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# service news

A SERVICE PUBLICATION OF LOCKHEED AERONAUTICAL SYSTEMS COMPANY–GEORGIA

# Preventing Corrosion

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A SERVICE PUBLICATION O
LOCKHEED AERONAUTICA
SYSTEMS COMPANY-GEOR

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**Vol. 17, No. 1, January-March 1990**

## CONTENTS



Photographic Support: John Rossino

Front Cover: In a Florida test of airborne mosquito-control equipment. a chase plane monitorsthedispersal pattern of simulated insecticide as it streams from wing-mounted nozzles on an Air Force C-l 30. The dye-containing water spray is shadowed behind the right wing by the vertical stabilizer. Aerial spraying is but one of the many specialized tasks of the worldwide Hercules fleet that expose the airframe to the destructive effects of corrosion.

Back Cover: Corrosion takes many forms, none of them attractive, and the bottom line is always the same: higher costs and reduced service life.

## Focal Point

Bard Allison

### Hercules Country

It is always a pleasure for me to speak for and comment about the Hercules team at LASC-Georgia.

Last month, the Hercules Country Employee of the Year was selected from the twelve monthly winners for 1989. The Hercules team was gathered for the ceremony, and I had a chance to thank them for their dedication and contribution to the success of the Hercules. With every aircraft delivered goes the pride of our Georgia people for a quality product ready to meet the customer's mission needs, but delivery does not end our commitment to the customer.

When a Hercules leaves the factory, we turn its lifetime care over to our Product Support team. This group is supported by our entire organization, as is the Manufacturing team on the production floor. Knowing that we have provided a quality product to you, the operators in the USA and around the world, lets us all sleep a little better at night.

Last year we delivered the 1900th C-130 to the U.S. Air Force. At that gathering we were delighted to have the very first production C-130 nose to nose on the ramp with number1900. That says a good bit for the capabilities, flexibility, and life expectancy of the C-130 program.

We are dedicated to Hercules production well into the next century, a continuous production line with continuous improvements in our process and product. If you have an opportunity to visit us here in Marietta, you will find a modernized production line. We haveendeavored to provide our people with a better work environment. New stands, improved lighting, adequate storage, more highly accessible power and air are just a few of the changes you will notice. These improvements and a renewed spirit of pride in producing quality products for you, our customers, are evident throughout the plant.

Our challenge is continuous improvement in both productivity and quality to keep the Hercules affordable in the world marketplace and serve your mission needs effectively. Although some of our people move on into retirement and others take their place, the Hercules heritage remains. "Hercules Country" is more than just our facilities. It is a dedication to a cause-to build and support the Hercules to the best of our abilities.

The feature article in this issue is entitled "Preventing Aircraft Corrosion." It is my job to prevent organizational corrosion, and I accept that challenge for the Hercules team. I extend to each of you an open invitation to visit us and see us in action.

Sincerely,

Bard Allison,
Executive Vice President-LASC
General Manager-Georgia

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# PREVENTING Aircraft Corrosion

*by* **Everett J. Smith,** *Specialist Engineer*
*Materials and Producibility Technology Department*

**This is the second of two articles concerning prevention and control of corrosion in the Hercules aircraft. As in the case of the first installment, thisdiscussion is not intended to be all-encompassing; rather, it presents an overview of the basic requirements for maintaining the Hercules airlifter regardless of airplane age.**

**The first article ("Understanding Aircraft Corrosion," Lockheed *Service News,* Vol. 15, No. 4, Oct.-Dec. 1988) pointed out that except for outward appearances, the Hercules has evolved into essentially a new airplane over the past 30-plus years. Along with numerous other improvements, advanced alloys, finishes, and sealing processes are now incorporated in every new Hercules for the purpose of enhancing structural integrity and increasing the aircraft's resistance to corrosive attack.**

**Unfortunately, new materials and improved processes cannot in themselves guarantee a permanently corrosion-free airplane. A certain amount of corrosion is inevitable even with the best of care. Furthermore, as an airplane ages, corrosion problems tend to increase. This leads to an increase in labor, parts, and materials costs. Just how rapidly these increased costs will accumulate depends to a great extent upon the quality of the operator's corrosion-prevention and control program and his commitment to following through on it.**

**Corrosion prevention must begin when the airplane is manufactured and continue until the airplane is retired. In theory, an airplane could be operated indefinitely if it receives thorough inspections and prompt repairs. In practice, at some point the operator will probably decide to retire the airplane because of escalating maintenance costs.**



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## Cleaning the Airplane

The two primary reasons for cleaning airplanes are to remove corrosion-causing contaminants and provide clean surfaces for good corrosion inspections. An added benefit, though perhaps the least important part of a corrosion-prevention program, is appearance of the airplane.

The importance of cleaning airplanes regularly cannot be overemphasized. How often an airplane requires cleaning is dependent upon its operational environment. For example, airplanes operating in arid, pollution-free environments require less frequent cleaning than airplanes operating in hot and humid climates, within about ten miles of seacoasts, or in most desert regions. Even though the climate may otherwise be acceptable, most deserts are the sites of ancient sea beds and the sand often contains a significant amount of salt. This has important consequences in terms of exposure to corrosive attack.

## The Washrack Crew

Safety must always be the first consideration in any activity involving aircraft, and the washrack is no exception. In particular, an appropriately designed safety device is necessary to protect workers from falls while they are cleaning upper wing surfaces. One such device is a cable running spanwise and 6-7 feet above the wing. Each end of the cable is fixed to the indoor facility wall, or to posts in the case of an outdoor facility. To this cable the worker attaches a lanyard which is fastened to his safety harness.

In spite of the recognized complexities involved in cleaning airplanes properly, many operators use washrack workers who have been given very little training in safe and effective airplane cleaning techniques. The most serious problem that results from this lack of training is the misuse of washrack chemicals. If not mixed and used correctly, these substances can do substantial damage to the airplane.

For example, Stoddard solvent and solvent-type cleaning compounds will cause deterioration of most rubber products if not mixed in the correct proportions or not rinsed off completely during use. Strong, alkaline cleaning compounds will corrode aluminum alloys, and can etch and damage some types of protective finishes. For the sake of the airplane, it is always best to use a dedicated cleaning crew. A well-trained, dedicated crew will soon master all the intricacies of airplane cleaning techniques, and perform more efficiently than a “made-up” crew.

Whether the operator has enough work to justify a dedicated crew or not, everyone engaged in cleaning airplanes must be thoroughly trained. In addition to the personal safety aspects, the crew must be knowledgeable about the handling, mixing, and storage of all chemicals used on the washrack. Each crew member must also know how to use the chemicals, tools, and equipment without causing damage to the airplane.

