SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR5541

Issued 2006-04

Recommended Actions When Disinfectants, De-icers, and Cleaners Come in Contact with Landing Gear Structure

RATIONALE

There are several operational situations occurring that result in various fluids contacting landing gear structures and components. Such events are spraying disinfectants to combat transmutable diseases (foot and mouth), de-icing sprays and cleaning solutions. These solutions can be caustic and have detrimental effects on landing gear components with possible material degradation. This document provides information on cleaning and removing caustic fluids. It suggests procedures and methods to document such occurrences and provides recommended inspections to help minimize the impact on the landing gear system.

FOREWORD

An outbreak of foot and mouth disease in Europe and the United Kingdom in 2001 resulted in many national authorities adopting stringent measures to prevent the spread of the disease. These measures included the use of strong disinfectants for decontaminating any object that had been in contact with foreign soil. The shoes of travelers, tires of travelers' vehicles, and the wheels and tires of commercial and military aircraft became the primary focus of those charged with stopping the disease at its points of entry to, and exit from, each country. The personnel charged with disinfecting the tires of aircraft were intent on doing a thorough job and did not understand the importance of protecting the aircraft structure from corrosive agents. As a result, many aircraft were sprayed without regard for the masking procedures used by maintenance personnel to prevent the pooling of liquids in corrosion sensitive areas, and to protect vulnerable components such as carbon brakes from contamination with chemicals.

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As the aerospace industry, airport authorities, and overhaul and maintenance facilities go to more environmentally friendly de-icers and cleaners, there is an increased risk that certain chemical compounds will actively attack the materials used in landing gear systems. There are concerns for the introduction of corrosion, degradation of the paint/protection coating, introduction of hydrogen embrittlement in high strength steels, and other breakdown of various materials used in landing gear. The simplest solution is to prevent direct contact of these chemicals with landing gear structure. The next best solution is to remove the chemicals as soon as possible and restore the system to a chemical free state. There is also a need to adequately address gear protection as stated in the maintenance manuals; such that when prolonged exposure to chemical agents are properly documented and dealt with. The intent is to perform adequate inspections and, if necessary, perform overhaul on affected parts.

As new cleaners and de-icers are introduced into service, sufficient material testing needs to be accomplished to determine impact on landing gear systems to ensure structural integrity has not been compromised.

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1. SCOPE:

This SAE Aerospace Information Report (AIR) advises that some of the chemicals being used to disinfect, de-ice, and clean airplanes can cause corrosion and/or degradation of landing gear components. Landing gear equipment includes shock struts, braces, actuators, wheels, brakes, tires, and electrical components. Some of the chemicals that have been recognized as potentially injurious are identified and recommendations for mitigating damage are presented.

1.1 Purpose:

The purpose of this report is to increase general awareness of the risks associated with exposing aircraft to corrosive chemicals that are being used for disinfecting, de-icing, and cleaning operations. This document also seeks to inform personnel responsible for landing gear systems of the action needed to mitigate and document the corrosion risk to an affected aircraft and its landing gear systems.

2. REFERENCES:

2.1 Applicable Documents:

1. Memorandum for HQ USAF/ILM, subject: Foot and Mouth Decontamination
2. Airworthiness Advisory, AA-01-03, dtd. 30 March 2001, subject: Use of Disinfectants on USAF Aircraft
3. Boeing Message M-7200-01-00653, dtd. 10 March 2001, subject: Applying Chemicals to Aircraft to Prevent Spread of Foot-and-Mouth Disease
4. HONEYWELL (BENDIX) ALERT SERVICE INFORMATION LETTER (SIL) #710, dated 10 MARCH 01, subject: Exposure of Aircraft Wheels and Brakes to Sodium Hypochlorite Disinfecting Solution
5. Flight Standards Information Bulletin for Airworthiness (FSAW) #01-04, dtd. 01 June 2001, subject: Landing Gear Spray for Foot-and-Mouth Disease
6. Sample Checklist: All Purpose Checklist: Attachment A
7. T.O. 1-1-691 Aircraft Weapon System, Cleaning and Corrosion Control
8. MIL-C-87937 Cleaning Compound, Aerospace Equipment (Alkaline Cleaners, Titanium)
9. ASTM B 600 Cleaning Titanium

2.2 Applicable Websites:

AMPN/DOD FOREIGN CLEARANCE GUIDE, AVAILABLE AT: WWW.FCG.PENTAGON.MIL//

AMPN/ARMED FORCES PEST MANAGEMENT BOARD, TECHNICAL INFORMATION MEMORANDUM NO. 31, CONTINGENCY RETROGRADE WASHDOWNS, AVAILABLE AT: HTTP://WWW.AFPMB.ORG/PUBS/TIMS/TIM31.PDF

