by General Thompson, CG, AMC, have led to a wide range of new initiatives in this area. Changes also have occurred within AMC recently. AMMRC, the Army Materials and Mechanics Research Center, changed its name to the Army Materials Technology Laboratory (MTL). MTL now is a part of the newly created LABCOM, which also includes the Army Research Office, the Ballistic Research Lab, the Human Engineering Lab, the Harry Diamond Lab, the Electronics Technology and Devices Lab, and the Office of Missile Electronics Warfare.

MTL has been designated as a "Center of Excellence" in Corrosion Prevention and Control. In this capacity, MTL will, under LABCOM and AMC guidance, execute many new initiatives in order to increase corrosion awareness throughout the design, manufacture, fielding, and maintenance of Army systems.

Major New Initiatives

Some of the major initiatives are:

- A model program will be established between MTL and AVSCOM to bring corrosion prevention and control technology into design through design reviews and corrosion prevention advisory boards.

- New corrosion training courses are being planned. An introductory course and more advanced courses for design and for maintenance personnel will be offered at MTL.

- Several initiatives to increase corrosion awareness are under way. This final 1985 issue of the U.S. Army ManTech Journal has been devoted to corrosion. The Tri-Service Conference on Corrosion was held in Orlando, Florida on December 2-5, 1985. An ADPA Conference devoted solely to CPC will be held April 21-23, 1986 at Williamsburg, Virginia. Next year's Sagamore Conference (August of 1986) is devoted to corrosion and will be organized by MTL.

- While the draft AR on corrosion is undergoing revision, an AMC supplemental "straw-man" has been written and soon will go out for review.

- The establishment of the Center of Excellence for Corrosion Prevention and Control at MTL provides a central location for management of the many initiatives required for the CPC Program. In addition, attention will be given to insure that the MTL R&D program responds to Army needs in corrosion technology. New technological developments at MTL and the R&D centers will be communicated and transferred to the Major Subordinate Commands. Failure analyses and technical resources will be provided through the Center of Excellence. And, of course, the compilation and dissemination of corrosion experience through the CPC data base and the Digest will continue.

Retrievability Increased

The format of the Digest has been changed to increase readability. The reports are sorted by the type of material involved—e.g., aluminum or steel. This will help readers pick out reports from other commands and depots related to their own experiences and systems. Also included is a list of Major Subordinate Commands and Depots reporting "no problems" or failing to submit a semiannual report. A current telephone list of CPC Deterioration Prevention Action Officers (DPAO's) is included. The reader should note that telephone numbers listed are Autovon numbers.

During the Coming Year

The next digest will be out in early Spring of 1986. During the coming year, the MTL staff will be reviewing several major data bases to see how the overall Army corrosion database should be expanded and improved. Potential sources include the quality assurance and maintenance database from the Major Subordinate Commands, which will be utilized as well as data from both the Air Force and the Navy. This represents a substantial undertaking requiring a considerable effort throughout AMC.

For additional information or questions, please contact Milton Levy (617)923-5331, AV 955-5331, or Patricia Farrell (617)923-5345, AV 955-5345.

Understanding the Problem: Half the Battle

Battelle/MCIC Attacks Corrosion

GERHARDUS H. KOCH is Associate Manager of the Corrosion and Electrochemical Technology Section at Battelle in Columbus, Ohio. Dr. Koch has extensive management experience in projects concerning materials degradation, the most recent at Battelle involving the corrosion chemistry of SO_2 scrubbers, materials failure causes in flue gas desulfurization systems, corrosion/erosion testing of candidate materials, and cyclic reheat studies of SO_2 scrubbers. He also is active on an Air Force program to monitor corrosion at wing-to-pylon fittings and the fuselage of C-141 cargo aircraft. His Ph.D. theses topic was on stress-corrosion cracking and gaseous hydrogen embrittlement of alpha titanium alloys, and he is coauthoring a book on the "Corrosion of Metals in Marine Environments". Dr. Koch is a member of the National Association of Corrosion Engineers and serves as Chairman of NACE's Technical Practices Committee T5F on Corrosion Problems Associated with Pollution Control. He has authored numerous papers on corrosion since receiving his Ph.D. in Metallurgical Engineering from the University of Illinois. He earlier had received B.S. and M.S. degrees in Aeronautical Engineering from the University of Technology, Delft, The Netherlands.

HAROLD MINDLIN is Program Manager of Battelle's Metals and Ceramics Information Center, a DoD-sponsored Information Analysis Center. During his more than 20 years at Battelle, he has been involved in the generation and analysis of materials properties under a variety of simulated service conditions. More recently, he has been involved in the computerized collection and analysis of materials properties data. He is a member of ASTM and AIAA. He received his B.S. in 1956 and his M.S. in 1960 from Lehigh University.

Corrosion problems facing America's military services and industrial firms now can be addressed more easily. This follows the recent initiation of a special task (funded by the three services) with the Metals and Ceramics Information Center of Battelle's Columbus Division. This effort will lead to the establishment of a separate Corrosion Information Analysis Center. The Center will provide a much more comprehensive, accurate, and timely focus to costly corrosion problems. It has been estimated that corrosion costs our nation, alone, as much as $70 billion each year. And it has worldwide impact.

In April, 1985, the DOD Metals and Ceramics Information Center at Battelle initiated the special task to expand its current coverage of corrosion and corrosion-related technology. This task is responding to the needs of the Department of Defense and its contractors and, in particular, the specific needs of the Joint Panel on Corrosion Prevention and Control. Mr. Fred Meyer, AFWAL/MLSA, is the Contracting Officer's Technical Representative (COTR).

Broad Responsibilities

The Corrosion Information and Analysis Task now is responsible for the collection, review, analysis, appraisal, summarization, and dissemination of the available scientific, technical, and commercial information and data on corrosion, corrosion effects, and other corrosion related matters. This information is being used to establish a corrosion database and support the activities described in a later section of this article.

As part of the functions of an information analysis center (IAC), these activities provide both an information storage and retrieval system and the technical capabilities (corrosion and related experience) needed to provide a variety of products and services to the user community. In addition, the corrosion task provides services that parallel those now offered by MCIC.

During the initial months of operation, several specific activities were undertaken:

- Initiation of data gathering activities to cover the expanded scope of the corrosion task
- Initiation of the current awareness function
- Visits to a selected group of DOD facilities.
- Initiation of a state-of-the-art report on "Corrosion of Electrical Connectors"

The corrosion task has initiated information collection and indexing that covers the areas listed in Table 1. A review of MCIC's current information holdings indicated that, since 1971, MCIC has collected approximately 7,700 corrosion information references. With the extended scope, this collection will expand at a greater rate to provide an improved resource for other products and services.

TABLE 1. RECOMMENDED SCOPE OF THE CORROSION INFORMATION AND ANALYSIS TASK

METAL ALLOYS	
FINISHES	U.S. AIRCRAFT
PAINTS	FOREIGN AIRCRAFT
ORGANIC/METALLIC/CERAMIC	MISSILES
COATINGS	SURFACE VEHICLES
SEALANTS	SHIPS
CHEMICAL TREATMENTS	SUBSYSTEMS
DESIGN ACTION	SUPPORT EQUIPMENT
ENVIRONMENTAL STRESS EFFECTS	
DIRECT CHEMICAL ATTACK	

The acquisition and input of source information (the corrosion computerized bibliographic database) includes the collection, review, and analysis of U.S. and foreign literature. With the expansion of this data effort, it was possible to initiate a current awareness activity in conjunction with the existing MCIC "Current Awareness Bulletin" (CAB). Input for the CAB is being provided by technical specialists who review specific items of current interest that are published in a special CAB insert, as noted later.

The MCIC database (and, in the future, the separate corrosion database) is on the Defense Technical Information Center computer (DROLS) and, hence, is available to all who have direct or dial-up access to DROLS. Of course, MCIC also can run a search as part of a technical or bibliographic inquiry.

Battelle/MCIC personnel recently completed a number of visits to various DOD facilities to

- Inform the DOD corrosion community of this activity.
- Identify and establish communications with key DOD personnel involved with corrosion alleviation and prevention.
- Identify field needs and establish priorities for coverage relative to the scope outlined in Table 1.

As a result of these visits, a list of DOD personnel involved in corrosion activities has been assembled. These names have been incorporated into the mailing list for MCIC's CAB to make sure that all pertinent mailings are received by interested parties. If someone is known who should receive future mailings, their addresses can be added to the list of recipients.

In order to assemble data that will assist in determining the needs of the community, a "Corrosion Interest Profile" was prepared. The basic categories of the profile are as follows:

- Aircraft
- Missiles
- Land-Based Surface Vehicles
- Ships, Submarines, Ocean Structures
- Subsystems
  - Structural
  - Electronics
  - Machinery & Engines
- Support Equipment

Data are being collected and analyzed for each of these categories under the following topics:

- Materials
  - Metals
  - Nonmetallics
  - Intermetallics
  - Metal Matrix Composites
  - Other Types

- Failure Modes
  - Corrosion
  - Stress Corrosion Cracking/Hydrogen Embrittlement
  - Corrosion Fatigue
  - High-Temperature Corrosion
  - Other (e.g., Erosion Fretting, etc.

- Environments
  - Atmosphere
  - Sea Water
  - Chemical
  - Brackish Water
  - Fresh Water
  - Flue Gases
  - Other

- Surface Finishes
  - Organic Coatings/Paints
  - Metallic Coatings/Plating
  - Chemical/Electrochemical (Anodizing)
  - Ceramic Coatings
  - Other (e.g., Ion Implantation, Laser Treatment)

- Related Topics
  - Sealants
  - Direct Chemical Attack
  - Design Actions
  - Maintenance
  - Inhibitors
  - Cathodic Protection
  - Corrosion Monitoring
  - Other

Contact the Metals and Ceramics Information Center at Battelle for a copy of this form or to add names to the distribution list of the Center's Current Awareness Bulletin.

Products and Services

The products and services that are offered include:

- Handbooks and Databooks
- State-of-the-Art Reports
- Critical Reviews and Technology Assessments
- Technical and Bibliographic Inquiries
- Current Awareness Bulletins
- Failure Analysis Summaries.

Since the objective of these services is to be responsive to the technical community, user feedback is requested both now and later to make sure that this objective is met. The present status of these products and services is as follows:

Handbooks and Databooks. During coming months, MCIC will propose further major topics with outlines to the COTR. Available government publications are presently being collected and reviewed to avoid needless duplication. A handbook effort has been started, but probably will not be completed during the current one-year contract.

State-of-the-Art Reports (SOAR). These reports will cover current or advanced technology and information that can be summarized and evaluated by a corrosion technologist in four to six weeks of technical effort. The objective is to provide rapid access to current technology. Several major topics with chapter outlines will be proposed to the COTR; one SOAR, "Corrosion of Metals in Marine Environments", will be available early in 1986. Another SOAR, "Corrosion of Electrical Connectors", is in the final stages of production and will be available in early 1986.

Critical Reviews and Technology Assessments will be accomplished as specifically requested. These assessments normally are undertaken under separate funding or in lieu of a SOAR.

Technical and Bibliographic Inquiries. Technical inquiries can be directed to corrosion specialists at Battelle. A rapid response will be provided. Inquiry responses can vary from a single over-the-phone answer to a report on a specific topic. Bibliographic inquiries can be handled through the simple generation of a bibliography from the MCIC computerized bibliographic database to a review of pertinent literature—including the extraction of pertinent data or a complete report that analyzes the data for a specific topic.

Inquiries will be handled on a no-cost basis—depending on the time required to formulate a response. In cases requiring the extended efforts of a Battelle staff member, a quote will be given. If authorization to proceed is given, the effort can be undertaken on a purchase order or through a MIPR to the MCIC contract. Procedures will be given to the inquirer as necessary.

Current Awareness Program. At the present time, expanded current awareness for corrosion topics is being handled through the monthly MCIC Current Awareness Bulletin. The long-term MCIC coverage has been expanded to cover the full scope of the corrosion task. A CAB insert has been initiated to include critical reviews of technical articles from U.S. and foreign literature. Future inserts will include 1 to 1½ page state-of-the-art summaries—i.e., reports on related technical meetings, workshops, or conferences, major research program reviews, and special items of interest to the corrosion community. Distribution is the same as with MCIC's CAB, with the addition of specific DOD personnel having corrosion-related interests.

It is anticipated that a Corrosion Bulletin may become a separate publication with limited distribution to the corrosion community.

Failure Analysis Summaries. MCIC is reviewing the possibility of establishing an indexed, retrievable file of failure analysis reports available from DOD agencies. This computerized file would permit the systematic review of such data to determine failure similarities, trends, commonality, etc., that would result in special corrosion reports. These reports would be useful to field activities to assist them in failure analysis and other alleviation and prevention activities. The sensitive nature of failure analysis reports will be accommodated in the setup of this activity.

How to Participate

For more information regarding this task, contact Dr. Gerhardus H. Koch, Associate Manager, Corrosion and Electrochemical Technology Section, Battelle's Columbus Division, Phone 614-424-4480; or Harold Mindlin, Program Manager, Metals and Ceramics Information Center, Phone 614-424-4425.

As mentioned in the title of this article, understanding the problem is half the battle. Through a many-pronged attack, MCIC and the future Corrosion Information Analysis Center hope to make an inroad into the major corrosion problems facing not only our military services but also the industry of this nation.

CORROSION INFORMATION AND ANALYSIS INTEREST PROFILE

	Materials					Failure Modes						Environments							Surface Finishes					Related Topics							
	Metals	Non-Metallics	Intermetallics	Metal Matrix Composites	Other (Specify Below)	Corrosion	Stress Corrosion Cracking	Hydrogen Embrittlement	Corrosion Fatigue	High Temperature Corrosion	Other (e.g. Erosion, Fretting, etc. Specify Below)	Atmosphere	Sea Water	Chemical	Brackish Water	Fresh Water	Flue Gases	Other (Specify Below)	Organic Coatings/Paints	Metallic Coatings/Plating	Chemical/Electrochemical (Anodizing, etc.)	Ceramic Coatings	Other (e.g. Ion Implantation, Laser Treatment, etc.)	Sealants	Direct Chemical Attack	Design Actions	Maintenance	Inhibitors	Cathodic Protection	Corrosion Monitoring	Other (Specify Below)
Aircraft																															
Missiles																															
Land Based Surface Vehicles																															
Ships, Submarines, Ocean Structures																															
Subsystems: Structural																															
Subsystems: Electronics																															
Subsystems: Machinery and Engines																															
Support Equipment																															
Other (Specify Below)																															

Comments ______________________________

Suggested Topics:

State-of-the-Art Reports ______________________________

Handbooks ______________________________

Please add the following names to your corrosion list:

Name: ______________________________

Organization/Code: ______________________________

Address: ______________________________

City, State, Zip (9 Digit) ______________________________

The address on the mailing label ☐ is correct ☐ has been corrected

I would like more information about the Metals and Ceramics Information Center ☐

The Army's Concern

Corrosion Costly to TACOM

Cesar Gaglio
Maintenance Directorate
U.S. Army Tank-Automotive Command

The backbone of the Army's tactical vehicle fleet consists of the ¼-ton M151 series vehicles, M880 1¼-ton vehicles, the 2½-ton truck series, and the 5-ton truck series. This fleet has been allowed to age to the point where a large percentage of these vehicles have exceeded their original expected life. Projections show that the tactical vehicle fleet has and will continue to age over the next several years as the following figures show:

FY	% of Tactical Vehicles Overage*
81	11.7%
82	19.4%
83	30.1%
84	34.3%
85	42.2%
86	45.3%

*Over their original expected service life.

This situation exists because the Army has not been able to procure enough new vehicles to replace those that are wearing out. As a result, the service life of our present vehicles has been extended. The life expectancy of the M151 ¼-ton vehicles has been extended from 7 to 12 years. The useful life of the 5-ton vehicle has been extended from 15 to 20 years. The expected life of the M880 series vehicles has been extended from 7 years to that time in the future when the Commercial Utility Cargo Vehicle becomes available. The administrative act of extending the service life of these vehicles has not in any way increased these vehicles' physical ability to remain in one piece for a longer period of time.

Due to this extension of service life there has been a significant increase in rust damage to these vehicles. The purpose of rustproofing is to take the necessary steps that will physically increase the life expectancy of both new vehicles and used vehicles, particularly those used vehicles which have received rust damage repair.

TACOM's Mission

TACOM reestablished the requirement for rustproofing procedures with the publication of TB ORD 401 in June 1976; this was the first Army publication to cover rust prevention techniques since a January, 1951 publication was rescinded. TB ORD 401 was published as a result of a request by the Marine Corps for updated rustproofing information. In 1978, TB ORD 401 was changed to TB 43-0213. At this time, additional information on the M151 series vehicle was included. The July 1980 edition of TB 43-0213 expanded the coverage of procedures for the 2½-ton and 5-ton vehicles. Change to this TB includes procedures for M880 series vehicles.

The Army's current level of involvement in repair, prevention, and rustproofing of equipment evolved from a visit to Hawaii in 1978 by AMC's Commander and

TACOM personnel. Hawaii has all the environmental elements needed to accelerate the occurrence of rust—high temperature, high humidity, and high salt concentration present in the air due to the proximity of the ocean.

In their initial visit to Hawaii, in June 1978, TACOM personnel discovered that rust damaged vehicles were being repaired in facilities that were inadequate for the tasks at hand. These vehicles were being repaired and returned to use without the application of a rustproofing compound.