Washrack workers need the protection of safety harnesses when working on the upper surfaces of the aircraft.

## Washing Facilities

An airplane cleaning facility need not be elaborate to be effective, but it must be adequate to do the job year-round. It could be just a concrete pad, or it might be an elegant indoor facility with all the modern amenities. In either case, there are certain requirements for even the most basic wash facility.

Unless built-in stands are used, the facility must be large enough to allow movement of portable stands completely around the airplane. Stands, movable or fixed, should be of sufficient height to allow easy access to all exterior surfaces of the airplane. If airplane cleaning is done at night, the lighting should be bright enough to provide good visibility, with a minimum of shadows, for all surfaces being cleaned.

An automated outdoor rinsing facility helps protect Coast Guard aircraft from the corrosive effects of salt spray.

Rinse water pressure is not as important as the volume of water. As a rule of thumb, adequate pressure is available when the top of the tail can be rinsed by a worker standing on the ground. The volume of water used should be sufficient to provide a free-flowing action over the surface being rinsed; this requires a minimum flow of about eight gallons per minute.

Note that in some parts of the world, the local water is not acceptable for cleaning airplanes because of its “hardness.” Hardness is a general term used to describe the amount of dissolved minerals, primarily calcium carbonate ($CaCO_3$), that a given water sample contains. Hard water containing no more than the following levels of dissolved solids in parts per million (ppm) is considered satisfactory for washing aircraft:

| | |
|---|---|
| Total dissolved solids | 472 ppm |
| Total hardness as $CaCO_3$ | 420 ppm |
| Bicarbonate ($HCO_3$) | 384 ppm |
| Sulfate ($SO_4$) | 107 ppm |
| Chloride (Cl) | 20 ppm |
| Hydrogen conc. (pH) | 6-8 at 50°F |

When water analysis indicates values significantly in excess of those listed, the water should be chemically treated to reduce the level of impurities before it is used to wash an airplane.

**Cleaning Hints-Aircraft Exterior**

All operators use the standard cleaning brushes, abrasive pad kits, buckets, and so forth, and most operators also provide safety equipment such as face masks, rubber gloves, and wet weather gear to their airplane washers. There are, however, additional items that some operators already use which make the job easier, provide a cleaner airplane, and help prevent corrosion.

- There is no substitute for a wet-or-dry vacuum cleaner to remove dirt and water from joints and crevices after washing.

- During the airplane exterior wash, in particular using outdoor facilities, it is a good idea to use a foam generator. This equipment applies a layer of cleaning solution foam which clings equally well to vertical and lower horizontal surfaces, thereby keeping the cleaning solution against the surface for better cleaning action. The foam also resists drying on the airplane surface longer than the liquid solution. Low-pressure compressed air is required to operate the foam generator.

- Although cleaning solutions can be mixed by hand, mistakes in cleaner-to-water ratios can happen. The use of a chemical proportioner will eliminate mixing errors. Built-in mixing equipment, although more sophisticated, functions much the same way as the portable proportioner. In use, the equipment is connected to a water source and to a container of concentrated cleaning compound. The operator turns a valve to the desired mix ratio, activates the machine, and applies the mixed cleaning solution to the aircraft surface.

- Unless a built-in bulk storage and pumping system exists at the wash facility, an air-operated barrel pump is needed to transfer cleaning chemicals from the storage drums to mixing tanks, etc.

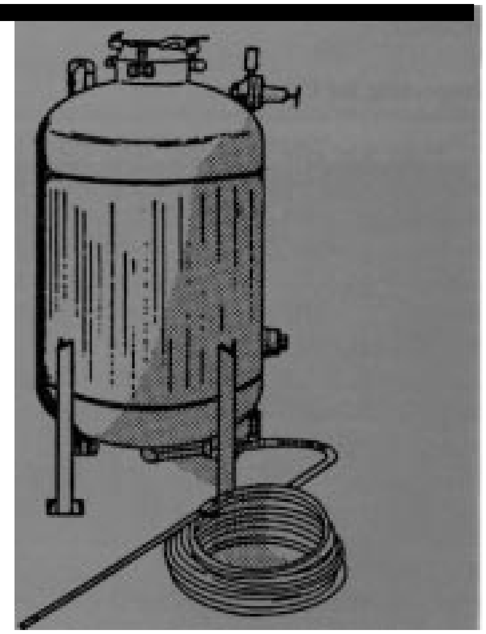
- The use of hot water (about 130’F) increases cleanability and rinsability, and reduces man-hours by as much as 20 percent, according to U.S. Air Force studies. If only a limited amount of hot water is available, use it for applying the cleaning solution and then rinse with cold water.

During airplane exterior cleaning, the brushes, mops, etc. should not be placed on the ground where they may pick up dirt that will damage the paint. Also, high-pressure water should not be directed toward wheel bearings or other lubrication points, or at thin-sheet honeycomb panels. After the wash, and before the airplane dries, apply a thin coat of soil barrier (Cee Bee A-6 or Eldorado PC 1020 or equivalent) to hard-to-clean areas and to areas subject to urine spray. Typical of such locations are engine exhaust tracks and aft fuselage belly and ramp skin panels. Relubricate all lubrication points within the cleaned area.

**Cleaning Hints-Aircraft Interior**

The use of water hoses for cleaning inside the airplane is not recommended because of possible damage to the electrical equipment, and also because of the corrosion that could be caused by water and cleaning solutions entering inaccessible areas of the airplane and remaining there. It is

**Foam generators can produce a cleaning solution foam that will adhere to both vertical and horizontal surfaces.**



best to use a rag or sponge to apply cleaning solution from a bucket. After scrubbing interior surfaces with a soft, bristle brush, wipe off all dirt and cleaning solution thoroughly with a rag or sponge, rinsing frequently in clean water. Use a wet-or-dry vacuum cleaner or dry rags or sponges to remove excess water. Apply corrosion-preventive compound to all joints and crevices.

Another criterion which must be taken into account is the type of cargo being hauled. Anytime a corrosive cargo such as cement, fertilizer, animals or animal carcasses, etc., is transported, the airplane interior should be thoroughly cleaned after each mission, including under the floor if a cargo spill is suspected. Each operator should evaluate his own operation and establish a cleaning frequency that will satisfy the requirements of his individual corrosion-prevention program.

### Fire Extinguishing Agents

Most fire extinguishing agents are corrosive and can very quickly produce severe corrosion on airplane structure. Foam and bromochloromethane-type agents are the most notable offenders in this regard. Some of the more commonly used dry powder-type agents such as potassium bicarbonate (PKP) are in themselves only mildly corrosive, but after exposure to heat the residue may convert to potassium hydroxide, which is very corrosive indeed.

