International Maintenance Review Board Policy Board (IMRBPB)
Issue Paper (IP)

Initial Date: 09/04/2008
IP Number: 97
Revision 3 / Date 03/11/2011:

Title: Fluid spillage / fluid ingress in composites

Submitter: EASA MRB Section

Issue: There is a certain inconsistency in treating fluid spill and the according consequences for the structure.
Some aspects of fluid spill are taken into account as environmental condition, some aspects are taken into account as accidental damage.
"Water entrapment" is listed under bullet No. 7 of the AD sources, while "Fluid spill from galleys" is listed under bullet a of the ED chapter.

Fluid ingress in composite is listed in the metallic ED chapter.

Problem: There is a distinctive difference between AD and ED if it comes to the nature of the event, and the applicability of thresholds.
If spillage is understood as AD, it is a discrete event of random occurrence
In this case no threshold could be implemented
If spillage is understood as ED, it is a typical event developing in a systematic manner
Probably the truth is somewhere between.
Events like Galley spillage or coffee spill by passengers are random events of high probability, that occur during several flights every week and could be understood as a typical environment for Galleys and surrounding floor structure.
Chapter 2-4-5-2 is therefore correctly listing "galley spillage, toilet spillage" as deteriorating environment to be taken into account when rating ED for metals.

Hydraulic spillage is typically related to the age of a system component like gaskets, piston rod seals or hoses. As those system component are subjected to their own maintenance tasks, such leaks should be detected at a certain stage, and therefore the effect of hydraulic spillage should be limited. Nevertheless, every aircraft type has certain areas that are typically contaminated by hydraulic fluid after some years in service.

Spillage attributed to replenishing tasks (toilet fluid refill, hydraulic fluid top up) also is a frequently occurring event and typically causes corrosion, but it could be well addressed under the "Human error during operation/maintenance" evaluation of the AD rating.

Some very rare events of spill can cause immediate damage to the structure, i.e. battery acid spill. This should be assessed as accidental damage.

Looking at service experience, most fluid spillage is an event with very high probability and a frequency of occurrence much lower than typical structural maintenance intervals. Structural damage due to fluid spillage is typically not occurring immediately after the event, but developing over time when fluid spillage frequently occurs in a certain area.
We constantly find a lot of corrosion in typical spillage areas around galleys and toilets, even in modern aircraft, so obviously MSG-3 still does not fully address the problem.

Taking into account this experience, Fluid spillage is most appropriately addressed as an environmental condition for the affected structure, and should be handled under ED analysis.

For honeycomb sandwich composite, fluid entrapment is a typical problem. Typical causes for fluids entering the honeycomb are accidental damage to the surface protection, systematic deterioration of paint and sealant or design shortcomings leaving some moisture path into the honeycomb (i.e. hoist fittings, unsealed blind fasteners). Fluid is typically not entrapped as a sudden discrete event, but as a result of long time exposure to moisture and long term accumulation.
The exposure to moisture, as well as freeze/thaw cycling is typical for the operational environment and therefore fully systematic, while the exposure to other liquids is mostly accidental.
Mentioning of “fluid incursion into permeable non-metallic materials” in the ED rating chapter for metallic structure is simply wrong, it should be moved to the according non-metallic chapter, explicitly mentioning sandwich design, but not limiting to honeycomb. (foam sandwich is also well known to absorb fluids and to deteriorate subsequently)

With health and safety regulations applied today, mercury has been banned from most applications. Therefore the example of mercury spill (Definition of “Level 1 Corrosion”) should be an extremely remote event today, so the example might be misunderstood. While it was intended to be an example for an isolated event not typical for everyday aircraft operation, it is today an example for something that practically will never happen.

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Recommendation Revision 2 (including Implementation):
The Text has been updateded during two WebEx teleconferences in September 2011

The following changes to MSG-3 are recommended to cover the issue:
Chapter 2-4-3
Bullet a (AD): Remove freezing/thawing, this is environmental, not accidental
Add remark to composite paragraph.
Bullet b (ED): Reword fluid spillage remark
Reword and add remark to composite paragraph
Add drainage system paragraph
Add note regarding combination of effects.

a. **Accidental Damage (AD)**, which is characterized by the occurrence of a random discrete event which may reduce the inherent level of residual strength. Sources of such damage include ground and cargo handling equipment, foreign objects, erosion from rain, hail, lightning, runway debris, discrete spillage events ~~, freezing, thawing,~~ etc., and those resulting from human error during aircraft manufacture, operation or maintenance that are not included in other damage sources.

The same sources of accidental damage as those considered for metallic materials are to be considered for non-metallic material such as composites. The sensitivity to certain AD sources may differ, depending on the material used. The consequence of damage may not be readily apparent and may include internal damage, e.g., disbonding or delamination.