It was determined that the WESTCOM facilities were inadequate to complete the rust repair/rustproofing effort their fleet required. The decision was made to award a contract to do rust repair and rustproofing work. A 25% sample survey of the WESTCOM fleet was made to determine accurate man-hour and dollar requirements for this program.

In January 1982, a contract was awarded to repair and rustproof approximately 3500 trucks and trailers. The contracted portion of the WESTCOM effort calls for an estimated 144,000 man-hours. This total is spread over 46 different vehicle models.

Since the initiation of "Operation Rustproof", TACOM has become involved in rust repair, prevention, and rustproofing programs in Europe, Korea, and the United States.

The TACOM rust repair, prevention, and rustproofing effort has these objectives:

- To return rust damaged vehicles to service.
- To reduce the number of vehicles that suffer rust damage in the future.
- To maintain our present vehicles until replacements can be procured.
- To develop the best possible techniques to prevent rust damage to vehicles procured in the future.

What is Corrosion?

Pure metals such as iron do not normally occur in the earth's crust. They exist as ores or natural compounds. In their natural state, these ores and compounds are of no use as structural materials for vehicles. They must be refined into the metals that are a major part of our everyday lives. The refining process requires the use of a large quantity of energy to produce the desired metal. These metals are in a high energy state (like a tightly wound spring waiting to be released) and would naturally like to return to a low energy state. The need to return to a low energy state is the driving force behind corrosion. Corrosion is nature's way of returning metals to their natural state (i.e., oxides or other chemical compounds). The rusting of iron and steel is the most common form of metal corrosion in the world today. Corrosion limits the useful life and increases maintenance costs of all metal products.

The magnitude of corrosion losses is greater than is commonly imagined. In 1975, the National Bureau of Standards reported that the annual cost of corrosion in the United States was approximately $70 billion; $8 billion of this total was in the Federal sector. The total Army corrosion bill was estimated at $2 billion. This $2 billion would equal 145,714 new M151s.

The word corrosion comes from the Latin word "corrodere" which means wearing or rubbing away of material. Today the term refers only to metals. We talk about iron rusting, silver blackening, and copper oxidizing. Types of vehicle corrosion include:

- Galvanic corrosion (dissimilar metals)
- Crevice corrosion
- Pitting corrosion (breaks in protective coatings).

Rusting of iron and steel is caused by an electrochemical reaction. This reaction is divided into four parts or elements (Figure 1):

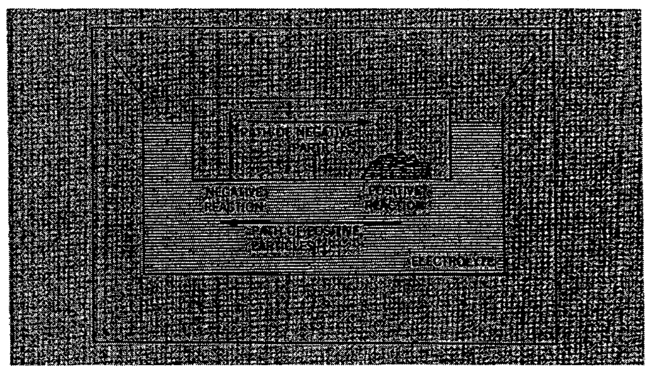


Figure 1

- A positive reaction
- A negative reaction
- A path for negative particles to flow
- A path for positive particles to flow.

This could be compared to a simple electric circuit. In this circuit, there is a positive and negative reaction at the battery terminal, a path through the battery electrolyte for positive particles to pass and a path through the wire for negative particles to pass (Figure 2).

Electrolyte Completes Circuit

In the case of corrosion, positive and negative reactions take place either on two pieces of metal or on two

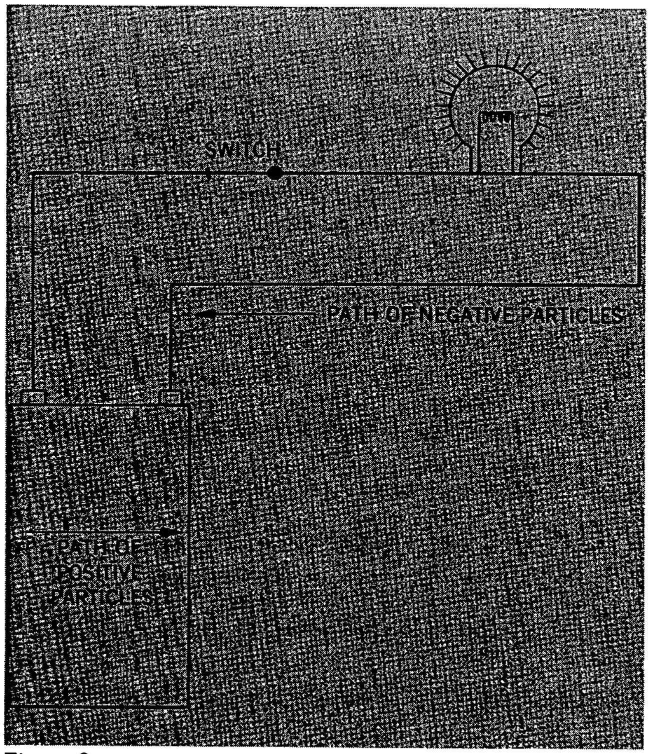


Figure 2

places of the same piece of metal. The negative particles either flow through the joint between the two metals or through the metal itself. The final, crucial element in the corrosion reaction is the path for the positive particles (the electrolyte). This electrolyte most often is water or salt water (Figure 3).

In both cases—electric circuit or corrosion reaction—movement of charge particles takes place. In both cases, if the circuit is broken, the reaction stops (Figure 4).

The problem of vehicle corrosion has been heightened by the use of calcium chloride and common salt on roadways. The use of thinner gauges of sheet metal in vehicle bodies has also increased corrosion problems.

Rustproofing is an attempt to slow down and control Mother Nature's corrosion process so that the user can preserve his vehicle during its normal useful life.

Almost all body components of modern day vehicles are subject to corrosion. Modern vehicle economics of manufacturing dictates the use of parts made of stamped, low carbon steel. This low carbon steel offers little resistance to rust.

Unitized body structure creates many pockets, box sections, and other hollow areas that encourage the development of rust. This is why it is important to have a working knowledge of how rust forms. Rust is nothing more than an electrochemical reaction breaking iron down into more stable compounds. Rust results both from the attack of air and water on metals. A small amount of air which may come in contact with a moist surface promotes rusting. By the same token, a large amount of air dries the surface and slows the rusting process. Thus, areas that receive a large volume of air such as underbodies are less prone to rust than hollow box sections which require a prolonged drying period.

Hollow boxed-in areas located in the lower twelve inches of the vehicle are the most vulnerable areas for corrosion. These areas are most subject to splashing from the road surface forcing water into seams and joints between body panels. In a short time, corrosion forms at the lowest points in these cavities. With the lack of air circulation in these areas, moisture remains for a long time, causing extensive corrosion development. Ice and snow melting chemicals remain in place and are active long after the actual ice and snow are gone. In fact, the greatest amount of salt induced corrosion occurs in the spring months when temperatures are higher.

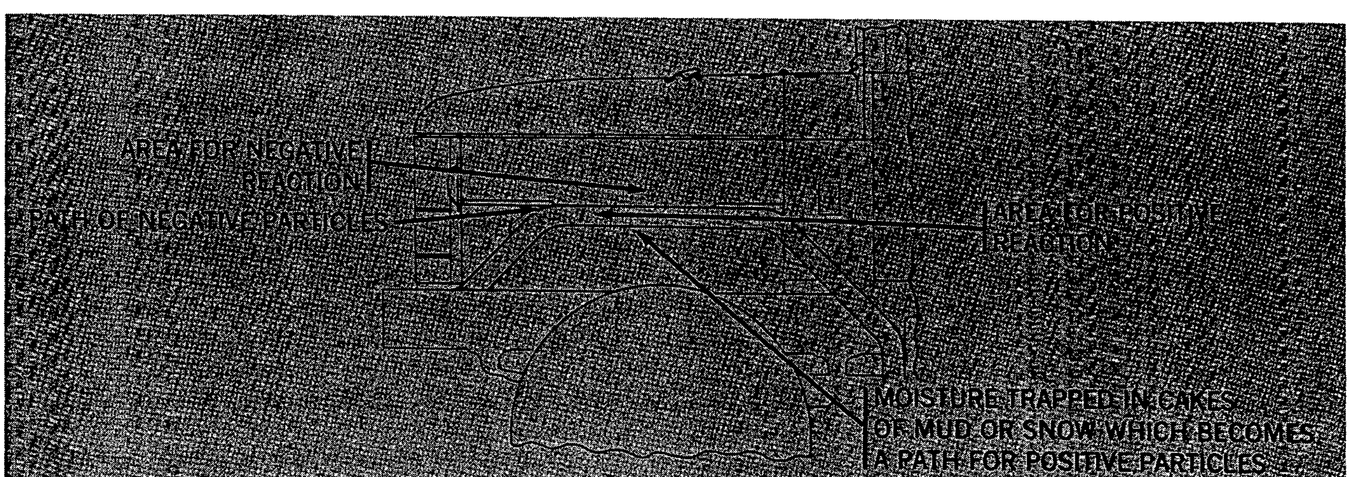


Figure 3

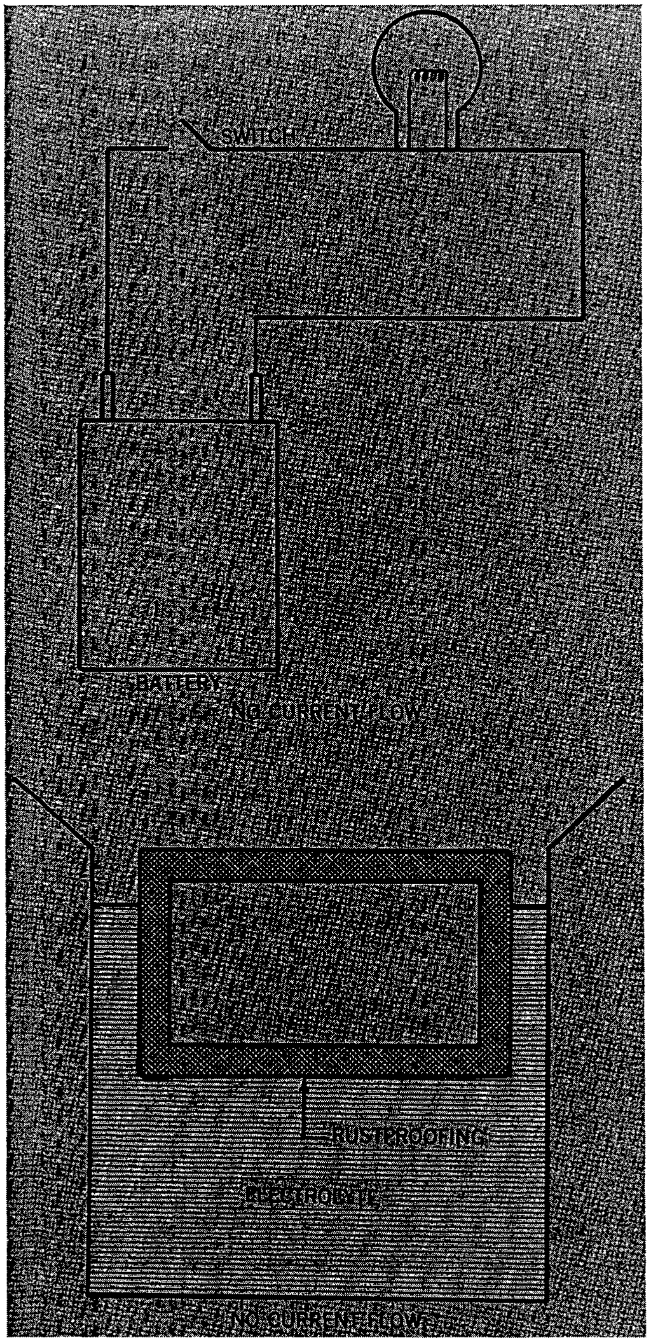


Figure 4

Rain also contributes to the corrosion process. Although it can act to rinse out road chemicals when a vehicle is new, as the vehicle ages and debris accumulates in boxed areas, this rainfall turns accumulated dirt and dust into mud. This mud and debris is slow to dry as a result of little air circulation. This situation promotes the development of corrosion. During winter, even the breath from vehicle occupants can condense on inner body panels and lower body sections.

Air pollution in populated areas has added to corrosion problems. This pollution is causing internal as well as external vehicle corrosion. Considering all factors leading to corrosion, its rate of attack in heavily populated areas can be four time of that in rural areas.

Military Environments All-Encompassing

Military vehicles are operated in a wide variety of environmental conditions that can promote metal corrosion. Equipment must be capable of operating in any of a number of climates encountered in different parts of the world. Some of the environmental factors facing military vehicles are:

- Operation in water containing dissolved salt and other minerals
- Relative humidities ranging from 35 percent to 100 percent
- Temperatures ranging from -50 F (46 C) to +125 F (+52 C)
- A wide range of annual precipitation
- The presence of microorganisms, fungi
- The presence of sulfur dioxide, salt, and other corrosive substances in the atmosphere
- The use of sodium and calcium chlorides for melting ice and snow.

Corrosion — Geographically

Rust occurs worldwide. However, the areas of most concern to the Army are shown in the accompanying figures, along with degree of severity (see Figures 5-10).

Corrosion Prevention

To prevent or retard corrosion, one of the four main elements of the rust reaction must be eliminated. Clearly, the most easily eliminated is the electrolyte (water, especially salt water, etc.).

Corrosion develops where all four of these elements are in existence. Any place where two sheets of metal join, any place where moisture can collect, any enclosed area where moisture will not evaporate easily, and any place where dirt can collect and not be removed during routine cleaning are likely areas for corrosion development. These areas include:

- Rubrails (Figure 11)
- Stiffeners

CORROSION AREA

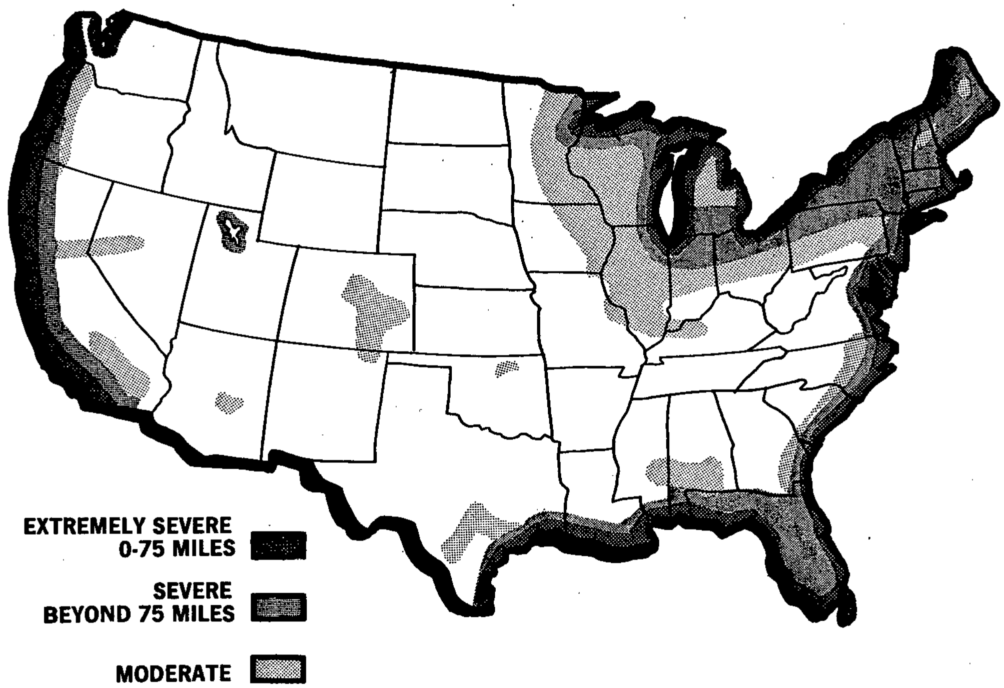


Figure 5

CORROSION AREA

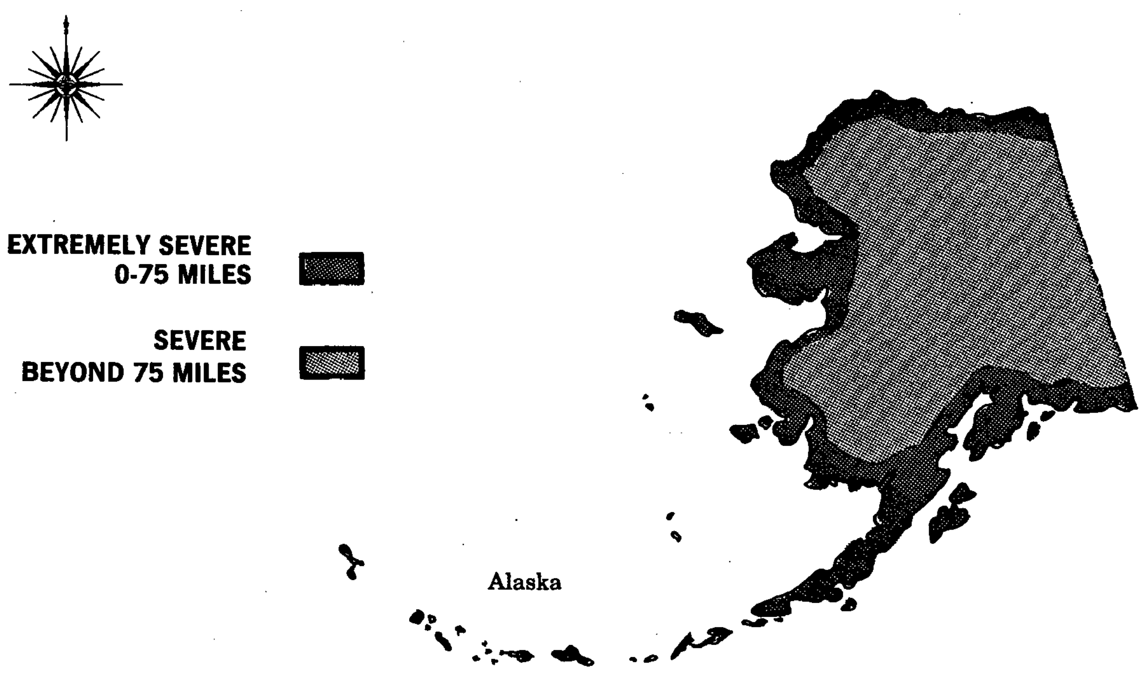


Figure 6

CORROSION AREA

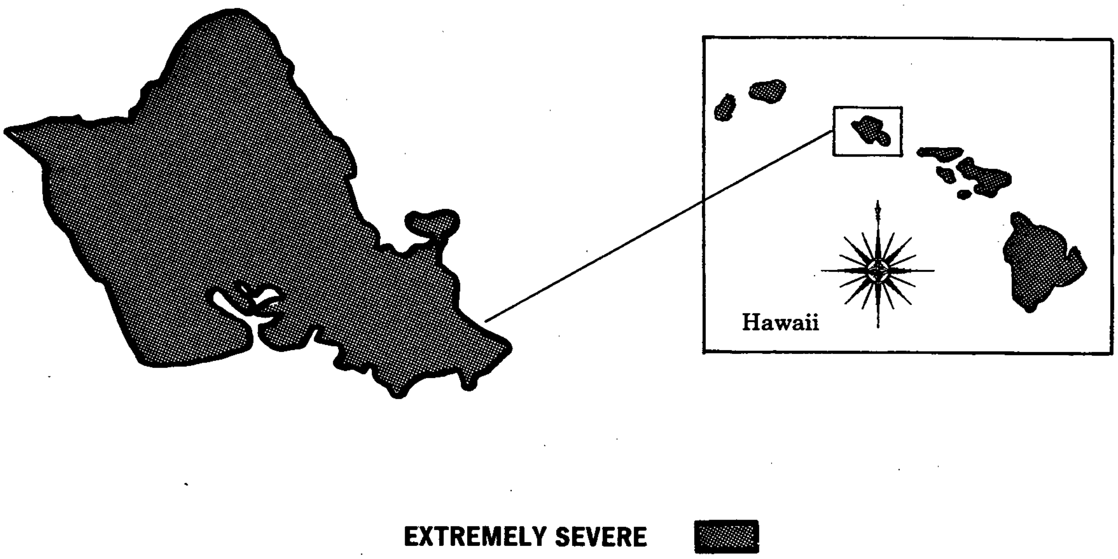


Figure 7

CORROSION AREA

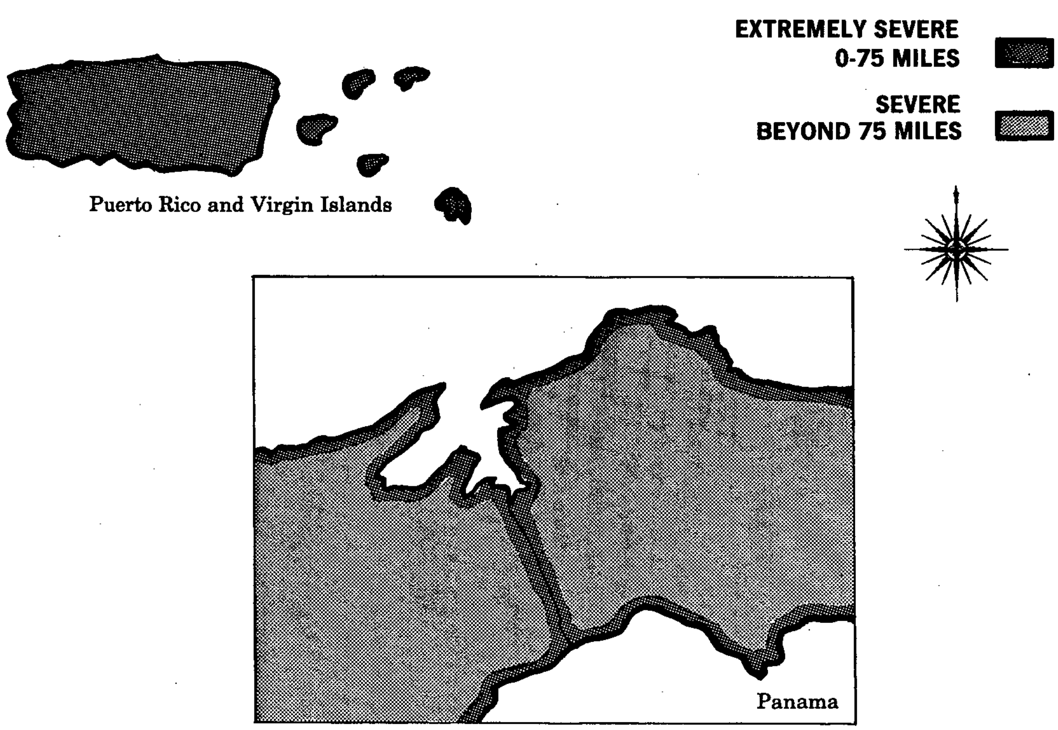


Figure 8

CORROSION AREA

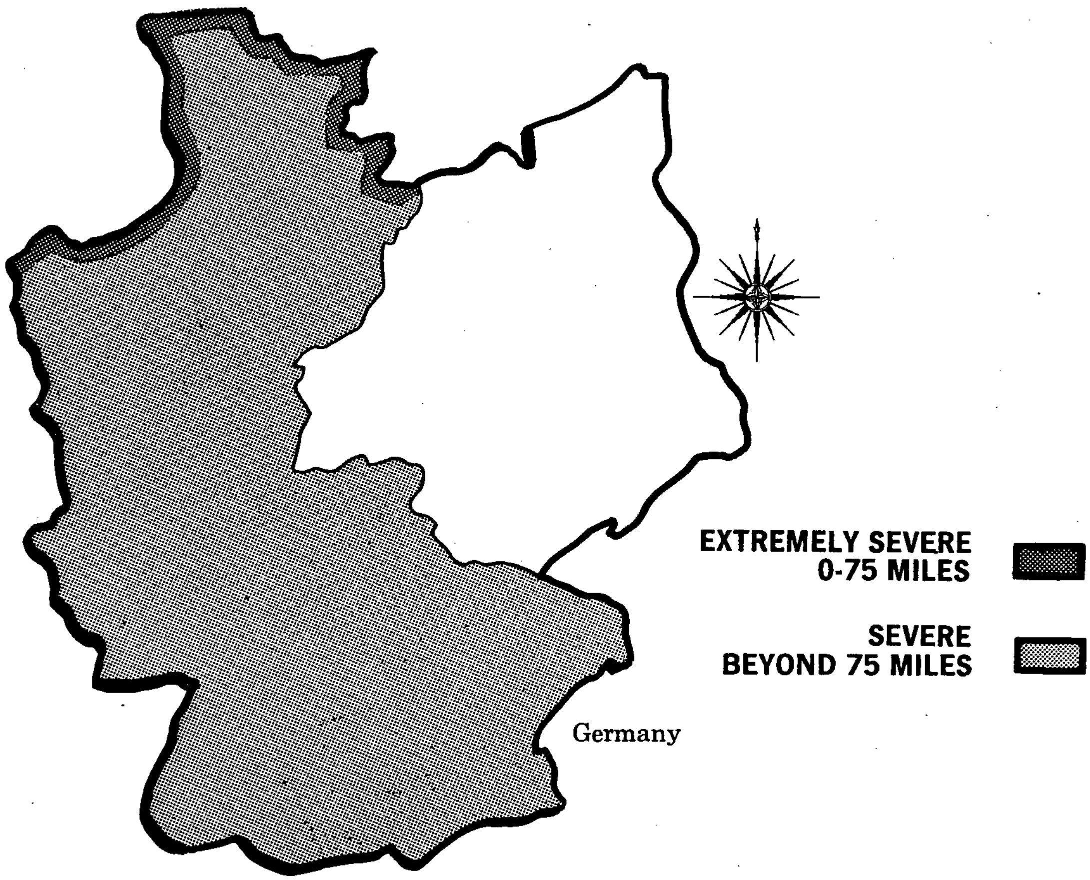


Figure 9

CORROSION AREA

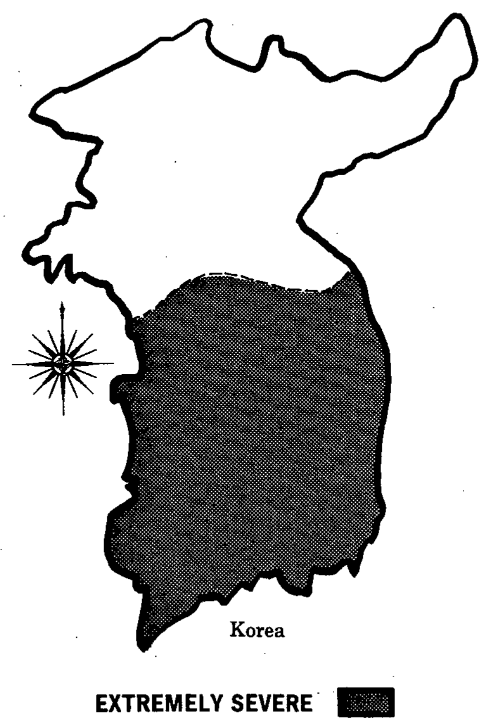


Figure 10

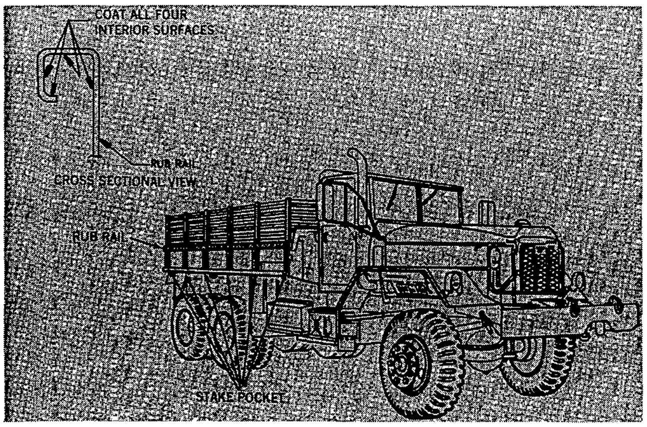


Figure 11

- Pockets
- Sills (boxed in areas, Figure 12)
- Panels
- Support Channels
- Tube Rails
- Seams (Figure 13).

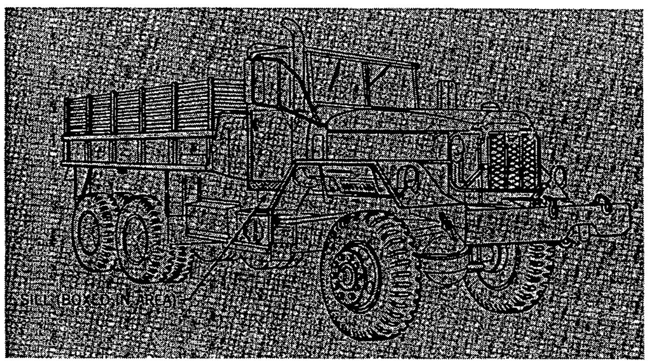


Figure 12

Several steps have been developed to aid in corrosion prevention:

(1) Operators should wash their equipment daily with fresh water when operated in areas where salt is used to melt snow, or in areas where there is a high salt concentration in the air.

(2) Fiber or rubber floor mats should be permanently removed from tactical vehicles to prevent water from being trapped under mats, causing floor pans to rust. Floorboards should be cleaned, repaired if needed, and sprayed with "non-slip deck covering compound".

(3) Drainholes, including drilled holes on the underside of the vehicles, should be kept clean and open to prevent moisture accumulation.

(4) In areas with high salt concentration, canvas covers for vehicles and trailers should be retained in place on static vehicles in motor pools to reduce the amount of rain and mist entering crew and cargo compartments.

(5) Vehicles and trailers should be parked under shelter, when available.

(6) Tactical vehicles and trailers treated with rustproofing materials should not be steam cleaned or cleaned with solvent, as the protective rustproof coatings may be damaged or dissolved.

(7) When corrosion is found on items, the rusted area should be promptly treated to prevent further corrosion by sanding or grinding the rusted area, spraying with primer, and camouflaging and topcoating.

(8) If possible, park trailers on a slope to allow drainage.

(9) Tilt dump beds to allow drainage.

Each of these steps aids in preventing the development of corrosion. One of the best methods of rust prevention now is a thorough application of the approved rustproofing

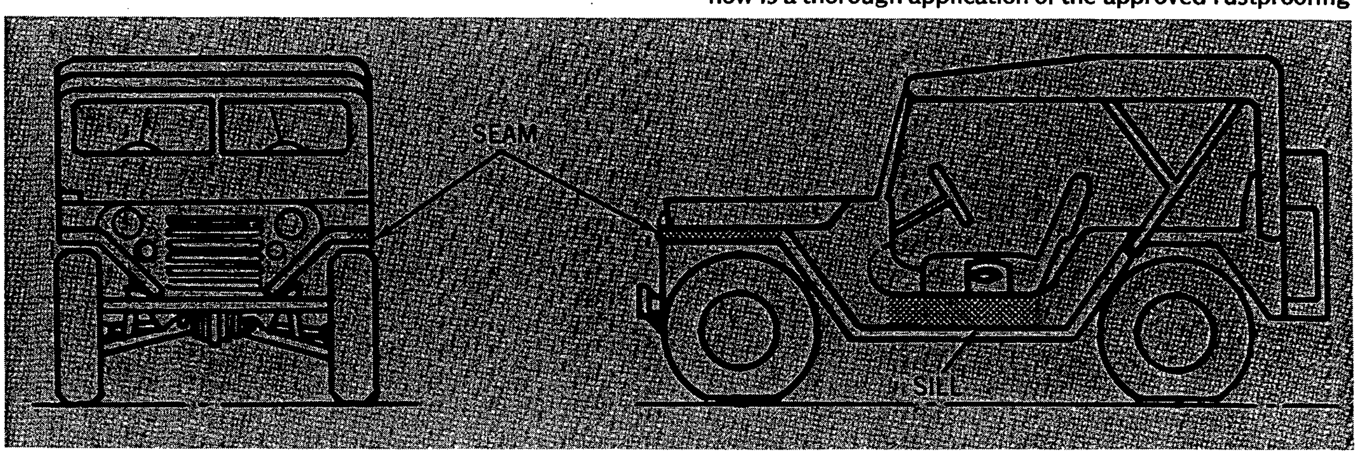


Figure 13

compound for fielded equipment. Before rustproofing can be applied, each vehicle must be cleaned and thoroughly dried and all corrosion damage must be repaired according to approved procedures.

Repairing Corrosion Damage

As an aid in evaluating corrosion damage and planning repair procedures, corrosion has been classified into four stages (Figure 14):

Stage 1—Red, black or white corrosion deposits on surface accompanied by minor etching and pitting. Base metal is sound.

Stage 2—Powdered granular or scaled condition resulting in errosion of material from the surface. Base metal is sound.

Stage 3—Surface condition and corrosion deposits are similar to Stage 2 except that metal in the corroded areas is unsound and small pin holes may be present.

Stage 4—Corrosion has advanced to a point where the surface has been penetrated. No metal remains at the point of severest corrosion. There are corrosion holes in the surface or metal is missing along the edge.

Vehicles with Stage 1 or Stage 2 corrosion will be cleaned, primed, topcoated, and rustproofed as necessary. Vehicles with Stage 3 or Stage 4 corrosion should be repaired and painted in those areas or should have assemblies replaced with new assemblies if repair is uneconomical. All repaired vehicles shall be rustproofed.

In addition to corrosion repair, there are various body replacement parts available for the corrosion damaged vehicles. These include:

- Underbody kits for M151
- Body replacement kit for M151A2
- Cargo boxes, body parts available for other vehicles.