As if that were not already bad enough, both of these potassium salts are hygroscopic and will absorb moisture, creating a corrosive poultice on airplane surfaces. The soot generated by an airplane fire is carbon contaminated by a variety of combustion byproducts, depending on what is being burned. Like the agents in dry powder extinguishers, soot is both corrosive and hygroscopic. Airplanes contaminated with fire extinguishing chemicals and soot must be cleaned and neutralized as soon as possible after exposure.

### Inspecting for Corrosion

Have you ever wondered why some mechanics are better at finding corrosion than others? In addition to being well-trained, mechanics who show a special knack for finding corrosion have developed the ability to recognize corrosion "indicators." Indicators are those little things that point toward a potential corrosion problem. These can be anything out of the ordinary, such as missing sealant in a joint, a wet area or tide marks where water has been in contact with aircraft surfaces, or chipped or discolored paint.

Finding corrosion is perhaps as important as removing it because once the corrosion is found and documented, the airplane's condition has become a "known." As long as safety of flight is not affected, the corrosion may be removed at another time.

Aircraft interiors must be cleaned thoroughly after each mission involving the transportation of animals.

Remember, however, that the severity of corrosion increases with time, so repairs should not be delayed too long. After a few inspections, a pattern often emerges in which corrosion will be found in the same areas on all Hercules aircraft operating out of a similar environment. Some problems will differ from model to model because of changes in materials and processing, and the finishing improvements that have been incorporated over the years since the first Hercules airplane was built.

Training for anyone performing corrosion inspections should, as a minimum, consist of thorough familiarization with the types of corrosion which may be encountered, and the corrosion history of the airplanes that will be inspected. The only tools required are a bright light, a 10x magnifying glass, a mirror, a pit depth gage, and a machinist's scribe for probing suspected corrosion. A borescope is ideal for looking into small openings without requiring disassembly of the adjacent structure.

### Corrosion Removal

There are two recognized methods of removing corrosion, chemical and mechanical. For a number of reasons, the chemical method of corrosion removal is not widely used by operational organizations. Chemicals work more slowly than the mechanical methods, and there is a danger that chemicals will enter joints, be difficult to remove, and cause further corrosion. There are also questions of personal safety and waste disposal to be considered.

Most corrosion problems have to be attacked mechanically, and there are a number of methods by which this can be done. These include everything from the use of sandpaper to complex methods involving abrasive blasting. The method of selection will depend upon the type of metal, the

Most corrosion must be removed mechanically; in many cases an abrasive blaster can speed up the cleaning chore.

location and accessibility of the corroded area, the degree of damage, and the type of corrosion involved. A typical corrosion removal sequence proceeds as follows:

- Protect the area surrounding the corroded area from damage during the corrosion repair.
- Clean the affected area of dirt, grease, etc.
- Remove the corrosion. To avoid stress risers (crack starting points), be sure the corrosion removal surface is left in the shape of a saucer, with no sharp angles. Also ensure that all corrosion is removed and the affected area is polished smooth.
- Check the depth of the area where corrosion was removed with a depth gage and do the necessary documentation. Some operators require this step before and after removing corrosion.
- Shot-peen the treated area when required.
- Apply conversion coating (Alodine) to the removal area on aluminum. Follow the operator’s finish requirements for other pretreatments.
- Fill depressions on upper horizontal surfaces with a corrosion-inhibiting sealant to prevent water puddles from forming in them.
- Reapply appropriate finish after sealant has cured.

## Sealants

Sealant may be the most versatile and effective weapon in preventing aircraft corrosion ever introduced. It is used to exclude moisture and water, and to separate joined metals. Exterior joints and gaps are filled with sealants to prevent water and chemicals from entering. Sealant is also used for wet-installation of fasteners and for pressure sealing.

The use of sealant specifically to combat corrosion in the Hercules aircraft started with the manufacture of Lockheed serial number LAC 4127 in May of 1965. At first, a non-inhibiting sealant of the MIL-S-8802 type was employed. Beginning with LAC 4331, which was built in September of 1968, a corrosion-inhibiting sealant conforming to MIL-S-81733 was introduced.

Some sealants are formulated for specific uses such as applications in high-heat areas, containment of fuel, and electrical conduction with corrosion protection. In general, a sealant should be used only for its intended purpose, but some sealants may be used as substitutes for others when necessary. Listed below are sealant types commonly used in the Hercules aircraft and a chart describing sealant charactistics and where these products may be.obtained:

- MIL-S-38249-A polyacrylate firewall sealant, this material is formulated for use in sustained temperatures ranging from -65°F to +400'F Type I can withstand a flash temperature of +2000'F for 15 minutes and Type II for 15 minutes at +35OO'F Lockheed also uses a silicone high-temperature sealant, AMS specification 3374 (RTV 133, manufactured by General Electric Co.), interchangeably with MIL-S-38249.
- MIL-C-83982-This material is a chemical-resistant polyurethane sealant with a temperature range of -65°F to +180'F. It is used in areas where chemicals, paint remover, urine, etc., would damage other types of sealants and cause premature failure. For this reason, MIL-C-83982 is used to fill exterior skin panel and wing panel

The use of sealants during aircraft manufacture has proved an effective and versatile weapon against corrosion.