AMPN/USEUCOM CUSTOMS EXECUTIVE AGENCY WEBSITE: HTTP://WWW.HQUSAREUR.ARMY.MIL/OPM/CUSTOMS.HTM

AMPN/USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE WEBSITE: WWW.APHIS.USDA.GOV

AMPN/UNITED KINGDOM MINISTRY OF AGRICULTURE, FOOD, AND FISHERIES WEBSITE:WWW.DEFRA.GOV.UK//

EUROPEAN AVIATION SAFETY AGENCY WEBSITE: HTTP://EUROPA.EU.INT/AGENCIES/EASA/INDEX_EN.HTM

3. TECHNICAL CONSIDERATIONS:

Certain chemical compounds that are in use for disinfecting commercial and military aircraft can lead to corrosion damage of aircraft structure and equipment. Disinfectants are often applied to the tires of aircraft, both on arrival and before departure, as a precaution against the spread of pests and diseases. The probability of disinfectant overspray contacting adjacent areas of the landing gear such as the wheels, brakes, axles, other landing gear structural components, and electrical equipment on or near the landing gear poses a significant threat of corrosion damage. Aircraft, runway de-icers and aircraft cleaners often come in contact with landing gear materials. Some of these de-icers and cleaners can cause material degradation and corrosion. For known incompatibility, appropriate protection should be incorporated into the landing gear design and sufficient handling, inspection and reporting procedures in place to negate or minimize any adverse reactions.

3.1 Disinfectant Chemicals:

Chemicals that are in use as tire disinfectants include, but not limited to, sodium hypochlorite, sodium carbonate, citric acid, and VIRKON S. To date all identified disinfectants present a corrosion risk to metallic and carbon structures.

3.1.1 Sodium Hypochlorite (Chlorine Bleach): Boeing has investigated several cases of fractured landing gear components where the cause of the fracture was traced to exposure to chlorine-based chemicals. An example where an operator experienced two events of fractured landing gear axles is discussed in Reference 3. A detailed examination of the damaged axles showed unusually high levels of chlorine in corrosion products near the fracture site and damage to areas of chrome plate, both of which were attributed to exposure from chlorine-based chemicals. There are industry concerns (airframe and engine) about rapid corrosion of magnesium wheels, stainless flex lines, and any other materials that could come under attack from bleach.

In addition to causing corrosion on metallic parts, sodium hypochlorite will also damage carbon composite brakes. An aircraft brake manufacturer, Honeywell/Bendix, has recently released an alert service information letter discussing the effects of these chemicals on wheels and brakes, with particular emphasis on the carbon composites used in some brakes (see Reference 4).

3.1.2 VIRKON S: VIRKON S is a disinfectant with a chemical composition that includes 50% potassium peroxomonosulphate. Potassium is known to degrade the disk material of the carbon-carbon brakes that are used on many aircraft including the U.S. Air Force C-5, USAF C-17, and Navy F-18. VIRKON is acidic; it has a pH of 2.6 in a 1% solution. The acidity of compounds such as VIRKON and citric acid, especially when mixed in stronger than recommended solutions with water, is a cause for concern.

The USAF has issued a memorandum (Reference 1) recommending a 1:1300 solution of Virkon S over the use of sodium carbonate with sodium silicate. Testing shows that both promote and accelerate corrosion, but the sodium products degrade aromatic polyimide wiring insulation, and is highly conductive. This can result in shorts and arcing, greatly increasing the risk to aircraft and air crews.

3.1.3 Other Compounds: Solutions of sodium carbonate, commonly known as washing soda, are strongly alkaline. The application of solutions that have a pH value outside the range of 6 to 8 is accompanied by the risk of corrosion. As users become aware of different chemicals in use, they should develop procedures to test impact to landing gear materials. For example, USAF C-17 M&P (Maintenance and Processes) requires that anything applied to the C-17 should be tested in accordance with Boeing Long Beach Commercial Service Document (CSD) #1 tests as a minimum. CSD #1 contains basic corrosion, transparency, and compatibility tests.

TABLE 1

Chemical	Corrosion	Catalytic Oxidation	Reduced Brake Performance	Polymer Degradation	Hydrogen Embrittlement
Sodium Hypochlorite (NaClO)	X	X		X	X
Bromine based formulas (Br)	X			X	
Iodine based formulas (I)	X			X	

3.2 Contaminants on LG Structure (Cleaners):

For landing gear with respect to chemical exposure, the four main categories of concern are corrosion of metal components, catalytic oxidation of carbon/carbon composites, reduction in brake performance, and polymer degradation (seals). There has been some extensive compatibility work performed on various products (cleaners, de-icers, and disinfectants) when applied to landing gear components. The so-called “list” of detrimental chemicals is not by product name per se, but categorized more by the product chemistry. All products used in conjunction with landing gear should be aerospace approved. Manufacturers must test their products to aerospace guidelines performing compatibility tests such as hydrogen embrittlement, sandwich corrosion testing, etc. to ensure there is no detrimental effect to the landing gear system. Cleaners generally should be in a pH range of 8.0 to 10.0, preferably buffered solutions, and free of elements such as sodium (Na), potassium (K), calcium (Ca), silicon (Si), and phosphorous as phosphate (PO_4).