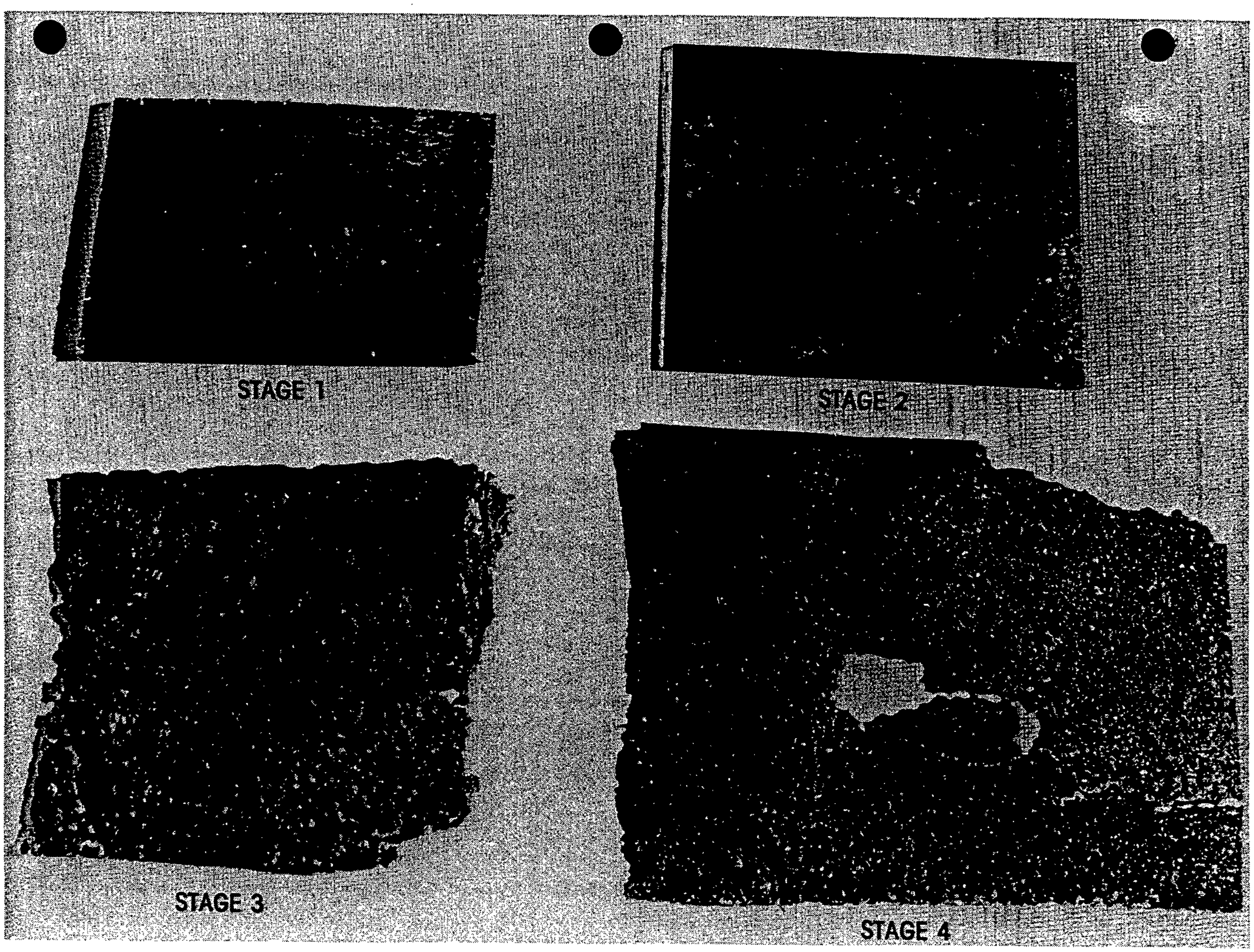


Figure 14

Rustproofing

The following outline consists of general procedures to be followed in completing a rustproofing operation. Some of the information contained here applies only to specific types of vehicles. Specific details for the application of rustproofing compound for each vehicle are covered in TB 43-0213.

Pre-cleaning the Vehicle. (1) Every vehicle will be clean and dry before rustproofing. Since it takes at least 1½ hours to dry a vehicle completely under ideal conditions, all vehicles to be rustproofed during the day should be cleaned first thing in the morning. A high pressure wash is recommended to aid in cleaning vehicles. It is necessary to direct the water spray at every area where dirt may have accumulated. Be sure to feel such areas as the fender lips, lower fender brace, top of frame members, etc., to be certain that the entire underside is clean. Particular attention should be given to the front fenders since dirt is often packed around headlight housings and in the eyebrow areas. (2) Pre-cleaning and drying vehicles in the morning can be reduced by having cleaned a number of vehicles the afternoon before. This allows washing the afternoon before and the assurance of dry vehicles to start the morning production.

Preinspection Procedure for Fielded Vehicles. (1) Using an inspection light, inspect the entire vehicle, while paying particular attention to the areas where dirt and moisture will collect. Any seam that has begun to split or expand should be repaired, and all other metal surfaces that have begun to pit or flake. (2) If the rust is in the first or second stage of development, it will be successfully neutralized by rustproofing if the area is properly cleaned and sanded, primed, and painted where possible.

Inspection Procedure. (1) Start by removing vents or plugs that will enable you to get a good look at the interior surfaces of the sheet metal where the serious rust may develop. (2) Begin at the front of the vehicle. With the hood up, check the perimeter of the hood, top seams of the fenders, and eyebrows. Look through openings in fenders (where possible) to check as much of the front fender and wheelhouse seam as possible. Look down on the frame (check for flaking). Check the battery box, radiator supports, and headlight hardware. (3) Work your way around to the driver's side of the vehicle. Generally, this side of the vehicle will rust faster because the oncoming traffic will splash more salt-laden water and slush onto the vehicle. As you walk around the vehicle, check for bubbling and discolored paint, which could be (and in most cases is) caused by rusting from the inside. If you do find any rusted area on the outside of the vehicle, you must determine whether it is just surface rust due to a paint nick or a bad paint job or whether it is working its way out from the inside. Also, keep checking for any signs that may indicate that the vehicle has been repaired. If the area was repaired because it was damaged by an accident, and was properly repaired, then plastic fillers were not used. Penetrant will damage these fillers. In some instances, only an expert bodyman can recognize a proper repair job, so be extremely careful. (4) With the front door open, look through the door hinge opening (when possible) to check the front fender, wheelhouse seam, and fender brace. The fender brace is probably the most critical area of the vehicle and should be inspected very carefully, both from the inside and outside of the vehicle. (5) If a seam has begun to discolor, it is usually an indication that the seam may soon begin to split. If the seam has begun to split, it must be repaired along with other rust damage repair. (6) Check all seams on doors, door jambs, and dog legs. Look for chipped or bubbling paint, discoloration of the painted seams and splitting seams. If the paint is chipped, you will probably only have a surface rust problem. However, if the paint is bubbling, there is a good chance that second or third stage rust has developed. If there is good metal under it, then the bubbling paint is probably due to the fact that the metal wasn't prepared properly before painting or a small chip in the paint enabled impurities to get under the paint and begin to corrode the metal. If you cannot find good metal under the bubbling paint, the rust has worked its way through the metal and must be repaired. (7) If the seams have begun to split, it is an indication that stages three and four rust have developed and should be repaired/replaced. (8) On most vehicles, if you roll the window all the way down, you can look through the top of the door to inspect the outer skin. If this is not possible, the condition of the seams will give you a true indication of the condition of the door. (9) You can inspect the rust of the quarter panel and wheelhouse seam, floor extensions, and seams around taillights. Inspect the perimeter of the tailgate, particularly the rear or bottom seam where dirt and moisture will settle. (10) On some vehicles, it may be necessary to remove the taillights or even loosen an interior panel to properly inspect the quarter panel. (11) If you take a look through the wheelwell openings, you can get a good indication as to the condition of the underwide. Check the wheelhousings, floor pan, frame, etc. If you do not feel that you can properly inspect the underside this way, put it up on a hoist.

Helpful Hints

Enlarged or elongated holes are sometimes hard to plug. If you keep a few plastic plugs in a container or solvent, they will swell up and more readily fit such holes. Rags must be placed over brake, gas, and clutch pedals and remain in place during processing. This is to prevent transfer of rustproofing compound from the rustproofers' shoes to these pedals. This can cut cleanup time considerably. Cleanup time can also be reduced by wrapping a rag around windshield wiper blades before processing.

NOTE: The positive (red) terminal of a vehicle's battery must be covered to prevent grounding the battery through a spray tool. Such grounding could cause sparks and a fire. Also, cutters are designed to cut best at between 2100 and 3000 RPM. High speed drill motors will cause the blades to overheat and become work-hardened, making them brittle and easy to break.

Further, cutters should be dipped in oil after every other vehicle is drilled. This will considerably lengthen their useful life. On cool, damp days, material pumps can be kept from freezing up by injecting three or four spoonfuls of antifreeze (ethylene glycol) into the air intake. If heavy overspray is wiped off of fenders, doors, etc., immediately, the final cleanup process will be quite a bit easier. For maximum efficiency, air and material hoses should be kept clean. After cleaning, dry them off with a rag and coat them with a silicone spray. This will help prevent sealant from sticking to them.

To avoid excessive dripping in hot weather, note the following tips: (1) Turn the pressure down on the pump until the spray pattern from the tools turns to a finger-like pattern. Increase pressure until a fan-shaped pattern takes shape. You then have the proper spray pattern at the lowest pressure. (2) If possible, put vehicles in the sun and allow them to drip for a few hours. Then put them in the shade for a half hour to cool. (3) Make your technicians aware of the fact that the material will drip more in hot weather. They will have to move the tools quickly, so as to apply the material in thinner coats until complete coverage with 5 mil thickness is achieved. (4) The more the vehicle is driven after rustproofing, the quicker it will set up. (5) After cleanup of a vehicle, leave doors open enough so the material drips on pavement and not all over the rocker panels. (6) When processing undersides, hold spray tool approximately 12 inches away from the bottom. This will result in thinner, more uniform coating. It has been found that when the technician who processes a vehicle has to clean it up he will generally be more careful about overspray.

All chips from drilling holes should be removed immediately. Flying chips could injure personnel. They can be easily picked up by a rag and result in severe scratches to the paint. The powerwash should never be directed into window moldings or seams as it can wash away the rustproofing compound on interior surfaces. The rustproofing compound will penetrate sound deadener in doors. It will also prevent undercoating from drying out, cracking, peeling, etc., if it is applied within a reasonable time. If possible, the underside of the vehicle should be processed last. This will give it more time to dry after pre-cleaning and also make it easier to clean the vehicle, as the overspray will not have a chance to set up.

Emission Control Devices

Emission control equipment is installed as an integral part of the anti-pollution package. This is a very complex system. However, our concern in the rustproofing process is the emission control canister and the instruction placard. Federal law prohibits covering up or destroying the placard and interfering with the filter element on the canister. The instruction placard and emission control canister are all located in the engine compartment. The placard can normally be found either on the inner wheel housing or radiator support shield. The canister is normally located in the forward lower section of the engine compartment.

To comply with this Federal law, the following procedures must be followed:

(1) Locate the emission control placard, as mentioned above, and use masking tape to cover before spraying. Remove the tape after spraying engine compartment.

(2) Locate emission control canister and either tape or wrap a rag around the filtering element to prevent coating. This should be done while processing the bottom side. The canister can be identified by its round, black can-shaped appearance with two rubber hoses coming from it. The filter element is on the bottom side of the canister and is of a foam or fiber type.

Vehicle Areas for Rustproof Application

Disc Brakes: As in the case of conventional brakes, disc brakes should never be sprayed. Be certain that the technician knows the location of all brakes and uses caution to avoid them. It helps to cover these areas prior to processing the underside.

Engine Compartment: When processing the engine compartment area, do not get material on transistor electrical systems, regulators, alternators, generators, radiators, horns, engine blocks, or electrical wiring. Also, avoid ignition resistors, windshield washer solvent reservoir, heater assemblies, and pollution control systems.

Eyebrow Sections: Before opening any holes in this area, be certain that there is no electrical wiring inside the boxed section. Such wiring would be found on vehicles which have fender-mounted turn signals.

Front Ends: It is sometimes necessary to remove headlight rims in order to spray coat headlight buckets and associated hardware. If the rims are metal, be sure to paint the back side of the rims before they are replaced. Some late model commercial vehicles may have the air intake for the carburetor located inside one of the front fenders or on either side of the radiator. Be certain that no foreign material plugs these intakes.

Seat Belts: Vehicles with seat belts that roll back into the rocker panel should be pulled out be before processing. Use caution when processing this area so you

Seat Belts: Vehicles with seat belts that roll back into the rocker panel should have the belts pulled out before processing. Use caution when processing this area so you don't coat the return rollers.

Fenders: The lower rear exterior areas of both front and rear fenders on many vehicles are subject to abrasion due to debris thrown up by the tires. This abrasion can lead to serious surface corrosion.

Radiator Shutters: Many large trucks are equipped with moveable radiator shutters. These shutters are opened either automatically or manually according to engine temperature. When rustproofing vehicles so equipped, be careful not to coat the shutters, hinge areas, or electrical connections. Shutters which are stuck shut with rustproofing material can cause the engine to overheat and possibly "freeze up".

Rocker Panels: Some vehicles use internal baffles in the rocker panels to increase their strength. These baffles can be located by the visible spot weld marks on the underside of the rocker panel. Be sure to open an access hole between each set of spot welds in order to cover all boxed-in areas.

Drive Shafts: Drive shafts could be bent when placed on the frame contact hoists improperly. Special care should be used placing all vehicles on lifts.

Front and Rear Soft Fascia: Do not spray parts made of plastic. Rustproofing may cause distortion and unsightly appearance.

Underside: Any overspray should be removed from the radiator, oil pan, transmission pan, clutch control rods, drive shaft, brakes, shock absorbers, and tires. Material left on the tires, wheels, or drive shaft may cause excessive vibration, which could result in costly damage. Material on the brake mechanism may render the brakes ineffective due to the lubricative properties of rustproofing compound. Clamps which hold the brake and gas lines should be thoroughly covered.

Figure 15 shows how these clamps can accelerate corrosion:

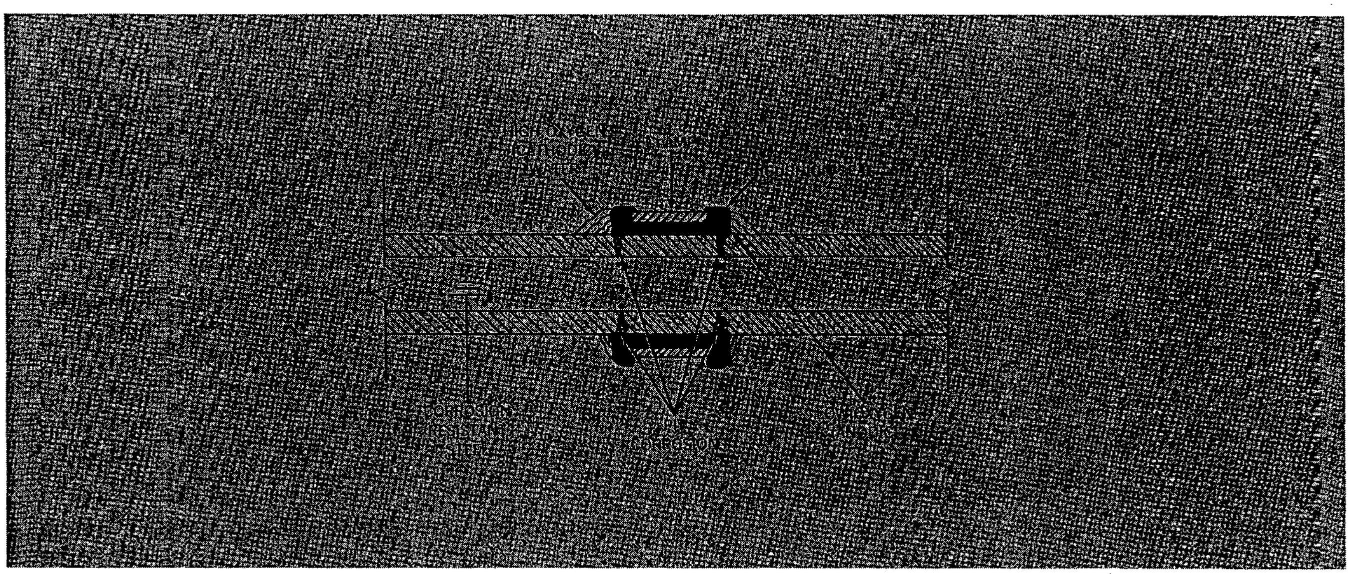


Figure 15

Corrosion is accelerated in areas where there is a differential in the amount of oxygen present. In Figure 15, it can be seen that the cushion seal results in a low oxygen area, while the line itself is in a high oxygen area. This differential, with water as an electrolyte, results in a rapid pit corrosion and line failure. Process these areas thoroughly.

Window Channels: Because of rustproofing compound's adhesive qualities, care must be used to avoid getting the material into the window channels or doors and tailgates. Material in these channels can cause two kinds of damage. First, the solvents in the material may affect the adhesion between the window channel and the channel liner, allowing the liner to fall off or stick to the window itself. Second, the material may either prevent the window from being lowered all the way or keep the window in the down position. After processing, each window should be checked by raising and lowering it a few times. Windows must be in the up position after rustproofing.

Wiring: Use caution when replacing headlight or taillight assemblies. Some vehicles have little or no insulation on some of the wires; and faulty replacement could lead to shorts. In some cases, entire wiring harnesses have been ruined, resulting in costly repairs.