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## SEALANTS

| ITEM | SPECIFICATION | USE | APPL. TIME | TACK FREE | CURE TIME | MANUFACTURER'S DESIGNATION | DISTRIBUTOR | ADDRESS (See PQ. 15) |
|---|---|---|---|---|---|---|---|---|
| Sealant, Firewall | MIL-S-38249. Type I-1/2 | Faying surface sealing, wet insllation of fasteners and fillet sealing in hot areas. | 1-1/2 hrs | 24 hrs | 72 hrs | Pro-seal 700 | Products Research | 34 |
| Sealant, Polyurethane Fluid-Resistant | ML-C-83962, Class B2 | Fillet sealing and brush over-coating to protect against chemical. exposure. | 2 hrs | 24 hrs | 46 hrs | PL-106 Primer, PL-410 Sealant | B. F. Goodrich | 19 |
| | Class B6 | | 6 hrs | 46 hrs | 166 hrs | | | |
| Sealant, Synthetic Rubber, Electrically Conductive, Corrosion Inhibiting | STM 40.114, Class B1/2 | Faying surface and wet install-ation of fasteners where electrical conductivity is rewired. | 1/2 hr | 10 hrs | 30 hrs | Pro-Seal 872. B1/2 | Products Research | 34 |
| | Class B2 | | 2 hrs | 40 hrs | 72 hrs | Pro-Seal 872, B2 | Products Research | 34 |
| Parting Agent | | For separable seals where conductivity is required. | | | | RAM 225 | Ram Chemicals | 36 |
| Parting Agent | | For separable seals where conductivity is not required. | | | | Plastilease 643 | Ram Chemicals | 36 |
| Sealant. Synthetic Rubber, Low Adhesion | MIL-S-6764 Class B1/2 | Faying surface seal-ing, wet installation of removable parts and fasteners. | 1/2 hr | IO hrs | 166 hrs | PR-1321, B1/2<br>GC-200, B1/2<br>CS-3300, B1/2 | Products Research<br>Goal Chemical<br>Chem Seal Corp. | 34<br>16<br>9 |
| | Class B2 | | 2 hrs | 24 hrs | 166 hrs | PR-1321, B2<br>GC-200, B2<br>cs-3300, B2 | Products Research<br>Goal Chemical<br>Chem Seal Corp. | 34<br>16<br>9 |
| Sealant, Synthetic Rubber, Low Adhesion Corrosion Inhibiting | AMS 3267 Class B1/2 | Faying surface seal-ing. wet installation of removable parts and fasteners. (NOT for use in fuel-wetted areas.) | 1/4 hr | IO hrs | 46 hrs | PR-1403G. B1/2 | Products Research | 34 |
| | Class B2 | | 2 hrs | IO hrs | 46 hrs | PR-1403G. B2 | Products Research | 34 |
| Sealant, Synthetic Rubber, Fuel Tank | MIL-S-8802 Type II-U | Fillet sealing in fuel areas. | 1/2 hr | 10 hrs | 46 hrs | CG-408, B1/2<br>PR-1422. B1/2<br>Pro-Seal 690, B1/2<br>CS-3204. B1/2 | Ram Chemicals<br>Products Research<br>Products Research<br>Chem Seal Corp. | 36<br>34<br>34<br>9 |
| | Type II-2 | | 2 hrs | 40 hrs | 72 hrs | CG-408, 82<br>PR-1422, B2<br>Pro-Seal 690. B2 | Ram Chemicals<br>Products Research<br>Products Research | 36<br>34<br>34 |
| | Type II-4 | | 4 hrs | 46 hrs | 90 hrs | CG-406, B4<br>cs-3204, B4<br>PR-1422, B4 | Ram Chemicals<br>Chem Seal Corp.<br>Products Research | 36<br>9<br>34 |

## SEALANTS (contd)

| ITEM | SPECIFICATION | USE | APPL. TIME | TACK FREE | CURE TIME | MANUFACTURER'S DESIGNATION | DISTRIBUTOR | ADDRESS (See Pg. 15) |
|---|---|---|---|---|---|---|---|---|
| Sealant. Synthetic Rubber, Fuel Tank (contd) | Type I-H | Brush coating in fuel areas. | 1/2 hr | 40 hrs | 72 hrs | CG-408, AH | Ram Chemicals | 36 |
| | | | | | | PR-1422. AH | Products Research | 34 |
| | | | | | | CS-3204, A1/2 | Chem Seal Corp. | 9 |
| | | | | | | Pro-Seal 890, AH | Products Research | 34 |
| | Type I-2 | | 2 hrs | 48 hrs | 90 hrs | PR-1422, A2 | Products Research | 34 |
| | | | | | | GC-408, A2 | Ram Chemicals | 36 |
| Sealant, Synthetic Rubber, Corrosion Inhibiting | MIL-S-81733 Type II-1/2 | Faying surface sealant, wet installation of fasteners. | 1/2 hr | 10 hrs | 30 hrs | PR-1422G, B1/2 | Products Research | 34 |
| | | | | | | Pro-Seal 870. B1/2 | Products Research | 34 |
| | Type II-2 | | 2 hrs | 40 hrs | 72 hrs | PR-1422G, B2 | Products Research | 34 |
| | | | | | | Pro-Seal 670, B2 | Products Research | 34 |
| | Type I-W | Wet installation of fasteners. | 1/2 hr | 10 hrs | 48 hrs | PR-1422G. A1/2 | Products Research | 34 |
| | Type I-2 | | 2 hrs | 40 hrs | 72 hrs | PR-1422G. A2 | Products Research | 34 |
| | | | | | | Pro-Seal 870, A2 | Products Research | 34 |
| | Type IV-12 | Faying surface sealing, wet installation of fasteners. | 12 hrs | 120 hrs | 180 hrs | PR-1431G, B12 | Products Research | 34 |
| | | | | | | Pro-seal 870, B12 | Products Research | 34 |
| | Type IV-24 | | 24 hrs | 192 hrs | 240 hrs | PR-1431G, B24 | Products Research | 34 |
| | | | | | | Pro-Seal 870, B24 | Products Research | 34 |

**NOTE: All application, tack-free, and cure times given in the above assume 77(+/-2) F temperature and 50(+/-5)% relative humidity.**

**joints, and for fillet sealing under the latrine** area. This two-part sealant is sold by B. F. Goodrich as PL-106 (primer) and PL-410 (sealant). It is available in both class B2 and B6 formulations.

- STM 40.114-This is a polysulfide corrosion-inhibiting sealant with aluminum particles added to provide electrical conductivity. Its temperature range is -65°F to +250'F It is used for faying surface sealing when corrosion protection and electrical conductivity are required; i.e., to protect structure under antennas. This material is commercially available as Pro-Seal 872, manufactured by Products Research Corporation.

- MIL-S-8784-A low-adhesion polysulfide sealant in the -65°F to +225'F temperature range, this material is used for sealing removable panels. It is available in formulations for brushing (Class A) or for use with a spatula or sealant gun (Class B). This material should not be used for permanent installations. Although MIL-S-8784 has a peel strength of only 2 pounds per square inch, be sure to apply a coat of bond release agent such as RAM 225 or RAM 843 to the panel during reinstallation to make removal even easier.

- AMS 3267-This is also a low-adhesion sealant with about the same properties as MIL-S-8784; however, this material contains corrosion inhibitors. It is used for the same purpose and in the same manner as MIL-S-8784. If given a choice between MIL-S-8784 and AMS 3267 sealants, choose the AMS 3267 to take advantage of its corrosion-inhibiting qualities.

- MIL-S-8802-This is a polysulfide sealant that is used for fillet sealing joints and brush-overcoating of fasteners in fuel tanks. Its effective temperature range is from -65°F to +250 'F. As a last resort, MIL-S-8802 may be used as a substitute for MIL-S-81733 for faying surface sealing and wet installation of fasteners.