CAUTION: It is not permissible to mix cleaners of different manufactures or type.

CAUTION: Do not substitute cleaning products; use of unqualified products may result in landing gear failures.

TABLE 2

Chemical	Corrosion	Catalytic Oxidation	Reduced Brake Performance	Polymer Degradation	Hydrogen Embrittlement
Formulas with a pH <8.0 or >10.0	X			X	
Tetra Sodium Pyrophosphate ($Na_4P_2O_7$)		X	X	X	X
Sodium Phosphate (Na_3PO_4)		X	X	X	X
Sodium Silicate ($Na_2Si_3O_7$)		X	X		X
Potassium/Sodium formates (HCOOK)	X	X		X	
Potassium/Sodium acetates (CH_3COOK)	X	X		X	
Calcium based formulas (Ca)	X	X		X	

3.3 Runway De-icers:

Runway de-icers must be tested and certified to AMS 1435A, for fluid-based products and AMS 1431 for solid-based products, standards before use. These standards measure performance, corrosion, and environmental compatibility. Currently, some airports use high volumes of runway de-icer with formulas based in Potassium and Sodium, such as formates and acetates. These elements can cause catalytic oxidation of carbon/carbon composite brakes at elevated braking temperature (1200 °F). This can cause a shorter life span of the brakes resulting in their early removal. The runway de-icer formulas should minimize the amount of K and Na used, while not affecting its performance as a de-icer. Also, it should contain liquid and vapor phase corrosion inhibitors to protect against corrosion of metal components. Other airports may use glycol based products on their runways, which would have different effects on the landing gear materials.

4. RECOMMENDED ACTIONS:

4.1 General Precautions:

In all cases the air vehicle's operating technical procedure must be followed. For any application of any type of chemicals on the air vehicle, the proper protection of landing gear components should be followed. In cases where chemicals do come in contact with landing gear structure and components, proper documentation of the event should occur. Corrective action must take place to clear all chemical contact with landing gear components, followed by appropriate inspections and/or overhaul as necessary.

4.1.1 Disinfectants: There has been very little testing with respect to disinfectants with the exception of sodium hypochlorite (bleach). In review of the formula's chemistry both sodium and chlorine can promote corrosion of the landing gear metal components. The compatibility literature suggest that disinfection products containing other halogens, bromine(Br), iodine (I) etc. can react in a fashion similar to sodium hypochlorite when in contact with metal landing gear components. Polymers internal to the landing gear should not be exposed to any foreign chemicals. The polymers should only be exposed to the specific chemicals for which they are designed (i.e., hydraulic fluids, oils, etc.).

Until the use of disinfectants is brought under better control, it is recommended that aircraft manufacturers encourage in-depth review by users to ensure all options are considered before flying to, from, and through the countries that may be spraying for reported foot and mouth disease outbreaks. Possible alternative routes or other means of transportation should be considered.

Exposure to any disinfectant chemicals should be discouraged or at least limited to what is absolutely necessary.

Crews may have little or no option, but to comply with the requests of host nation officials to spray the aircraft interiors or tires. It is USEUCOM policy to cooperate fully in control measures implemented by host nation governments in the EUCOM AOR and by the United States Department of Agriculture (USDA). Crews should request the use of alternative cleaning methods other than Virkon or bleach, and ask that the spraying of interiors be avoided if possible. However, they should not resist to the point of creating an incident.

NOTE: Where the host nation and the USDA requirements differ, it is EUCOM policy to implement the stricter of the two. The USDA has established an emergency operations center with the following telephone numbers: 1-800-601-9327 (push #2 for FMD) or 1-301-734-9257. Further information can be found on the USDA Website: HTTP://WWW.USDA.GOV/SPECIAL/FMD/FMD.HTML;

Or contact the USAFE CAT at DSN 480-6351 for the latest available information and policy guidance.

Some airport authorities may want to spray the interiors of cargo aircraft. If there is a choice, it is recommended that it not be done. The U.S. is researching various procedures for safely removing the chemicals from aircraft interiors. In the interim, if airport authorities apply disinfectant to the interiors of an aircraft, then mops or rags dampened with clear water should be used to remove the disinfectant. If cleaning can not be performed immediately after application, then the nature of the disinfectant application should be documented in the aircraft forms, and the aircraft should be cleaned at the first possible opportunity.