Catalytic Converters and Heat Shields: Since 1975, catalytic converters have been a mandatory requirement on vehicles weighing 6,000 pounds or less. These converters operate at extremely high temperatures of 1,000 F (580 C) to 1,700 F (927 C) and could be a potential fire hazard. To eliminate the possibility of fires, heat shields have been installed between the bottom side of the floor and the converter to dissipate heat generated by the converter. Therefore, rustproofing of any kind must not be applied to the converter or heat shield.

NOTE: Do not apply rustproofing materials closer than 12 inches to the converter and heat shields. Wipe off overspray prior to removing vehicles from hoist. Failure to do so will cause overheating and possible damage.

Safety Precautions Important

When working with chemical substances, such as rustproofing compound, the effect of that substance on people exposed to it must be studied. Industrial toxicology is the study of the effects of these substances on the human body. Some of the factors considered in toxicology include:

- Quantity or concentration of the material
- Duration of exposure
- State of dispersion (size of particles, are the particles dust, fumes, gas)
- Attraction of the chemical to human tissue fluids
- Solubility (ability to dissolve) in human tissue fluids
- Sensitivity of human tissue or organs.

Each of these six factors allows a wide range of variation. More importantly, each person's reaction to these factors may vary greatly. The reaction of different people exposed to the same quantity and quality of a chemical substance may range from no effect through severe poisoning. The exact reasons why some people are relatively unaffected by a particular exposure to a substance, while others are severely affected, are not known.

Toxic dosage is measured in threshold limits (TL) which are set by the American Conference of Governmental Industrial Hygienists. They represent conditions under which a majority of workers can be repeatedly exposed without adverse effect. These values represent a time weighted average concentration for a normal 8 hour, 5 day week.

THRESHOLD LIMIT VALUES

Toxicity	Parts Per Million (PPM)
Slight	0-100
Moderate	101-500
High	Over 500

The rustproofing sealant is a combination of polar petroleum waxes and petroleum based polar chemical additives in an aliphatic petroleum naptha. The modifier or solvent is also an aliphatic petroleum naptha. The threshold limit value for these substances is 500 ppm in airborne concentration.

The potential hazards of exposure to rustproofing compounds can be controlled in two ways: through proper medical/sanitation control and through the use of adequate facilities.

Medical/Sanitation Controls

Education: To inform the user of the potential harmful nature of rustproofing material (this is not to indicate that rustproofing compound must be handled like radioactive material, but rather that good sense must be used in handling and applying this material). It should not be swallowed, sprayed on others or inhaled.

Personnel Protection Devices: Masks should only be relied upon when it is impossible to insure proper ventilation. Reliance on masks is only permissible when the exposure is short (only a few minutes) and infrequent (no more than 10-20 times daily). Eye protection is mandatory during all cleaning, drilling and rustproofing operations.

Personal Hygiene: Proper washing facilities, including hot water and mild cleaners should be readily available to the rustproofer. Clean work clothes should be worn daily.

Facilities

- Ventilation which consists of local exhaust and general spray.
- Enclosures to confine spray when underbodies are being sprayed.

Definitive Analytical Results

Rubber Based Gas Mask Deterioration

Robert E. Sacher
Polymer Research Division
U.S. Army Materials Technology Laboratory

A first step has been taken at the U.S. Army Materials Technology Laboratory toward prevention of gas mask deterioration. A preliminary series of analyses indicate the natural rubber from which the masks are fabricated remains relatively unaffected by environmental effects, but that compounds intermixed with the base material undergo changes that degrade the effectiveness of the mask.

Two M17 gas masks which varied in the extent of dry rot and cracking were analyzed by a number of different techniques to determine the cause of deterioration. These techniques included solvent extraction followed by both infrared and gas chromatography-mass spectroscopy analysis and thermal analysis. The results show that the disappearance of a wax protector and the antiozonant incorporated in the system is the cause of rotting and degradation. The natural rubber system appears to stay intact upon aging.

Analysis Program Initiated

Three masks were submitted to AMMRC in order to seek a method for the nondestructive evaluation of the condition of the rubber in these masks. Such a method would be useful for deciding whether the rubber has residual life or has to be retired for cause, when masks are brought back to the depot. The methods to be evaluated included techniques which would identify the cause of deterioration not only in natural rubber type masks but also in silicone rubber masks.

The three masks received by AMMRC were identified by the following:

- **Sample 1:** Relatively new mask
- **Sample 2:** Slight amount of dry rot barely visible
- **Sample 3:** Dry rot throughout entire mask

The masks were reported to have the following chemical formulation and meet MIL-STD-51495:

Differing Approaches Taken

Four analytical techniques were utilized in assessing the deterioration of the M17 rubber masks.

Solvent Extraction followed by **Infrared Analysis** of the extract. Approximately 10g of the material was taken from around the mouth area of each gas mask. Each sample was then extracted in both acetone and methylene chloride for 24 hours. The extract solution was then filtered and dried at room temperature under vacuum. The extracted rubber was also dried under vacuum at room temperature.

Each residue was then redissolved in methylene chloride. A film was deposited on a potassium bromide salt crystal. An infrared spectrum was taken from 4000 cm^{-1} to 600 cm^{-1} (Figures 1-3).

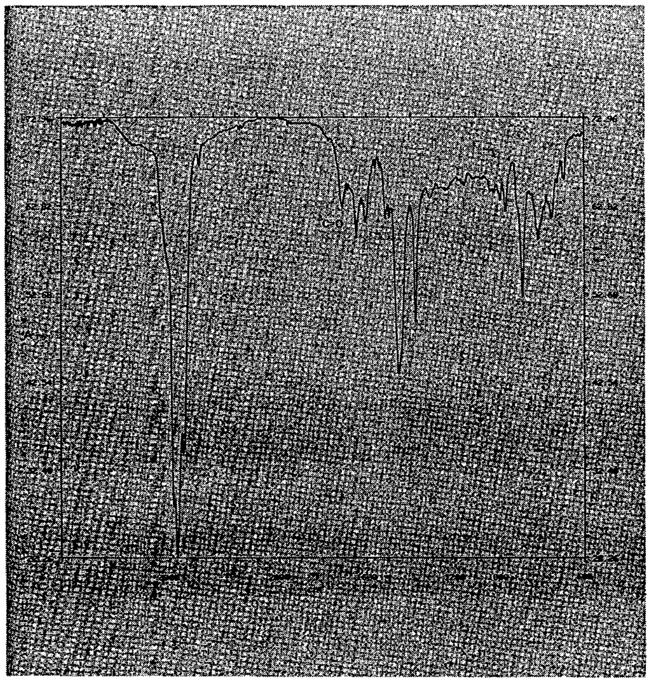


Figure 1. Infrared Spectrum of Methylene Chloride Extract of Relatively New Mask, Sample #1

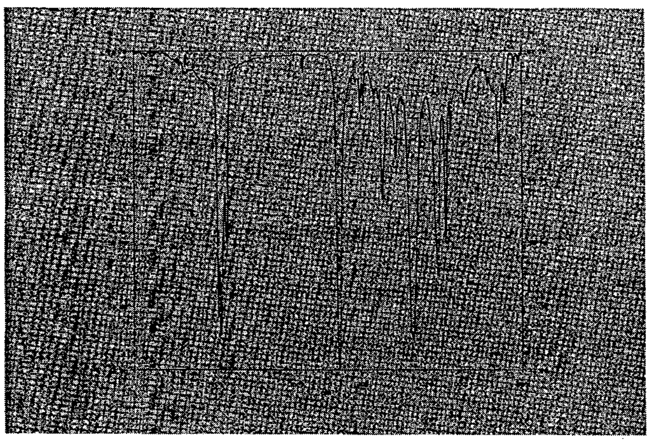


Figure 2. Infrared Spectrum of Methylene Chloride Extract of Gas Mask, Sample #2

Pyrolysis Infrared Spectra control wave was measured for samples of the M17 rubber mask taken around the mouth area and from the extracted samples produced from the methylene chloride and acetone extractions. Each sample was pyrolyzed using a Foxboro Analytical Model 40 pyro-chem accessory. The Pyrolysis temperature was set at 450 C for 45 seconds. The pyrolysis chamber was purged with nitrogen gas prior to actual pyrolysis to avoid sample oxidation. The pyrolyzate was deposited onto a KBr salt plate which was introduced directly into the sample compartment of the FTIR spectrometer. A model 1550 FT-IR manufactured by the Perkin-Elmer Corporation with a Model 7500 PE computer was used to obtain all the FT-IR spectra, which yielded results identical to those obtained via the solvent extraction procedure.

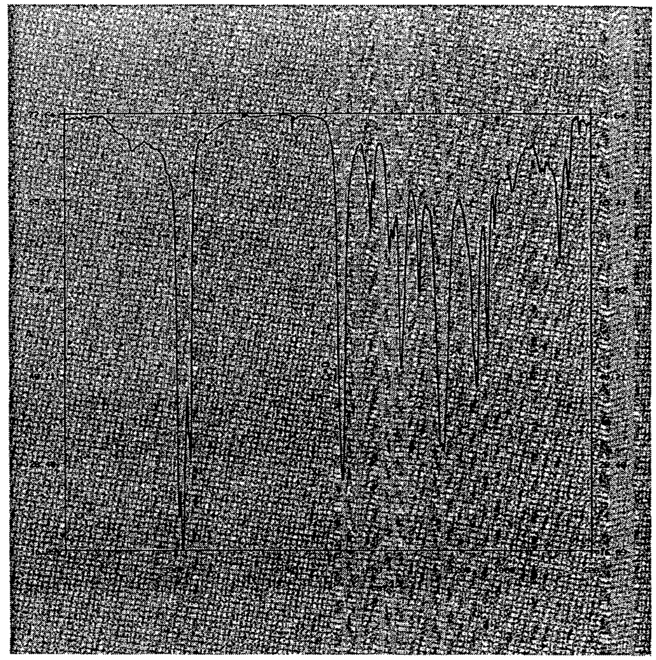


Figure 3. Infrared Spectrum of Methylene Chloride Extract of Dry Rot Throughout Entire Mask, Sample #3

- **Differential Scanning Calorimetry Analysis (DSC), Thermogravimetric Analysis (TGA) and Thermomechanical Analysis (TMA).** The thermal analysis measurements were made on a Dupont 1090 thermal analyzer system utilizing a 910 DSC cell, a 951 thermogravimetric analyzer, and a 941 thermomechanical analyzer. Copies of the DSC scans are included with the experimental conditions listed on each scan (Figures 4-6).

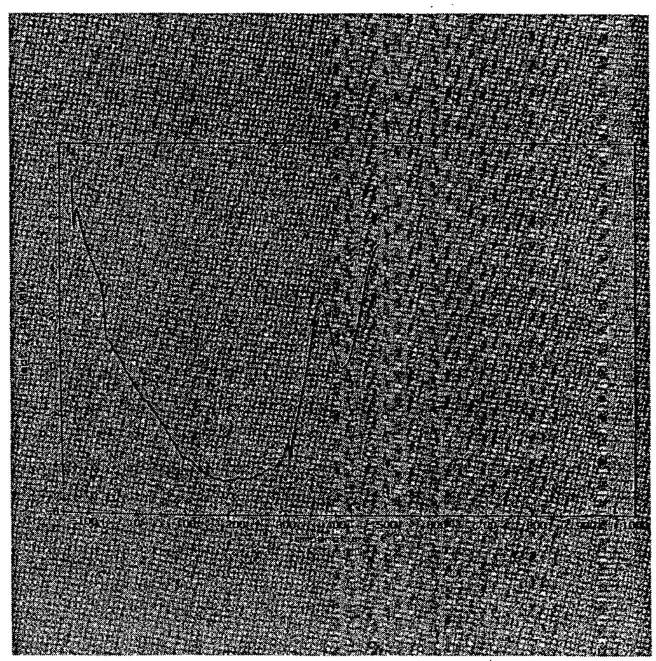


Figure 4. DSC Scan of Relatively New Mask, Sample #1

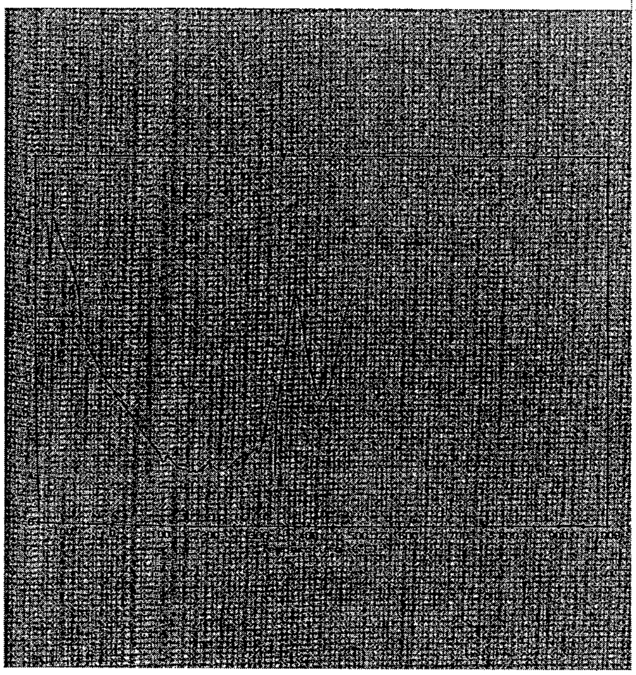


Figure 5. DSC Scan of Gas Mask, Sample #2

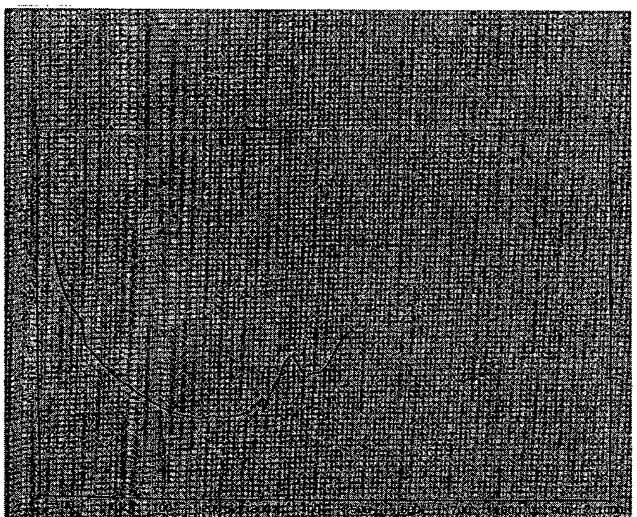


Figure 6. DSC Scan of Dry Rot Throughout Entire Mask, Sample #3

- **Acetone Extraction/Gas Chromatography/Mass Spectroscopy Analysis** was performed on each extract using a Hewlett Packard Model 5996 GC-MS interfaced to a 1000 data systems. A 12 meter fused silica capillary column of cross-linked methyl silicone (SE-30) was programmed from 50 C to 260 C at 10 C/min. A mass range of 33-450 amu was repeatedly scanned at 2.5 second intervals. The chromatographic effluent was subjected to electron ionization spectrometry analysis at 70eV at 5 x 10-5 torr. Spectra derived from each analysis were compared to a computerized reference spectra contained in the Wiley-NBS data base. The pyrograms are shown in Figures 7-9.

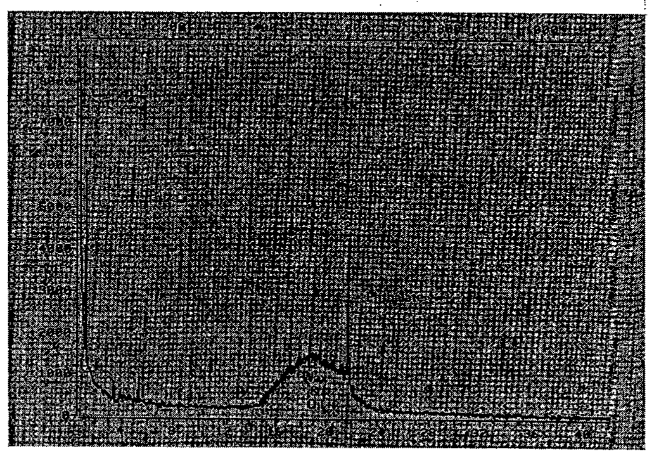


Figure 7. Gas Mass Chromatogram of Relatively New Mask, Sample #1

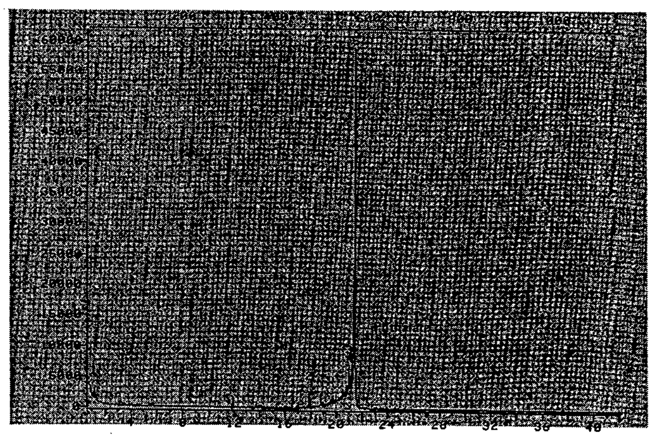


Figure 8. Gas Mass Chromatogram of Gas Mask, Sample #2

Results Definitive

Extraction of rubber masks (samples taken from area around mouth piece):

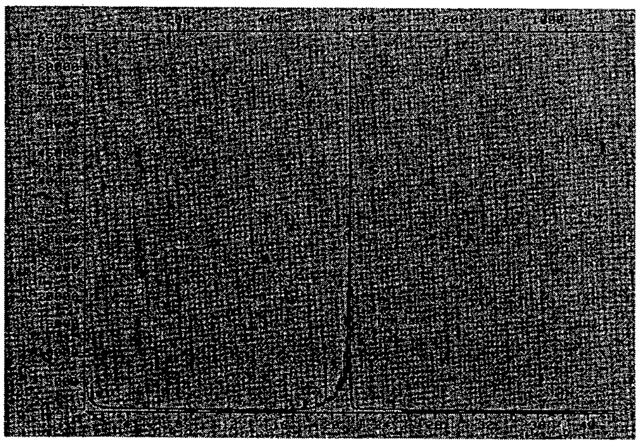


Figure 9. Gas Mass Chromatogram of Dry Rot Throughout Entire Mask, Sample #3

Sample	Solvent Extraction Weight Loss, %	
	Acetone	**Methylene Chloride**
1	**6.15**	**6.80**
2	**8.86**	**9.10**
3	**8.37**	**8.41**

Infrared Analysis of the solvent extracts and pyrolysis products of the extracted and nonextracted M17 mask show the growth of a carbonyl absorption at 1740 cm^{-1} for Mask #2 and Mask #3. This frequency is most likely due to oxidation of the rubber surface and is not detected in the control sample.