- MIL-S-81733-This material is a polysulfide sealant that contains corrosion inhibitors. It is widely used for faying surface sealing of permanently joined repairs and structure, and also for wet-installation of permanent fasteners. Its temperature range is -65°F to +250'F. Type I is brushable; Type II is a paste for use with a spatula or sealant gun; Type III is sprayable; and Type IV is used when extended assembly time is required.


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Structure under antennas is a common site for corrosion, particularly where the antenna is not sealed, or gaskets have been damaged.

**Sealant Sawy**

All sealants have a specified shelf life listed on the container. Shelf life is the length of time the material may be stored before use without affecting its integrity. However, to reach its full shelf life, a sealant should be stored in a cool, dry area. Under no circumstances should sealant be stored where a temperature of 80°F is exceeded. Since the temperature in most parts of the world rises above 8O'F, at least during the summer, it is advisable to use an explosion-proof refrigerator for sealant storage.

Some sealants may still be usable for a while after expiration of their shelf life date, but extreme caution should be exercised before using them. It is very disappointing to discover that the sealant will not cure after structure has been assembled. To avoid encountering this situation, mix a small amount of sealant as a test and note the cure time. If the base material is smooth and free of lumps, if the catalyst has not dried out, and if the cure time is within the manufacturer's specification shown on the container, the sealant is usable.

There are three main problems encountered while mixing and using sealants, and all are avoidable with proper care and attention to detail. (1) When sealant does not cure or takes too long to cure, the problem usually is that the sealant was over- or under-catalyzed. Occasionally, outdated sealant will be the cause. The use of a gram scale to weigh the sealant base and catalyst accurately will ensure a correct mix ratio every time. (2) Marbleized (streaky) sealant is caused by incomplete mixing, and as a result the streaked areas of catalyst or base material will not cure. **(3)** Surfaces must be really clean for good sealant adhesion; otherwise, moisture will penetrate between the sealant and the structure by capillary action and cause hidden corrosion.

Temperature and humidity greatly affect curing of sealant. For example, curing times for sealants are based on a standard condition of 77°F and 50 percent relative humidity. A 15°F decrease in temperature will double the cure time, and a 15°F increase in temperature over the standard condition will halve the cure time. Cure times may be shortened by applying heat, but do not exceed 140°F during the cure cycle. Before applying sealant, ensure that the structure is 40°F or warmer and will remain so until complete cure of the sealant.

**Corrosion Preventive Compounds**

There are several types of corrosion preventive compounds (CPCs) available, formulated for various uses. All provide excellent temporary protection against corrosion. The two categories of CPCs are water-displacing and non-water-displacing. Non-water-displacing CPCs provide corrosion protection for longer periods because they contain grease of a more viscous oil than the water-displacing kind.

Since the water-displacing types contain lighter oil, they penetrate tight joints better than the non-water-displacing formulations. Neither type provides permanent corrosion protection. Reapplication is required every four to six months and more often in damp or wet regions. Although CPCs contain oil, they provide poor lubricity and should not be used in sliding joints. Also, CPCs should not be used on or near liquid oxygen systems and equipment, on or off the airplane. Oxygen in contact with CPCs could result in fire or explosion. Most CPCs may be obtained in either bulk form or packaged in aerosol containers. The bulk material may be applied by spraying, dipping, or brushing, depending upon the viscosity of the material being used.

Three commonly used CPCs are identified below:

- MIL-C-16173-This CPC may be obtained in five grades, ranging from a very viscous, cosmoline-type material to a very thin, transparent film CPC. Grades 3 and 4 are the two types most often used on airplanes. Grade 3 is a water-displacing type and Grade 4 is non-water-displacing.

- MIL-C-81309-There are two types and classes of this CPC, all of which are water-displacing. Type II, Class 1, is supplied in bulk form; Type II, Class 2, is distributed in aerosol containers. Both Class 1 and Class 2 are for corrosion protection of metallic structure. Type III, in both Class I (bulk form) and Class 2 (aerosol container) is avionics grade. The dielectric of both types is 25,000 volts.

- MIL-C-85054-This material is also known as Amylguard. It forms a clear, dry flexible film which is removable with solvent. Amylguard should not be used in tight-fitting joints, or moving or sliding parts. It offers excellent temporary protection for chipped paint spots, etc.



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## rials and Vendors Listing

above, several types and two categories of of the proper CPC will help in preventing the onset of corrosion in many areas of the Hercules aircraft. Remember that while CPCs are very practical weapons in the corrosion control arsenal, they are not intended to provide permanent corrosion protection and must be periodically reapplied to remain effective. The following table lists a selection of CPCs by military specification and where they may be obtained commercially.