4.1.2 Cleaners: When air vehicle cleaning event occurs ensure that proper procedures to protect the landing gear system are followed. If the landing gear itself is being cleaned follow approved procedures and only use cleaners recommended by the original equipment manufacturer. Rinse thoroughly to remove all traces of the cleaner. Follow with specified inspections of landing gear system to verify acceptable condition of structure and components.

Any deviations from normal procedures or unauthorized cleaners should be documented immediately. The cleaner must be removed completely. Original equipment manufacturer should be notified and an assessment made relative to possible impact to the landing gear's material, structure, and operation.

Users should develop specific listings of approved cleaners that can be used on landing gear equipment. For example, the USAF states that the landing gear may be cleaned using products meeting the requirements of AF Specification Control Drawing 9825019 (98747). Landing gear equipment may be washed using solvent wash qualified to Specification MIL-PRF-680 Types II or III. Shock struts may also be steamed cleaned with cleaner conforming to Commercial Item Description A-A-59133 or Federal Specification P-C-437.

4.1.3 De-icers: Whenever a deicing event occurs on the air vehicle, proper procedures and protection of the landing gear components should be followed as specified by the original equipment and/or de-icer manufacturer. If air vehicle operations occur on a de-iced runway, the landing gear system should be cleared of all de-icing residue at the next available opportunity. If not cleared of the de-icing compound then the event should be documented and appropriate inspection and overhaul procedures initiated. Note: It is necessary that there is an open communication between the airport authority and the airlines/users stating what de-icing material was used and if the compound has any effect on metals or composites.

4.2 Specific Procedures:

4.2.1 Limiting Exposure: In instances where it is practical, and brake temperature permits, the parking brake should be applied during disinfectant spraying to reduce the amount of solution allowed to penetrate the brakes.

Preferably, the sodium hypochlorite solution should only be applied to the tires and not to the brakes, wheels, or the landing gear structure. The application should be by a controlled method that minimizes overspray or spillage.

NOTE: While these chemicals may have a detrimental effect on tires, tires are easily inspected for damage and are frequently cycled on-and-off the airplane.

4.2.2 Mitigating Damage: If sodium hypochlorite or similar chemicals are used, we recommend the following precautions:

Do not allow disinfectants, de-icers, and cleaners, especially sodium hypochlorite, to remain on the aircraft any longer than required by the local airport authorities. When disinfectants and cleaners are used, ensure that exterior areas that were sprayed are promptly flooded with high volume, low-pressure clean water. Prompt, clear water rinsing of tires is especially important with disinfectants. If this wash occurs on airport grounds then they need to be informed of the wash and what was washed off so they can address the environmental concerns.

NOTE: The brakes should be exercised several times during taxi-out since brakes can freeze solid in flight if they are flooded with water immediately before take-off.

Upon arrival back at the home station (or the next station with capability), exterior areas (and interior, if applicable) should be washed again in accordance with the applicable aircraft technical data procedures and the landing gear technical orders. Where aircraft washing is not performed in an authorized washing location, the environmental function must be consulted for compliance with applicable regulatory requirements and local wastewater discharge permits. All affected areas should be lubricated to ensure that water and disinfectant residue is displaced from bearings.

It is recommended that grease fittings on the lower portions of the landing gears be lubricated on a more frequent basis to ensure that water and disinfectant residue is displaced from the bearings.

For disinfectants, after proper dwell contact time, flush with fresh water, warm if possible. For areas where flushing is not practical, wipe clean using dirt free cloths or sponges wetted with fresh water. Wiping cloths and sponges are to be rinsed repeatedly and the rinse water changed frequently.

Solutions that promote corrosion or deterioration to various aircraft components (if allowed to remain in contact for extended periods) make rinsing essential to the protection of the aircraft and landing gear from long-term damage.

4.3 Tires:

Chemical treatment for foot and mouth disease has the potential to cause tread and sidewall cracking of aircraft tires (minor to severe). Many countries are now fumigating all tires coming from the UK and Ireland with a mixture of Sodium Hypochlorite and Water. The potential exists for other chemicals to also be used as disinfectants. Please refer to Table 3 for findings on other chemicals. The main factor that operators must be advised about is the percentage of chemicals in the disinfecting solution. This directly influences the severity of the cracking. Moderate to severe cracking should be noticed during normal inspections. Any questions about tire cracking due to chemical treatment should be directed towards the manufacturing tire company. Also reference tire care and maintenance manuals for each individual tire company.

TABLE 3

Chemical	Percentage (%)	Effect
Sodium Carbonate (Na_2CO_3)	4	No effect
Citric acid ($HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$)	0.2	Minimal effect
Sodium Hydroxide Lye (NaOH)	2	Moderate effect (weather_checking/ozone_cracking)
Sodium Hypochlorite (NaOCl)	10	Severe effect (weather_checking/ozone_cracking)