The **Differential Scanning Calorimetry** and **Thermomechanical Analysis** show a Tg of approximately -60 C for all samples. This is the typical Tg found for all natural rubber. In addition, the typical exotherm for natural rubber is found in all three samples peaking at 400 C.

The **Thermogravimetric Analysis** curves illustrate similar features for the natural rubber, carbon black, and inorganic composition for each mask. The volatile components have changed. Less volatiles are detected in the two aged samples between room temperature and 150 C, but a higher concentration of volatiles in the 200 C to 300 C range.

Acetone Extraction/Gas Chromatography/Mass Spectroscopy Analysis shows difference between the control sample and the two aged masks. The extract from the control sample showed bis 2-ethylhexylphthalate, UOP-688, the antiozonant in the formulation, a wax substance most likely, the heliozone wax applied to the surface of the masks for environmental protection, and an oil substance. The extracts of the control material only detected the phthalate material. There was complete absence of UOP-688, any waxes or oil materials.

Findings Reviewed

- **Solvent Extraction** of the gas masks illustrated a higher concentration of extractable material for the rotted samples than the relatively new material. The additional material is very likely a result of degradation or oxidation products.

- **Infrared Analysis** shows the aged rubber to have formed organic oxidation products on the surface. It is very likely that the heliozone wax and the antiozonant, UOP-88, have been consumed, leaving the surface ripe for attack by light and oxygen.

- From the **Differential Scanning Calorimetry** and **Thermomechanical Analysis** results, it appears that the natural rubber component is still intact in its original structure.

- **Thermogravimetric Analysis** further supports the disappearance of the wax protector and the antiozonant material along with the onset of oxidation products in the aged masks.

- **Gas Chromatography/Mass Spectroscopy Analysis** of the solvent extracts illustrates the disappearance of the environmental protective wax coating and the total consumption of the antiozonant, UOP-688.

Future Study Required

In order to determine the effectiveness of the heliozone wax toward the prevention of environmental deterioration of the gas mask (cracking, rotting, and crazing) and the antiozonant (UOP-688) and its current effectiveness toward protecting the system from the attack of ozone and oxygen and, also, the effect of other additives, a fundamental study is required in order to determine the effect of all the ingredients toward deterioration. A variety of compositions need to be made up which require all the raw materials. These formulations would be aged under a variety of natural and accelerated conditions in order to determine the rate and mechanism of rotting and cracking. As a final product, a recommendation would be made which would include the ideal formulation and processing history to provide the optimum environmental-durable gas mask system.

The Technical Arm At Work

NACE: Corrosion Control Protecting Government and Industry

Carolyn Donahoo
Technical Activities Manager
National Association of Corrosion Engineers
P.O. Box 218340, Houston, Texas 77218

The National Association of Corrosion Engineers (NACE) has long been known for its work in combating corrosion problems. However, one important aspect of the Association often is not given credit due. This is the membership and active participation in the Association's technical committees.

The technical committees of the National Association of Corrosion Engineers serve as the technical arm of the Association. They are composed of interested and technically competent professionals from a variety of disciplines concerned with corrosion and its control. Committee members work together to identify and document important information related to corrosion and to discuss and develop solutions to corrosion problems confronting industry. Members of technical committees range from technicians to engineers, from research scientists to managers, and encompass a diversity of educational, industrial, and technical occupations affected by corrosion processes.

NACE membership is a prerequisite to Technical Committee participation. Information about membership in NACE can be obtained from:

National Association of Corrosion Engineers
P.O. Box 218340
Houston, Texas 77218 7131492-0535
Telex: 792310

Technical Committee Objectives

The primary purpose of NACE's technical committees is to document and disseminate information about corrosion and methods of controlling corrosion. The technical committees prepare technical state-of-the-art and informational reports, NACE Standards, and other documents of value to guide and assist persons in corrosion work. Corrosion publications completed by the technical committees are developed through a process involving an open exchange of information between experienced corrosion professionals in which solutions are considered, discussed, and documented. In addition, the committees sponsor annual technical symposia, information exchange meetings, and various other forums for the dissemination of corrosion related technology.

NACE's technical committees address virtually every conceivable corrosion related subject and encompass a range of industrial topics—pipeline corrosion, corrosion within the petroleum refining industry, protective coatings and linings, biological corrosion, corrosion within nuclear systems, corrosion in petroleum production, and the economics of corrosion. These corrosion topics and many more technical areas are addressed by the more than 300 technical committees. Furthermore, emerging corrosion technology and potential new areas of committee interest are constantly being investigated. In many instances NACE becomes cognizant of the need for information relating to a particular area of corrosion control through its contact with industry, government, or business and works to fill this need with documentation of technical information. If no appropriate technical committee exists, one may be formed to address a specific corrosion issue.

Their Structure and Operation

The Technical Practices Committee (TPC) represents the NACE technical committees in matters of policy within the structure of the National Association of Corrosion Engineers. The TPC serves as the administrative and policy-making body for the technical committees and provides direction to these committees as needed. Under the direct leadership of the TPC and within the stairstep series of subcommittees are group committees, each of which directs its attention to a broad industrial or phenomenological area as it pertains to corrosion control. Group committees are usually divided into one or more unit committees, which focus efforts toward more specific areas within the scope of the parent group committee. Task groups are components of unit committees; task groups undertake corrosion research, review data, and investigate diverse technologies; the end result is that most activities that lead to the development of documents address particular corrosion problems or issues. When a more specific focus of activities is needed, task groups may, at their option, establish work groups to perform segments of the task group's assignment. Figure 1 illustrates the basic structure of the technical committees under the Technical Practices Committee. A listing of all group and unit committees is included for reviewing the specialized areas of interest represented within the technical committee structure.

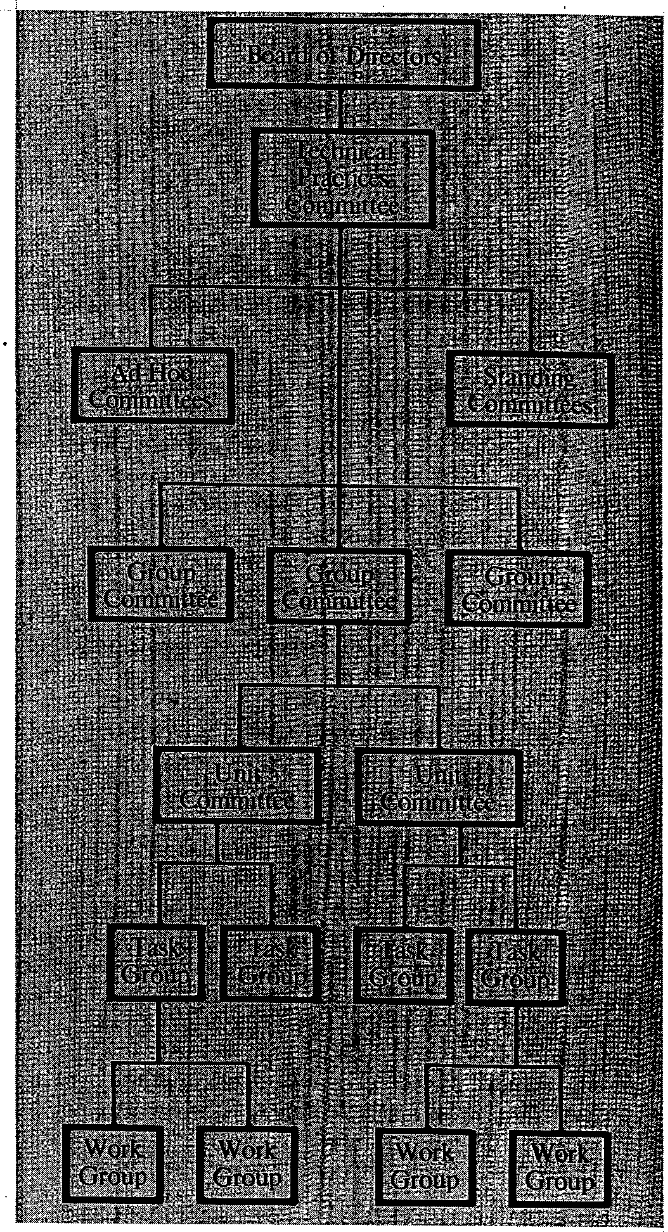


Figure 1

Responsibilities of Committee Members

Responsibilities which accompany membership in a NACE technical committee usually vary with an individual's level of participation. In general, group and unit committee members must vote on documents developed by their own committees. In addition, the periodic review of technical committee publications and comment on committee documents is undertaken by all group and unit committee members. This review and comment is not an individually assigned task. When document reviews are required, committee members must make comment or respond to NACE Headquarters if they do not feel technically qualified to comment.

Task group members have the same responsibilities and are assigned additional tasks vital to the functioning of technical committees. Members of task groups participate in the completion of technical committee documents and are often asked to research and write segments of technical committee publications.

Prior to committee document publication, a series of reviews, ballots, and response requirements are completed to ensure consensus among qualified corrosion personnel. This process further ensures that NACE's technical committee documents are accurate and reflect the best current technology and practice as determined by experienced corrosion professionals within the many technical fields.

The Benefits of Membership

NACE technical committee members benefit both personally and professionally through participation in committee activities. A wealth of information on specific corrosion problems and technologies is available to individuals through participation in technical committees. Employers also benefit by members' increased knowledge of corrosion control technology. A knowledgeable staff is an asset if a company is to keep pace with technological advances of importance to its operations.

Recognized corrosion experts participate and share their experience and expertise with technical committee members. Membership in a technical committee not only provides the opportunity to gain knowledge and strengthen personal understanding of corrosion and corrosion related phenomena, but also allows one to develop professional relationships with persons in specialized fields of interest. Finally, an active technical committee member may also enjoy the personal satisfaction that accompanies undertaking a project and filling a need within industry; this, indeed, is a valuable accomplishment.

Requirements for Membership

All members of NACE are eligible for membership within technical committees. Membership is obtained by joining at the unit committee level by simply contacting the Technical Activities Department at NACE Headquarters. Upon joining a unit committee, an individual automatically becomes a member of its parent group committee. To participate as a task group member requires membership in the unit committee under which the task group functions. In addition, membership must be approved by the task group chairman. If a task group is writing an NACE Standard, the individual requesting membership must also have approval from his or her employer to participate.

Meeting Frequency, Location

The location and frequency of technical committee meetings depends upon the level of activity and project status of a committee. However, all unit committees typically meet during NACE's Annual Conference, which is held in either March or April.

Fall Committee Week, which is held in September, also provides an optimum opportunity for many technical committees to meet; group committees and task groups meet during these times when the need exists. In addition, task groups and work groups usually schedule meetings between the two scheduled major meetings if the nature of their work requires a more frequent meeting schedule. NACE Headquarters makes arrangements for meeting facilities and handles administrative details in most cases.

Attendance/Committee Membership

The best way to keep informed about committee activities is to participate in committee meetings and review and read all committee correspondence thoroughly. However, attendance is not absolutely necessary for group and unit committee membership as long as the member keeps active by correspondence and realizes the importance of maintaining committee participation through correspondence. Attendance at task group and work group meetings is more critical. Maintenance of membership on task and work groups without attendance at meetings is dependent upon the particular committee member, the level of participation required of him in relation to the committee project, and the needs of the committee chairman.

Recommended Membership

While there is no set policy limiting the number of technical committees a member may join, it is recommended that the potential member join only one or two committees at first. By initiating committee participation in a few specific committees, the potential member will be able to judge how much time he will be able to devote to committee activities and expand his participation from that point if he feels that it is feasible, or focus on only a few activities if this would be more valuable to him.

Procedures and Operations

The Technical Committees utilize operating manuals for coordinating committee activities. These manuals outline in detail how committees operate; copies of these manuals are available upon request to technical committee members and may be obtained from NACE's Technical Activities Department.

NACE Group and Unit Committees

NACE currently has ten major committees. Each of these is broken down into subcategories as shown below, while the basic structure of committees is shown in Figure 1.

Group Committee T-1: Corrosion Control in Petroleum Production

- T-1C Detection of Corrosion in Oilfield Equipment
- T-1D Control of Oilfield Corrosion by Chemical Treatment
- T-1E Cathodic Protection of Oilfield Equipment
- T-1F Metallurgy of Oilfield Equipment
- T-1G Protective Coatings and Nonmetallic Materials for Oilfield Use
- T-1K Carbon Dioxide Corrosion in Oil and Gas Production

Group Committee T-2: Energy Technology

- T-2A Nuclear Systems
- T-2E Geothermal Systems
- T-2F Fossil Fuel Combustion and Conversion

Group Sommittee T-3: Corrosion Science and Technology

- T-3A Corrosion Inhibitors
- T-3B Corrosion Products
- T-3C Economics of Corrosion
- T-3E Stress Corrosion Cracking and Corrosion Fatigue
- T-3H Tanker Corrosion
- T-3J Biological Corrosion
- T-3K Corrosion and Other Deterioration Phenomena Associated with Concrete
- T-3L Electrochemical and Electrical Techniques for Corrosion Measurement and Control
- T-3M Chemical Cleaning
- T-3N Automotive Corrosion and Its Prevention
- T-3R Atmospheric Corrosion
- T-3S Arctic Corrosion Problems

Group Committee T-5: Corrosion Problems in the Process Industries

- T-5A Corrosion in Chemical Processes
- T-5B High-Temperature Materials Performance (Temperature Corrosion)
- T-5D Nonmetallic Materials of Construction
- T-5F Corrosion Problems Associated with Pollution Control
- T-5H Corrosion in the Pulp and Paper Industry
- T-5J Corrosion Control in the Steel Industry

Group Committee T-6: Protective Coatings and Linings

- T-6A Coating and Lining Materials for Immersion Service
- T-6G Surface Preparation for Protective Coatings
- T-6H Coating Materials for Atmospheric Service
- T-6Q Quality Assurance of Protective Coating Materials and Their Application

Group Committee T-7: Corrosion by Waters

- T-7A Cooling Water
- T-7C Sea Water
- T-7E Waste Water Corrosion
- T-7G Corrosion and Its Control in Water-Supply Systems and Water Using Systems in Buildings
- T-7H Corrosion and Its Control in Industrial Boilers
- T-7K Non-Chemical Water Treating Devices
- T-7L Cathodic Protection in Natural Waters

Group Committee T-8: Refining Industry Corrosion

Group Committee T-8 has no Unit Committees. All committee activities are accomplished directly through Group Committee and Task Group work.

Group Committee T-9: Corrosion of Aerospace Equipment

T-9B	Protective Systems for Materials
T-9D	Materials of Construction
T-9E	Corrosion of Electronic Equipment

Group Committee T-10: Underground Corrosion Control

T-10A	Cathodic Protection
T-10B	Interference Problems
T-10C	Electric Power and Communications
T-10D	Protective Coating Systems
T-10E	Internal Corrosion of Pipelines

Group Committee T-9: Corrosion of Aerospace Equipment

Now, let's look at one of NACE's specific committees—T-9: Corrosion of Aerospace Equipment. This committee addresses corrosion prevention and control for extended materiel life, ease of maintenance, conservation of resources, monetary savings, and increased combat readiness of military equipment through greater equipment and material reliability. Group Committee T-9 is actively involved in the study of all aerospace equipment including aircraft, missiles, aerospace vehicles and equipment, and related ground support equipment and property.

To fulfill this responsibility, Group Committee T-9 conducts meetings at which specific corrosion problems related to aerospace equipment are discussed. From these discussions, cooperative tests and surveys may be made on which to base committee reports and standards. These may be used by all interested parties to help eliminate the millions of dollars that are lost each year to corrosion of military equipment, ranging from motor vehicles to missiles.

Specific areas being studied by Group Committee T-9 and its unit committees include the materials of construction of aerospace equipment, the control of corrosion of electronic systems and electrical equipment, and the types of protective coatings used on military equipment (study in the last topic area recently culminated in the publication of a handbook by the committee.)