### CORROSION PREVENTIVE COMPOUNDS

| ITEM | SPECIFICATION | MANUFACTURER'S DESIGNATION | DISTRIBUTOR | ADDRESS (See Pg. 15) |
|---|---|---|---|---|
| Heavy Grease, Hard Film | MIL-C-16173, Grade 1 | Valvoline Tectyl 690 | Ashland Petroleum Co. | 4 |
| | | Braycote 103, 103-T | Burmah-Castrol Inc. | 7 |
| | | 890-BC, Rusterizer 12 Rusterizer 12-R-2 | Bulk Chemicals Dist. | 6 |
| | | convoy 731 | Convoy Oil Corporation | IO |
| | | Nox-Rust 201 8 | Daubert Chemical Co. | 12 |
| | | Veedol Anorustol 297 | Deutsche Veedol GmbH | 13 |
| | | Interfilm Type II black | Esgard Incorporated | 14 |
| | | F&L 5890 | F&L Company Inc. | 16 |
| | | Rust-Foil 161-l | Franklin Oil Corp. | 17 |
| | | Cosmoline 1056 | E. F. Houghton & Co. | 22 |
| | | Jesco 707 | Jesco Resources Inc. | 23 |
| | | Petrotect 1X, Petrotect 1XA | Penreco | 32 |
| | | Royco 103 | Royal Lubricants Co. | 37 |
| | | No-Rust 21 B | Steven Industries | 36 |
| | | Nokorode 731, Nokorode 731-R | Lion Oil Company | 24 |
| | | Visconorust 1601 Black | Viscosity Oil Co. | 40 |
| Heavy Grease, Soft Film | MIL-C-16173, Grade 2 | Valvoline Tectyl 502C | Ashland Petroleum Co. | 4 |
| | | Braycote 137, 137E | Burma-Castro1 Inc. | 7 |
| | | 502C-BC | Bulk Chemicals Dist. | 6 |
| | | Convoy BH 16D 2, Convoy 732 | Convoy Oil Corporation | 10 |
| | | Nox-Rust 207 | Daubert Chemical Co. | 12 |
| | | Veedol Anorustal 260 | Deutsche Veedol GmbH | 13 |
| | | Lubra Kote Black | Esgard Incorporated | 14 |
| | | F&L 5502-C | F&L Company Inc. | 16 |
| | | Rust Preventive 1612A | Franklin Oil Corp. | 17 |
| | | Cosmoline 1102 | E. F. Houghton &Co. | 22 |
| | | Rustek PP 11 | A. Margolis & Sons Corp. | 25 |
| | | Steelgard MS IO | Harry Miller Corp. | 20 |
| | | LPS-3 | Holt Lloyd Corporation | 21 |
| | | Petrotect 2 | Penerco | 32 |
| | | Royco 137R | Royal Lubricants Co. | 37 |
| | | ST 1502, No-Rust 27, P2A | Steven Industries | 38 |
| | | Visconrust No. 1602 | Viscosity Oil Co. | 40 |
| Water Displacing, Soft Film | MIL-C-16173, Grade 3 | Valvoline Tectyl 694 | Ashland Petroleum Co. | 4 |
| | | Braycote 153E | Burmah-Castrol Inc. | 7 |
| | | 694-BC | Bulk Chemicals Dist. | 6 |
| | | Convoy BH 18D 3, Convoy 733 | Convoy Oil Corporation | IO |
| | | Nox-Rust 206 | Daubert Chemical Co. | 12 |
| | | Veedol Anorustol 270 | Deutsche Veedol GmbH | 13 |
| | | F&L 5694 | F&L Company Inc. | 16 |
| | | Rust-Foil 161-3 | Franklin Oil Corp. | 17 |
| | | Rustek RP 12 | A. Margolis & Sons Corp. | 25 |
| | | Steelgard MS-12 | Harry Miller Corp. | 20 |
| | | Omega 512-5. Western Omega 512-5 | MSCI Limited | 26 |
| | | Oakite Special Protective Oil Q | Oakite Products Inc. | 26 |
| | | Petrotect 3 | Penreco | 32 |
| | | Ferrocote 364-BL. Ferrocote 376-BL | Quaker Chemical Corp. | 35 |
| | | Royco 153R | Royal Lubricants Co. | 37 |
| | | STI894, No-Rust 26, P3A | Steven Industries | 36 |
| | | Visconorust No. 1603 | Viscosity Oil Co. | 40 |

CORROSION PREVENTIVE COMPOUNDS (contd)

| ITEM | SPECIFICATION | MANUFACTURER'S DESIGNATION | DISTRIBUTOR | ADDRESS (See Pg. 15) |
|---|---|---|---|---|
| Transparent, Non-Tacky Film | MIL-C-16173, Grade 4 | Valvoline Tectyl 646 | Ashland Petroleum Co. | 4 |
| | | Braycote 194, Braycote 194E | Burmah-Castrol Inc. | 7 |
| | | 646-K | Bulk Chemical Dist. | 6 |
| | | convoy 734, | Convoy Oil Corporation | 10 |
| | | Nox-Rust X-110 | Daubert Chemical Company | 12 |
| | | Veedol Anorustol | Deutsche Veedol GmbH | 13 |
| | | Rust-Ban 397 | Esso A.G. | 15 |
| | | F&L 5646 | F&L Company Inc. | 16 |
| | | Cosmoline 1112 | E. F. Houghton & Co. | 22 |
| | | Rustek R P 13 | A. Margolis & Sons Corp. | 25 |
| | | Petrotect Amber | Penreco | 32 |
| | | Poly Oleum 5000 | Poly Oleum Corporation | 33 |
| | | Royco 194R | Royal Lubricants Co. | 37 |
| | | ST1846, No-Rust X-IO, P4A | Steven Industries | 38 |
| | | Visconorust 1600 Amber | Viscosity Oil Company | 40 |
| LOW Pressure Steam-Removable Film | MIL-C-16173, Grade 5 | Valvoline Tectyl 511 M | Ashland Petroleum Co. | 4 |
| | | Braycote 198E | Burmah-Castrol, Inc. | 7 |
| | | 51 1M-BC | Bulk Chemicals Dist. | 6 |
| | | Convoy 735, Convoy BH 18D 5 | Convoy Oil Corporation | 10 |
| | | F&L 5511 M | F&L Company Inc. | 16 |
| | | Petrotect 5 | Penreco | 32 |
| | | Royco 195 | Royal Lubricants Co. | 37 |
| | | ST 1511, P5A | Steven Industries | 36 |
| Water-Displacing, Ultra-Thin Film Bulk | MIL-C-61309, Type II Class 1 | Alox 2026CM Bulk | Alox Corp. | 2 |
| | | 2775 | Omega Chemical Corp. | 30 |
| | | Octoil 5068 | Octagon Process Inc. | 29 |
| | | Aldchim Alox 2026 | Aldchim Limited | 1 |
| | | Ardox 3204 | Ardox Incorporated | 3 |
| | | Batco Rust Preventative, Type II | Battenfield Grease & Oil | 5 |
| | | D-5026 Bulk | Zip Aerosol Products | 41 |
| Water-Displacing. Ultra-Thin Film, Aerosol | MIL-C-81309, Type II Class 2 | 2028-8000 | Bulk Chemicals Dist. | 6 |
| | | Care 2023-B | Murd Co. | 27 |
| | | LPS813A | Holt Lloyd Corporation | 21 |
| | | 22028C2 | Steven Industries | 36 |
| Water-Displacing, Utra-Thin Film, Bulk | MIL-C-61309, Type III Class 1 | Alox 2028D | Alox Corporation | 2 |
| | | 2780 | Omega Chemical Corp. | 30 |
| | | Octoil 5069 | Octagon Processes Inc. | 29 |
| | | Omni 4150A | Omnitech International | 31 |
| | | Technolub.? FE-006 | Technolube Products CO. | 39 |
| | | D-5026 | Zip Aerosol Products | 41 |
| | | CRC 3-36 | CRC Chemicals Europe | 11 |
| | | Ardox 3205 | Ardox Incorporated | 3 |
| | | Batco Rust Preventative. Type II | Battenfield Grease & Oil | 5 |
| Water Displacing, Ultra-Thin Film, Avionics Grade, Aerosol | MIL-C-81309. Type III Class 2 | 22028C2-3 | Steven Industries | 36 |
| | | LPS-814A | Holt Lloyd Corporation | 21 |
| | | 2028-MLCO | Bulk Chemical Dist. | 6 |
| | | Care 2023-A | Murd Company | 27 |
| | | CRC 3-36 Aerosol | CRC Chemicals Europe | 11 |
| Water Displacing, Hard Film (Amylguard) | MIL-C-85054; Type I (Aerosol) Type II (Bulk) | 1900 (Aerosol) 1900 (Bulk) | Care Laboratories | 8 |

## Special Problems

Many engineering drawings and specifications have traditionally required that antenna mating surfaces and fasteners be free of insulating finishes in order to provide for electrical conductivity. Where antennas are not sealed, corrosion is commonplace on structure under the installation. Wherever metal-to-metal contact is required, the reason for corrosion susceptibility is obvious.