Large size accidental damage, such as that caused by engine disintegration, bird strike or major collision with ground equipment, will be readily detectable and no maintenance task assessment is required.

b. **Environmental Deterioration (ED)**, which is characterized by structural deterioration as a result of an ~~chemical~~ interaction with its climate or environment. Assessments are required to cover corrosion, including stress corrosion, and deterioration of non-metallic materials. Corrosion may or may not be time/usage dependent. For example, deterioration resulting from a breakdown in surface protection is more probable as the calendar age increases~~; conversely, corrosion due to galley spillage is a randomly occurring discrete event.~~ Frequently occurring fluid spillage, like galley spillage, that occur several times during typical inspection intervals should be taken into account when assessing the operational environment. Conversely, corrosion due to rare events, like battery acid spillage, should be assessed as a randomly occurring discrete event.

Stress corrosion cracking in a given environment is directly dependent upon the level of sustained tensile stress which may result from heat treatment, forming, fit-up, or misalignment.

In contrast to the environmental deterioration process of metallic structures, non-metallic structures such as composites are not normally susceptible to ~~degradation due to~~ chemical interaction with the environment, but may be adversely affected by moisture, heat or radiation. ~~However, t~~The effect of long-term aging in an operating environment has to be taken into consideration when developing the structural maintenance. Pressure/temperature cycling effects should be taken into account due to the potential for fluid ingress during the service life

When evaluating inspection requirements, attention should be paid to the design of the drainage system, as environmental deterioration is directly dependent on the time the structure is exposed to fluids.

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Chapter 2-4-5
Subchapter 1: Change bullet Nr. 7
Subchapter 2: Remove composite statement from metallic chapter
Subchapter 3: Add statement from subchapter 2, add more information than just the fiber material.

1. Rating Accidental Damage

Accidental damage rating systems should include evaluations of the following

a. Susceptibility to minor (not obvious) accidental damage based on frequency of exposure to and the location of damage from one or more sources, including:

1. Ground handling equipment
2. Cargo handling equipment
3. Those resulting from human error during manufacture, maintenance, and/or operation of the aircraft, that are not included in other damage sources.
4. Rain, hail, etc.
5. Runway debris
6. Lightning strike
7. ~~Water entrapment~~
7. Discrete spillage events

2. Rating Environmental Deterioration (metals)

Environmental deterioration rating systems should allow for evaluations of susceptibility to and timely detection of corrosion and stress corrosion.

Susceptibility to corrosion is assessed on the basis of probable exposure to an adverse environment and adequacy of the protective system. For example:

a. Exposure to a deteriorating environment such as cabin condensation, galley spillage, toilet spillage, cleaning fluids, etc.

b. Contact between dissimilar materials (potential for galvanic activity).

c. Breakdown of surface protection systems; for example, deterioration of paint, primer, bonding, sealant, corrosion inhibiting compounds and cladding systems with the resulting corrosion of metallic materials. ~~or fluid incursion into permeable non-metallic materials, etc~~.

Material characteristics, coupled with the likelihood of sustained tensile stress, are used to assess susceptibility to stress corrosion.

Timely detection is determined by sensitivity to relative size of damage and visibility of the SSI for inspection.

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3. Rating Environmental Deterioration (non-metals)

Environmental deterioration rating systems should allow for evaluations of susceptibility to, and timely detection of, structural deterioration (e.g., delamination and disbonding).

Susceptibility to deterioration (e.g., loss of stiffness) is assessed on the basis of materials subjected to environmental sources and the adequacy of the protective system. For example:

a. Aramind Fiber Reinforced Plastic (AFRP, also known as Kevlar) is sensitive to Ultra-Violet (UV) light, moisture and other fluids, when directly exposed.

b. Glass Fiber Reinforced Plastic (GFRP) may undergo long term degradation when directly exposed to UV light, but otherwise has low sensitivity to the environment.

c. Carbon Fiber Reinforced Plastic (CFRP) has low sensitivity to the environment.

Susceptibility to delamination and disbonding or to fluid ingress into permeable materials is assessed on the basis of material type, adequacy of the protective system, and structural composition (e.g., sandwich or monolithic laminate), coupled with the likelihood of AD, and exposure to certain environmental conditions.

Appendix A

Change example for untypical usage in Level 1 Corrosion definition.

Corrosion Level 1	Corrosion damage that does not require structural reinforcement or replacement. or Corrosion occurring between successive inspections exceeds allowable limit but is local and can be attributed to an event not typical of operator usage of other aircraft in the same fleet (e.g. ~~Mercury~~ Battery acid spill).
Environmental Deterioration (ED)	Physical deterioration of an item's strength or resistance to failure as a result of ~~chemical~~ interaction with its climate or environment.

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IMRBPB Position:
Date:
Position:

Status of Issue Paper (when closed state the closure date):

Recommendation for implementation:

Important Note: The IMRBPB positions are not policy. Positions become policy only when the policy is issued formally by the appropriate National Aviation Authority.