Advantages of Membership in Group Committee T-9

Many benefits may be derived from active participation in one or more of T-9's unit committees. Each unit committee meeting includes open discussions of specific corrosion problems relative to the unit's scope of activities. These discussions include comments and input from some of the aerospace equipment industry's leading experts. Individual members of the committee have the opportunity to present their specific questions and problems to the committee for discussion and possible resolution.

Other benefits to the individual group committee members are the professional association and contacts that may be made through active participation in committee projects.

In addition, most companies recognize the importance to industry of effective technical committee work and therefore encourage active participation in committees studying specific corrosion problems related to the company's fields of interest. Participation by one or more of a company's staff members provides the advantage of having representation on committees that are discussing, studying, and preparing reports and standards in the specific areas of interest to the company.

Another advantage for the individual company is the benefit of collective thinking from a committee that includes experts and experienced personnel on a particular subject from a broad cross-section of industry.

How to Join Group Committee T-9

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Nondamaging to Critical Surfaces

Plastic Media Blast Best for Stripping

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Development of new processing techniques to meet higher nonpollution and safety standards has produced many unique side benefits for the U.S. Army at its Corpus Christi Depot. Renovation of old but still serviceable equipment, and overhaul and replacement of components is done at this facility, and recent development of a new technique for stripping paint has brought these side benefits. Plastic Media Blast can be used safely both for operators of stripping equipment and for the surfaces of the equipment they strip. And it can be used on fragile materials or those that have specific vulnerability to damage from chemical stripping methods. Simultaneously, the new method does its job much faster and takes less material, producing considerable labor and operating cost savings.

Thrust for Development

Since the mid-70's, Corpus Christi Army Depot (CCAD) has been at the forefront of DOD installations in pollution abatement and control. With the increased public concern over the environment and stricter pollution control laws, the Depot has been constantly investigating new or modified production processes that either lessen or eliminate pollutants.

One area of concern has been the paint stripping processes at CCAD. As of November 1979, it was the first DOD overhaul facility that eliminated the use of phenolic based paint strippers. New paint strippers were solicited from manufacturers that would remove the organic coatings from airframe and component parts, meet production requirements, and satisfy the EPA wastewater requirements placed on the Naval Air Station. The new products that were adopted for use were methylene chloride and acid based paint strippers for airframe use and orthodichlorobenzene based strippers for vat stripping of component parts. Due to greater sophistication of the organic coatings on Army aircraft plus stricter water and eventual air quality requirements, the depot needed a form of paint stripping that would be neither polluting to water or air, safe to the employee, nondamaging to aircraft surfaces, and not degrade the facilities.

In 1980, Hill AFB researchers began a search for such a paint stripper. Through this investigation of three years, it was determined that paint removal with plastic media blasting was the prime candidate that would meet all of the requirements. In 1983, work was begun prototyping and developing plastic media blast (PMB) paint stripping for Air Force systems.

CCAD first became aware of PMB in November, 1983 and by February, 1984 was testing and developing plastic media blast processes for Army aircraft systems. By June, 1984, PMB was in production at CCAD for the removal of organic coatings on component and composite aircraft parts.

The PMB Process

The Army process has been successfully used on airframes, tail rotors, and other aircraft component parts including composites.

First, the aircraft surface must be cleaned with aircraft surface cleaner to remove any oils, hydraulic fluids, greases, etc. Then, all window glass is masked along with any other components that would be damaged by the blast media. All moving surfaces, actuators, linkages, etc., should also be masked to protect them from contamination with media and dust. Once the airframe is cleaned and masked, the paint film is removed by blasting by a pressure of 25-30 psig (maximum), with an impingement angle of 10-15 degrees and a stand-off distance of 24-36 inches. Blasting is done long enough to just remove the paint films and leave the skin clean. On thin skins or edges with thin skins, the stand-off distance is increased and the pressure decreased so as to remove the coating but not to distort or oil can the skin. Air pressures above 30 psig and an impingement angle greater than 15 degrees will oil can or buckle aluminum skins thinner than 0.030 inch.

By using the minimum pressure and controlling the stand-off distance, the operator can selectively remove acrylic and lacquer topcoats from epoxy primed surfaces without removing the latter. Once all the designated paint film and/or primers have been removed, the internal areas of the aircraft should be cleaned of blasting media and dust, utilizing a combination of compressed air blast cleaning and vacuuming.

For a tail rotor, once it is cleaned and masked,.the paint film is removed by blasting with a pressure of 25-30 psig (maximum), a stand-off distance of 8-12 inches in blasting glove box, and a stand-off distance of 24-30 inches with a blast hose. The impingement angle should be between 30-60 degrees. Pressures above 40 psig will distort skins and can close cracks on aluminum component subassemblies of the tail rotor.

Why PMB?

Beside its nonpollution advantage, PMB has several other pluses. Tests were performed with both plastic media and walnut shells. Plastic media removed less clad than walnut shells and was also more effective at removing paint systems at pressures as low as 20 psi. Walnut shells require pressures 2-3 times as high, and at the higher blast pressures the aircraft parts are damaged to such a degree as to be unacceptable. Further, all of the typical paint systems can be removed with plastic media blast. Epoxy enamels and polyurethane coatings are the slowest to remove, while lacquers over zinc chromate primers are the easiest. With good operator technique the topcoat can be removed from the primer. This is accomplished by pressure, stand-off distance, and impingement angle. It is usually harder to remove a polyurethane topcoat from an epoxy primer and leave the primer behind.

Composite and engineering plastic parts can be plastic blast stripped. Composite parts are these that are made of epoxy resin and either fiberglass, graphite, or Kevlar matrix. Engineering plastic parts are those that are higher strength plastics used on aircraft, such as polycarbonate (Lexan), ABS, and acrylics (plexiglass). Composite and engineering plastic parts cannot be chemically stripped safely. Plastic media blasting is the only way of stripping these types of parts. When blasting composite parts, a pressure of 20 psig is used to begin with and increased in 5-psig increments until the paint is just being removed by the plastic media. Too high of a pressure and too long of a dwell time will blast through the resin gel coat, exposing and/or damaging the supporting fabric matrix. Generally, 25 psig is the optimum blast pressure for composite parts. Plastic parts can be processed under the same blast parameters as composite components.

Chemical strippers are known to be a source of corrosion on aircraft. The strippers can become trapped between skins, resulting in a site for corrosion. Paint strippers also attack facilities by etching the concrete floor and corroding metal building components. Plastic media blasting will lessen or even eliminate the worker to the exposure of chemical strippers; it is much more efficient than chemical stripping. Time studies have indicated man-hour savings of 68-88%. Blast stripping will eliminate the costs associated with the purchase and disposal of paint strippers, their wastes, and drum disposal.

PMB's Effect on Adhesives, Sealants

Testing has shown that at 25-30 psig and with small media, adhesives and sealants are not effectively removed. Extended blasting in trying to remove a sealant or adhesive will result in excessive attack of the metal. On clad aluminum, too long of a dwell time will remove the protective cladding. On solid aluminum or magnesium components, too long of a dwell time will remove anodized surfaces on aluminum and remove either the protective chromate conversion coatings or anodic coatings on magnesium.

The PMB Media

There are many types of plastic media products on the market. Certain ones are the most effective in removing paint systems from aircraft components. For use at CCAD, Type IIL, size 30-40 mesh, is the safest and best all around media for Army use. Note: Other types of blasting products such as walnut shells or glass beads must not be mixed with the plastic media. All testing has been performed with clean plastic media and has been shown by lab testing at CCAD and testing by the Air Force and Navy to be safe on aircraft components. Any mixing of blasting medias could damage and affect the flight safety of the part.

Some Precautions Necessary

When using PMB, all oil passageways, bearings, lubricators, and hollow cavities must be masked with tape, barrier material, rubber stoppers and other special fixtures as required. It is imperative that no media and/or dusts are allowed to enter and remain. The media could clog an oil passageway or lubricator, causing failure due to lack of lubrication. Media and dust contamination in a bearing can result in a premature bearing failure. After blasting and demasking, it must be made certain that there are no oil passages or holes blocked to any degree by the media and its dust, nor any media trapped inside the part. When necessary, a flashlight, mirror, magnifying glass, boroscope or fiberoptics must be used to ensure that all media has been removed.

In addition, different blast pressures are used in different applications. Airframes are blasted at lower pressures than aluminum and magnesium components. Airframes are blasted with pressures between 25-28 psig, whereas components are blasted at pressures of 30-35 psig. The two major concerns in blasting airframes is oil canning of the skin and excessive damage of the protective clad. The blast parameters for airframes are 25-28 psig, a stand-off distance of 24-36 inches and an impingement angle of 15-30 degrees to the surface, just long enough to remove the designated coatings. Further, around hatch openings where the skin is thin and unsupported a flat impingement angle must be used and a dwell just long enough to remove the paint system. If this is not observed the hatch opening could be deformed by the blasting.

The skins on Army aircraft are clad with a protective layer of corrosion resistant aluminum, and testing has shown that an airframe can be blasted at least 5 times without removing all the clad nor penetrating the clad to the base aluminum. In the accompanying photomicrograph of an airframe skin that had been blasted five times (Figure 6), note that the clad has been disturbed but not removed.

Equipment Requirements

A standard cabinet-type continuous-flow dry air blasting machine is used in this process. The machine cabinets must be large enough to accommodate the largest parts to be blasted in such a manner that the cabinet door can be closed when the part is being blast cleaned. Compressed air machines and facilities must be capable of delivering a blast pressure of at least 25 psig when blasting through a new ½" nozzle. Automated rotating worktable-type cabinet machines shall be utilized when feasible. If the air supply for the blasting machines is excessively wet or oily, reliable water and oil filters must be placed in the air line before the air reaches the blasting machine.

Blasting machines shall be designed so as to contain a classification system (such as a cyclone separator, vibratory screening system, and dust bags, etc.) for removing small fragments and dust created during the blasting process. The blasting cabinet, blast equipment, and respiratory equipment are also designated and maintained in accordance with provisions of the Occupational Safety and Health Act.

Safety Important

PMB is a relatively safe process when compared to alternate forms of paint removal. However, some basic precautions must be taken. When blasting in a blast cabinet a fitted approved respirator should be worn at all times. The dusts generated by the blast operation contain chromium from corrosion inhibitors in the primer, lead from the pigment in the topcoat and cadmium from cadmium plating on steel fasteners. Since blasting generates high sound levels, hearing protection should be worn also. Magnesium-thorium parts must be plastic media blasted in booths segregated and designated for magnesium-thorium alloys only. Operators must also be equipped with respirators and face shields when vacuuming or otherwise cleaning the dust bags and when cleaning the blasting chamber, etc.

Further, plastic blast media and associated dust generated from paint removal and general cleaning will be disposed of as a solid hazardous waste, and its disposal will be accomplished via execution of specific regulations. Plastic blast media and associated dust generated from blasting magnesium-thorium containing alloys must also be segregated in labeled drums and disposed of as a hazardous magnesium-thorium (radioactive) solid waste.

PMB Economics and the Future

Testing is still ongoing for airframe paint removal. Due to the thin skins on Army aircraft, the development of the plastic media blast process is being developed and refined to the point where paint systems can be removed without damaging the skins through clad removal, finish requirements are met, and oil canning of the skin is prevented.

Plastic media blasting, besides meeting pollution and safety requirements, is cost effective. Economic analysis has shown that plastic media blasting will eliminate the expenditure annually of $134,921 for chemical paint strippers and save 16,947 man-hours, for a savings of $246,575, plus $29,789 dollars in disposal costs of empty drums. For estimated average savings over a 10-year life, the Depot will save $587,698 per year. An additional benefit is that plastic media blast will save 26.5 million gallons of water per year.

Fragile Parts Processed

The first rotary winged aircraft in the world to be stripped with plastic media was done at CCAD. Within DOD, CCAD was instrumental in the concept of lower blast pressures and smaller media size to remove aircraft coatings with minimal airframe skin disturbance. CCAD demonstrated that thin composite parts could be safely stripped and was the first facility to go into production with plastic media blast stripping of composites. To date, one helicopter has been fully stripped and six additional ones have had their composites portions blast stripped.

Corpus Christi Army Depot is firmly committed to the use of plastic media blast stripping and is continually investigating new uses for this environmentally safe process.

NOTE: The following section illustrates some of the exhibits and test results presented by Corpus Christi Army Depot in its Plastic Media Blast project folder of color photographs and notes.

PMB Removal Rate Faster

Figure 1 shows the relative times required to strip four different Army helicopters by Plastic Media Blast and by chemical means. Figure 2 shows the first rotary wing aircraft PMB stripped. The time required was 12 hours, compared to 32 hours by chemical strip. The effectiveness of PMB on fiberglass airframe components is seen in Figure 3, a closeup of the nose of the helicopter.

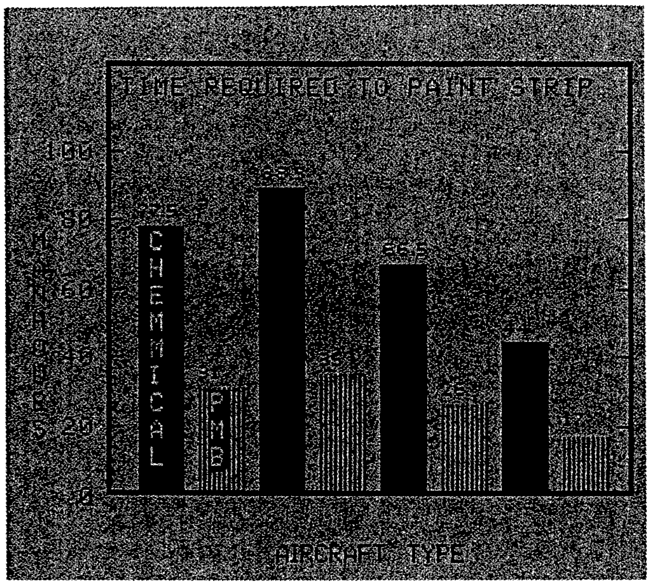

Figure 1

Figure 2

Repeated Strip Cycles Extend Life

Figures 4, 5, and 6 illustrate how the lack of damage to aircraft surfaces can extend the life of that aircraft. Figure 4 shows a helicopter tailboom which was primed, painted, and Plastic Media Blasted five times. Figure 5 is a closeup of the skin section of this tailboom. The darkened, smudged areas are residual primer still attached to the skin. It is not necessary to remove all of the primer down to white metal if MIL-P-23377 epoxy primer is used. Figure 6 is a photomicrograph of a skin section from this tailboom. The average clad thickness of the

Figure 3

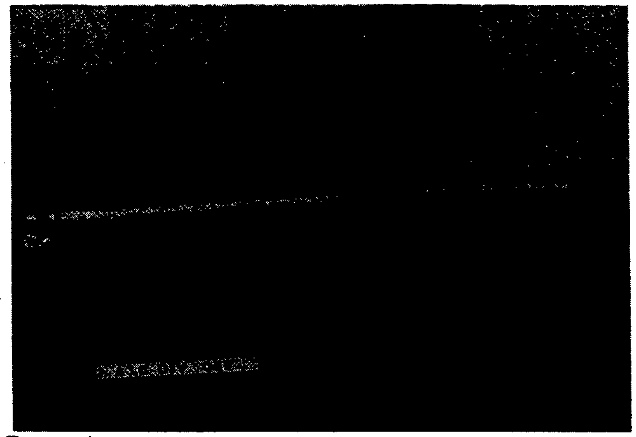

Figure 4

Figure 5

blasted side is 0.0015 inch, compared to a thickness of 0.0022 inch for the unblasted side. With five years between strip and paint cycles, this photomicrograph represents a life span of 25 years on the skin.

Materials Destroyed by Chemicals

Figure 7 shows an air conditioning duct that has been stripped by PMB which would have been destroyed if stripped by chemicals. The component is made of polycarbonates, which cannot withstand chemical strippers.

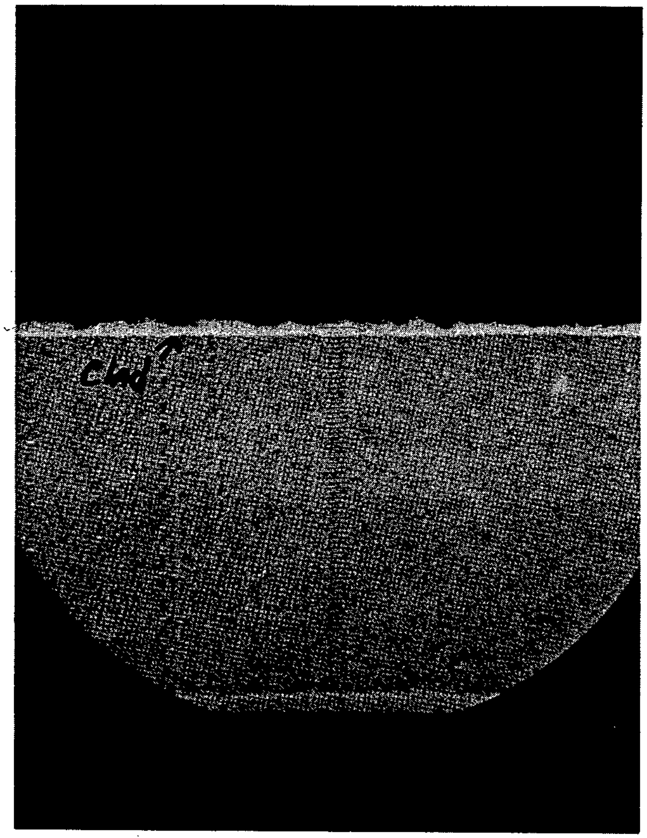

Figure 6

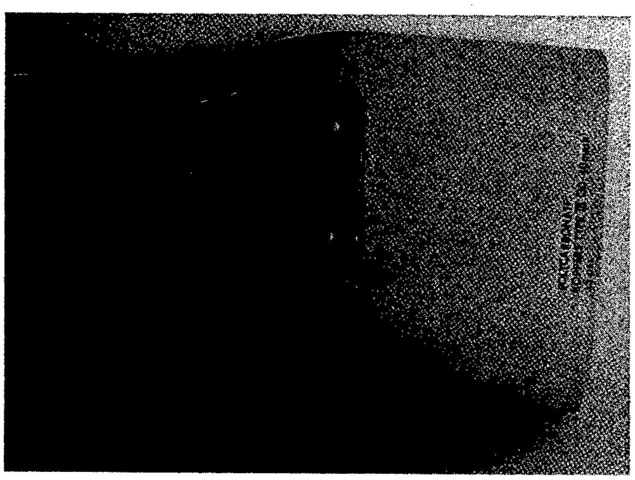

Figure 7

Fiberglass Delaminated by Chemicals

Figure 8 shows a fiberglass backing of helicopter crew armor which has been successfully stripped by using PMB. The fiberglass would have been delaminated if chemical strippers had been used. But PMB safely removed the paint from the fiberglass.