Some antennas are installed with rubber or cork gaskets. A common corrosion hazard associated with rubber gaskets is that they may be damaged or deformed by airplane cleaning chemicals and weathering, which allows moisture to penetrate. Cork gaskets are also somewhat problematical; they tend to wick water into the antenna and structure interface.

Service News, Vol. 14, No. 4 (Oct.-Dec 1987), provides a helpful procedure for sealing VHF NAV antennas. This procedure may be used to install any antenna where metal-to-metal contact is required. Don't forget to apply a bond release agent to the antenna before installation. The procedure may also be used in lieu of installing the rubber or cork gasket when its use is not prohibited by maintenance managers or engineering.

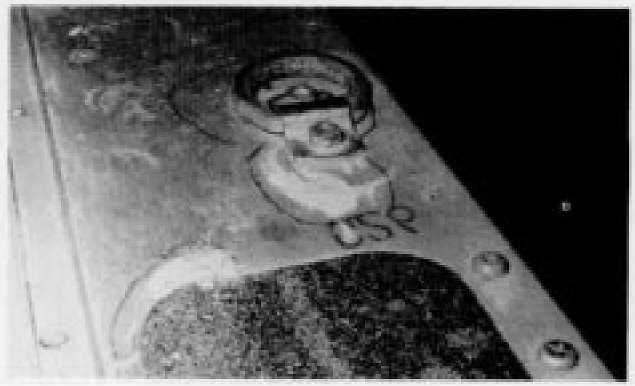
If a gasket must be used, apply about 10 mils of sealant to the structure before installing the gasket and antenna. After installation apply a fillet seal around the antenna periphery with MIL-S-83982 fluid-resistant sealant. Note that this is a two-part system which requires that the primer be applied before sealing.

## Prevention and Repair Examples

Regardless of airplane age, doing frequent inspections, cleaning regularly, removing corrosion promptly, and keeping finishes and sealant intact will minimize corrosion damage on the Hercules airplane. The following paragraphs offer several examples of corrosion-prone or corrosion problem areas and the recommended prevention and repair techniques:

Latrine, urinal, and galley areas are more subject to corrosive attack than anywhere else on the airplane. Special sealing and acid-resistant finishes have been used on structure under this equipment since Lockheed serial number LAC 4127. This means that airplanes that were manufactured previously will require more attention to these areas than the newer ones.

On all airplanes, look for corrosive fluids, dirt, chipped or deteriorated paint, and missing or damaged sealant on structure under and around these installations. After cleaning and drying, carry out the necessary corrosion, paint, and sealant repairs. Apply a coat of non-water-displacing CPC to the underfloor areas and especially to areas directly under the latrine, urinal, and galley. Pay particular attention to structural joints and crevices. If there is any chance of the CPC being inadvertently applied to avionics equipment under the galley, either protect the equipment or use an avionics-grade CPC in the galley area. Be sure to remove any CPC overspray which may have reached the floor; CPCs are slippery.



**The corrosion resistance of the cargo floor chine caps can be enhanced by cleaning, sealing, and painting the upper surfaces.**

Over the years there have been many instances of severe corrosion on the upper surface of cargo floor chine caps. Water entering through open doors and hatches, spilled cargo and latrine fluids all contribute to the corrosive environment of these chine caps. On airplanes with the aerial delivery system rails installed, fluids enter the rail and structure interface by capillary action. Fluids and soils can also be entrapped in the opening between the chine cap and the inboard portion of the Z-shaped doubler under the D-ring fittings where sealant is not used to prevent entry.

**Corrosion-preventive compounds should be applied regularly to structure under the latrine, urinal, and galley areas.**

Since moisture will remain under the rails and doublers longer than in an open area, corrosion will progress more rapidly. To prevent corrosion of the chine cap. remove the rails (if used) and the doublers and thoroughly clean the cap upper surface. Remove any corrosion found, apply conversion coating to the affected area and fill any depressions to slightly above the cap surface with corrosion-inhibiting sealant. Once the sealant has cured to at least a tack-free state, apply one coat each of epoxy primer and polyurethane enamel to the whole chine cap upper surface. After the paint has dried, reinstall the Z-doubler, D-ring, and bolts with a corrosion-inhibiting sealant between all contacting surfaces. Use low-adhesion sealant for bolt installation. Do not apply sealant to the underside of the rails.

There have been instances where attempts were made to grind corrosion from steel fasteners on wing and empennage panels with the fasteners still in place. This practice weakens both the fastener and the surrounding aluminum structure. When rusty fasteners are found, they should be replaced. Use corrosion-inhibiting sealant to install the new permanent fasteners. Wet-install temporary fasteners with low-adhesion sealant.

An alternative to fastener replacement is to remove the rust with Vat-U-Blast equipment and No. 13 glass beads. provided there is no corrosion in the fastener-to-structure interface. Adjust the air pressure to the lowest setting which will remove the rust but not cause damage to the fastener or surrounding structure. Immediately after corrosion removal or new fastener installation, clean the area and apply the appropriate finish system. Do not use the same glass beads for abrasive blasting more than one type of metal. The glass beads become contaminated with minute particles from the part being blasted, which could cause corrosion of a dissimilar metal. Also, blasting of metals with a thickness of 0.0625 inch or less could damage the metal.

Glued to the fuselage side panels are vertical rows of felt which act as stand-offs for the cargo compartment insulation blankets. There have been reports of corrosion forming behind these strips. If corrosion is found on your airplane. remove the felt strips and underlying old glue with wood or phenolic scrapers. Remove the corrosion, clean the affected area, apply conversion coating to unpainted spots, and touch up the paint. After the paint has dried, reinstall the felt strips (or install new strips) with sealant, extending the sealant slightly beyond the width of the felt to prevent moisture that may entrap in the felt from contacting the metal structure.

Have you ever seen a drain hole that appeared to be drilled in the wrong place because it did not completely drain the low spot? Misdrilled holes are not unheard of, but every effort is made to drill the hole at the lowest point. This is not always possible, however, because of structural considerations. When low spots are found not completely drained, take note of the water level and then thoroughly dry the area. Remove the dirt and debris and fill the spot up to the water line with corrosion-inhibiting sealant. Slope the sealant toward the drain hole, being careful not to clog the hole. After the sealant is tack-free, apply a thin coat of polyurethane enamel over the sealant.

Sometimes engineers design unusual drain systems which require special attention to remain effective. Such is the case with the rubber seal at the base of the pylons that support the external fuel tanks. Although this extruded rubber strip is designed as an aerodynamic seal, it is also supposed to permit fluids inside the pylon to drain out from beneath the seal and at sites where the seal strips overlap. Unfortunately, the seals may stick to the paint on the tank, trapping the fluid inside the pylon. If sticking of this seal becomes a problem, a simple remedy to maintain a water passage is to cut a narrow notch in the seal on each side of the pylon just forward and aft of the forward beam.

Remember that drainage problems are not limited to places that are easy to see and inspect. Under the right conditions, hidden drainage problems can turn up in some unusual parts of the aircraft structure, such as the dorsal and the horizontal stabilizer. Information on draining moisture from the dorsal of airplanes built prior to LAC 5058 can be found in *Service News*, Vol. 13, No. 4 (October-December 1986). Preventing moisture entrapment in the horizontal stabilizer is discussed in *Service News*, Vol. 14. No. 3 (July-September 1987).

## No Magic Formula

We have already noted that the evolution of the Hercules has resulted in a more corrosion-resistant airplane. It is not, however, immune to corrosion. The longevity of the Hercules aircraft is largely dependent on how well the airplane is maintained by the operator. In order for the Hercules to realize its maximum service life, each operator must establish a viable corrosion prevention and control program. There is no magic formula involved. It takes personal interest, professional attention. and a lot of hard work, beginning at the time of manufacture and continuing throughout the life of the airplane.

The operator should first review present capabilities versus what is required to establish and maintain an effective program. Second, he should build a tailored program, and ensure that everyone within the maintenance complex knows and does his part. The quality of the operator's program depends upon the skill and dedication of all involved. But the rewards are worth the effort. A good corrosion prevention and control program will help ensure many years of safe and reliable Hercules operation.

| Address Code | | Address Code | | Address Code | |
|---|---|---|---|---|---|
| 1 | Alchim Limited<br>P.O. Box 103<br>Roanana 43100<br>Israel | 15 | ESSO A.G.<br>Kapstadtring 2<br>2000 Hamburg 60<br>West Germany | 29 | Octagon Processes Inc.<br>596 River Road<br>Edgewater, NJ 07020 |
| 2 | Alox Corporation<br>P.O. Box 517<br>Niagara Falls, NY 14302 | 16 | F&L Company Inc<br>P.O. Box 4645<br>1537 E. Del Amo Blvd.<br>Carson. CA 90746 | 30 | Omega Chemical Corp.<br>6935 West 62nd St.<br>Chicago, IL 60636 |
| | Ardrox Inc.<br>16961 Knott Ave.<br>La Mirada, CA 90628 | 17 | Franklin Oil Corp.<br>40 South Park St.<br>Bedford, OH 44146 | 31 | Omitech International Inc.<br>600 North Arcadia Rd.<br>Thibodaux, LA 70301 |
| | Ashland Petroleum Co.<br>21st & Front Streets<br>Ashland, KY 41114 | 16 | Goal Chemical Corp.<br>3137 E. 26th St.<br>Los Angeles, CA 60023 | 32 | Penreco<br>P.O. Box 971<br>Butler, PA 16001 |
| | Battenfield Grease & Oil<br>1174 Erie Ave.<br>Box 726<br>North Tonowanda, NY 14120 | 19 | B. F. Goodrich Co.<br>500 South Main St.<br>Bldg. 513<br>Akron, OH 44316 | 33 | Poly Oleum Corporation<br>13531 Greenfield Rd.<br>Detroit, MI 46227 |
| | Bulk Chemicals Distributors<br>Division of Malter Intl.<br>60 First St.<br>Gretna, LA 70053 | 20 | Harry Miller Corp.<br>4th & Bristol Streets<br>Philadelphia, PA 19140 | 34 | Products Research & Chemical<br>5454 San Fernando Rd.<br>Glendale, CA 91203 |
| | Burmah-Castrol Inc.<br>Bray Products Division<br>16815 Von Karman Ave.<br>Irvine, CA 92714 | 21 | Holt Lloyd Corp.<br>4647 Hugh Howell Rd.<br>Tucker. GA 30064 | 35 | Quaker Chemical Corp.<br>Elm and Lime Streets<br>Conshohocken. PA 19426 |
| | Care Laboratories<br>P.0. Box F<br>3474 Germantown Pike<br>Collegeville, PA 19426 | 22 | E. F. Houghton & Co.<br>Madison & Van Buren Aves.<br>Valley Forge, PA 19482 | 36 | Ram Chemicals<br>210 E. Alondra Blvd.<br>Gardena, CA 30247 |
| | Chem Seal Corporation<br>11120 Sherman Way<br>Sun Valley, CA St352 | 23 | Jesco Resources Inc.<br>1437 Gentry St.<br>P.O. Box 12337<br>N. Kansas City, MO 64116 | 37 | Royal Lubicants Co.<br>River Road<br>East Hanover, NJ 07936 |
| 10 | Convoy Oil Corporation<br>1410 North Front St.<br>Philadelphia, PA 19122 | 24 | Lion Oil Company<br>1000 McHenry St.<br>El Dorado, AR 71730 | 36 | Steven Industries Inc.<br>39 Avenue C<br>Bayonne, NJ 07002 |
| 11 | CRC Chemicals Europe<br>Touwslagerstrstt 1<br>N9140 Zele<br>Belgium | 25 | A. Margolis & Sons Corp.<br>1504 Atlantic Ave.<br>Brooklyn. NY 11216 | 39 | Technolube Products Co.<br>5614 East 61st St.<br>Los Angeles, CA 90040 |
| 12 | Daubert Chemical Co.<br>4700 South Central Ave.<br>Chicago, IL 60638 | 26 | MSCI Limited<br>Surface Conditioners<br>6935 West 62ns St.<br>Chicago, IL 60636 | 40 | Viscosity Oil Company<br>3200 S. Western Ave.<br>Chicago, IL 60608 |
| 13 | Deutsche Veedol GmbH<br>Hauptabt. GroBverbraucher<br>Esplanade 39,<br>2000 Hamburg 36. W. Germany | 27 | Murd Company<br>2314 N. American St.<br>Philadelphia, PA 19133 | 41 | Zip Aerosol Products<br>Division of Mitann Inc.<br>21320 Deering Court<br>Canoga Park, CA 91304 |
| 14 | Esgard Incorporated<br>P.O. Box 2696<br>Lafayette, LA 70502 | 26 | Oakite Products Inc.<br>50 Valley Rd.<br>Berkeley Heights, NJ 07922 | | |

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# The cost of neglect: it's colossal !