Nylon Fabric Stripped

Figure 9 shows a nylon fabric backing for helicopter

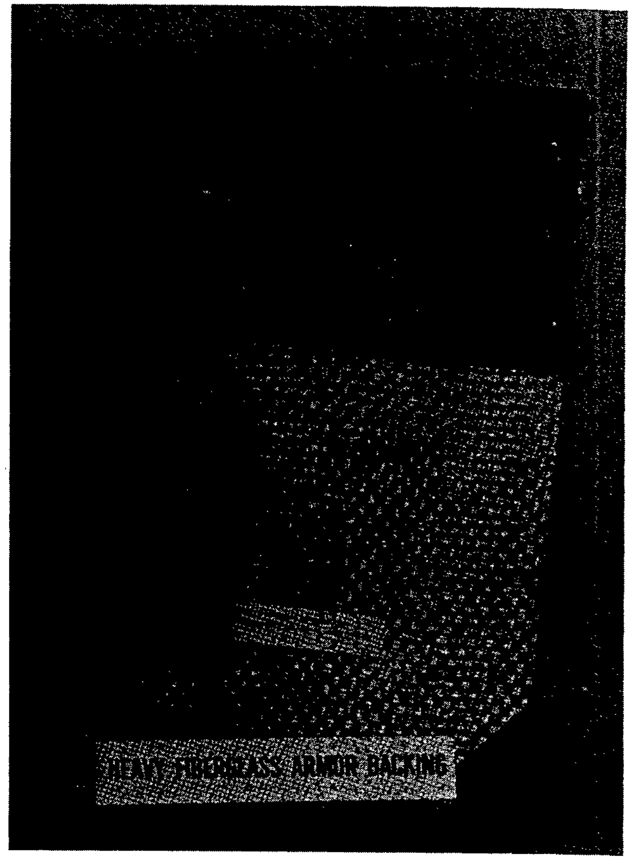

Figure 8

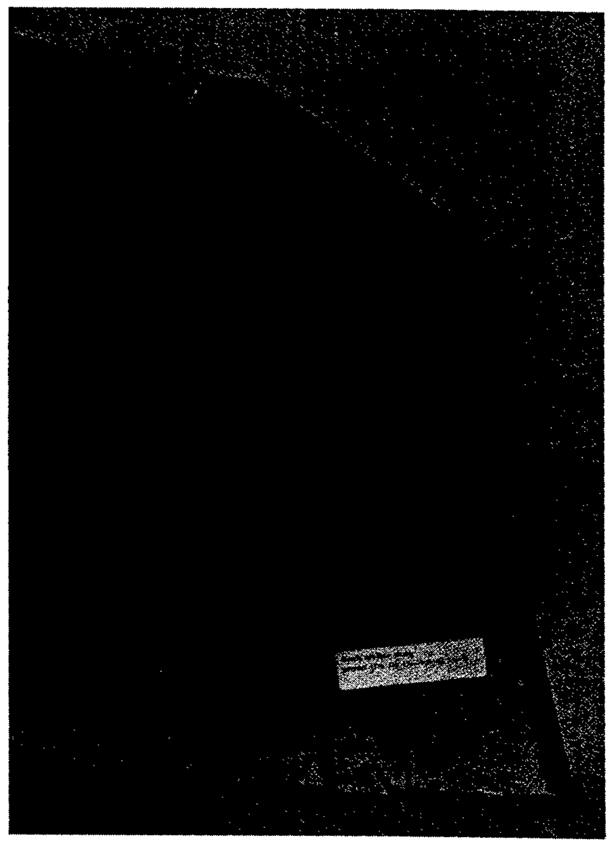

Figure 9

crew armor which has been successfully stripped by using PMB. Chemical strippers would have debonded the nylon backing from the armor. PMB safely removed the paint from the fabric.

Masking, Stripping Faster

Figure 10 shows a panel door from an older helicopter which was masked and stripped in 30 minutes, compared to 4 hours for masking and stripping by chemical means.

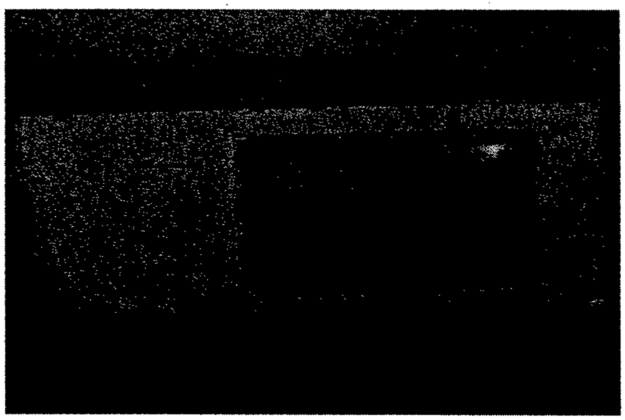

Figure 10

Another special benefit from PBM is seen in Figure 11, which illustrates how effective the technique is for removing finishes from rivets and screws without damaging the skin surfaces or the fasteners themselves and the joint itself.

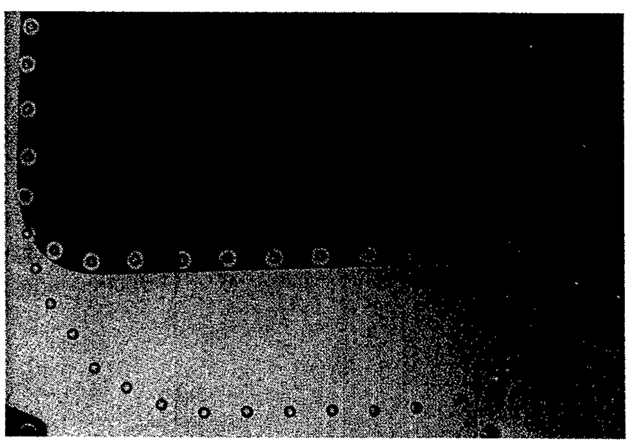

Figure 11

Topcoat/Selective Removal A Feature

Figure 12 illustrates another unique advantage of using Plastic Media Blast stripping. It shows a helicopter door after selective stripping using low pressure and small media, with only the top coat of paint removed.

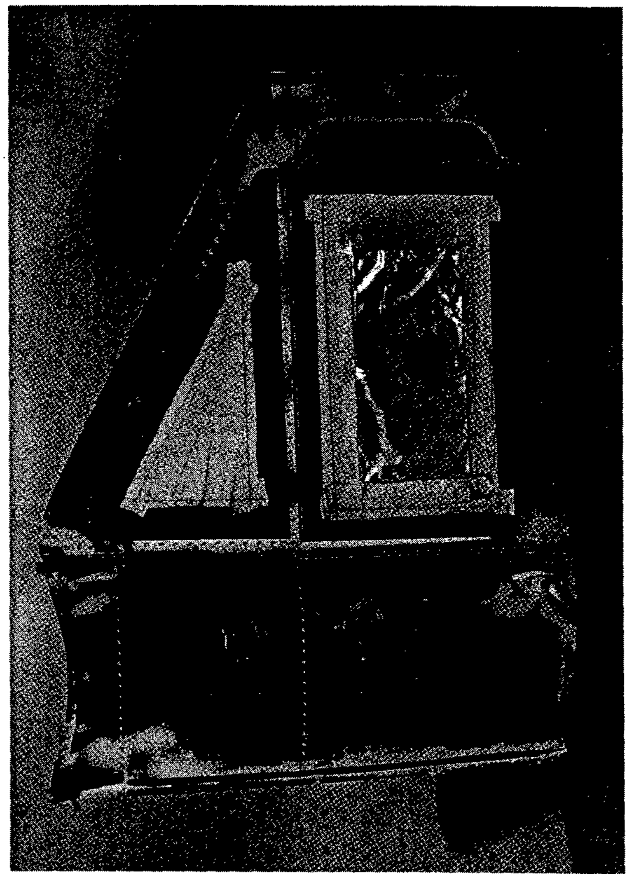

Figure 12

Masking Requirements

Figure 13 shows a helicopter window masked preparatory to PMB. Plexiglass windows are masked with 3M Tombstone tabe (rubber), aluminum tape, and aluminum barrier material.

Other specific components that have been successfully stripped by Plastic Media Blasting are shown in Figure 14, depicting a helicopter titanium skinned honeycomb firewall; Figure 15, an oil cooler shield; Figure 16, a tail rotor before/during, and after PMB; Figure 17, a floor deck of fiberglass and aluminum before and after PMB; and Figure 18, a fiberglass antenna before and after PMB.

Nonferrous Metal Stripping

Component parts made of softer nonferrous alloys such as aluminum and magnesium can be plastic blast cleaned without closing cracks before nondestructive

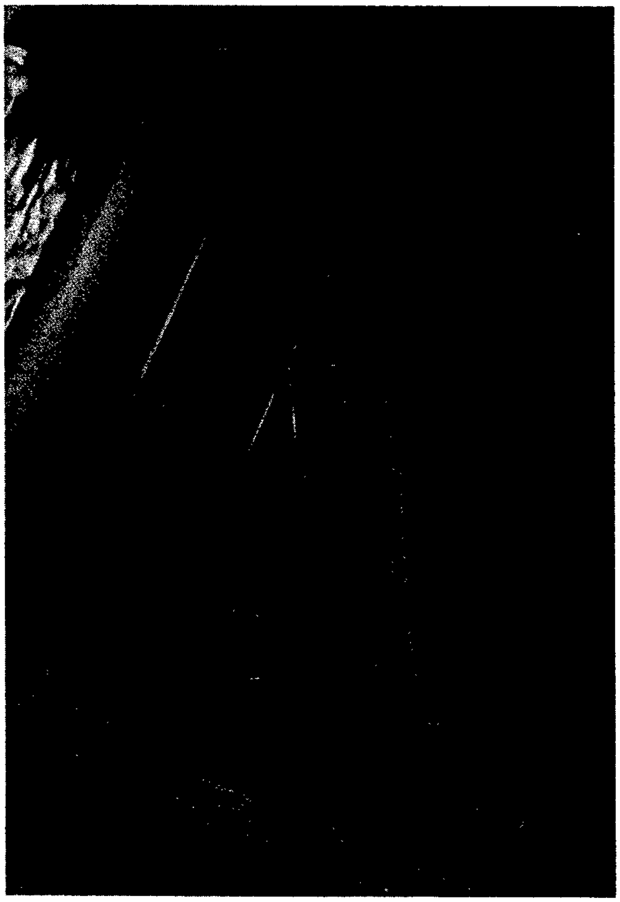

Figure 13

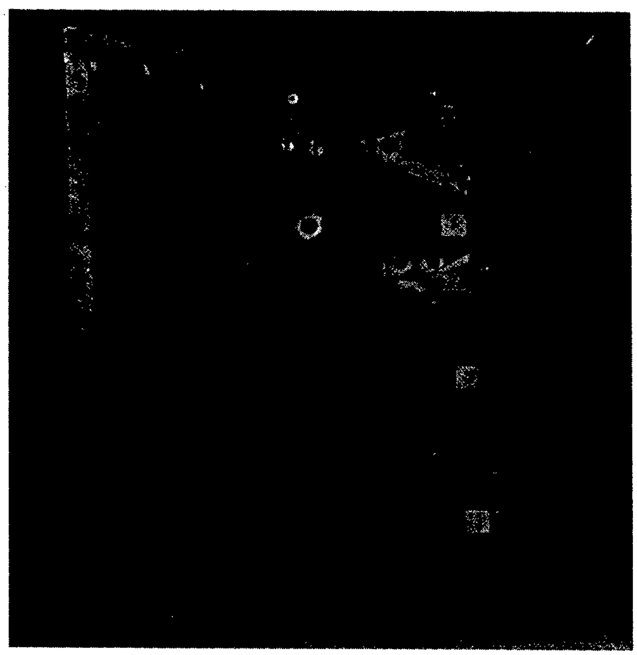

Figure 14

tests. Figure 19 illustrates an aluminum part that was Plastic Media Blasted, then had dye penetrant applied and developer sprayed on. Notice that the cracks were not closed on this part. Testing has shown that at pres-

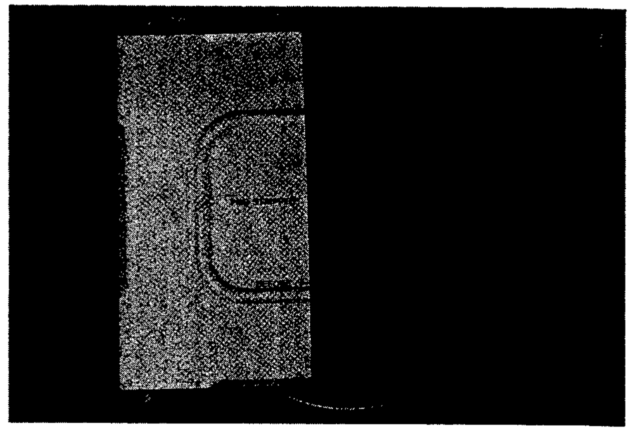

Figure 15

Figure 16

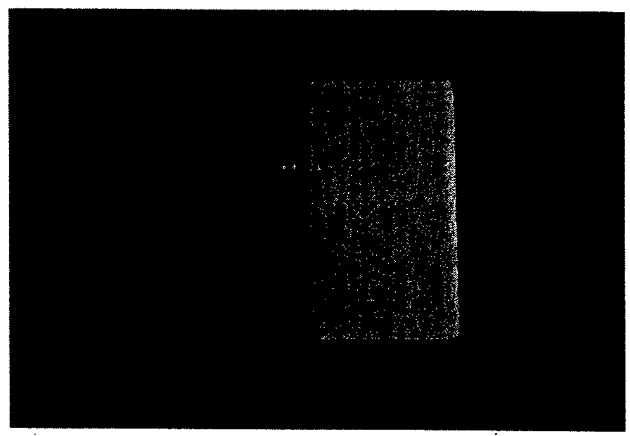

Figure 17

sures below 40 psig, cracks are not peened shut. Figure 20 is of a magnesium casting before and after PMB cleaning. Figure 21 is a 1:1 illustration of 30-40 mesh plastic blast media.

For further technical information on PMB applications by the U.S. Army at Corpus Christi Depot, contact John B. Bullington, Chemical Branch, 512-939-3555/2448, or Randy Williams, Engineering Branch, 512-939-2214/3243.

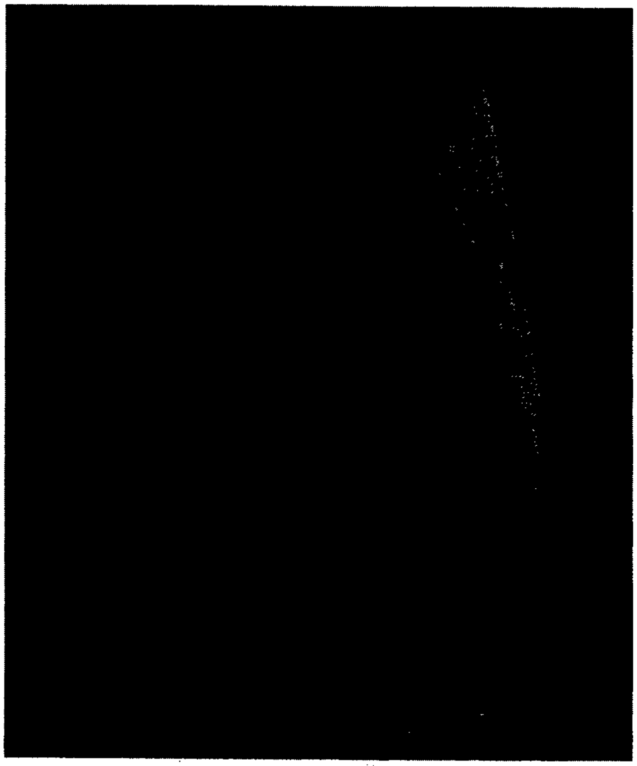

Figure 18

Figure 19

Figure 20

Figure 21

U.S. Army Materiel Command

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