François LEFEBVRE
Head of Quality Basics and FOD

Post-Maintenance Foreign Objects Damage (FOD) Prevention

1. Introduction

A Foreign Object Damage (FOD) is any damage attributed to an object, referred to as Foreign Object Debris (FOD), that is not part of an aircraft. FODs are usually associated to external causes like runway debris or bird strikes, but they can also be caused by foreign objects inside the aircraft, in which case they are referred to as internal FODs.

Internal FODs generally result from maintenance or outstanding work on aircraft, and may be divided into several families:

- Debris (swarfs, chips, paper, rubber, ...)
- Hardware (consumables like rivets, nuts...)
- Aircraft parts
- Personal Objects (phones, pencils, cigarettes, ...)
- Tools (mainly hand tools like screwdrivers, wrenches, lights, drilling tools, ...)
- Protections (plastic, foam, ...).

The common point to all these families of objects is that they may all affect the safety of operations, depending on where they are located on-board aircraft.

This article will illustrate, through a few examples, how foreign objects may impact safety and will give some recommendations on how to implement an efficient prevention program to minimize FOD occurrences.

2. Examples of FODs

There are many ways in which a foreign object can impair safety: a small metallic part may lead to an electric arc inside an electric cupboard, a plastic sheet may clog a bleed pipe or a fuel pump etc...

Here is an in-service incident, which illustrates the potential effect of internal foreign objects: on a landing A380, the crew perceived an electrical burning smell. They were then unable to stow an engine and experienced problems with the Auxiliary Power Unit (APU). Then, at power-off, the Ram Air Turbine (RAT) deployed.

Post-flight investigation revealed that the aircraft's Primary Electrical Power Distribution Centre (PEPDC), located at the rear of the cockpit, was partially burnt.

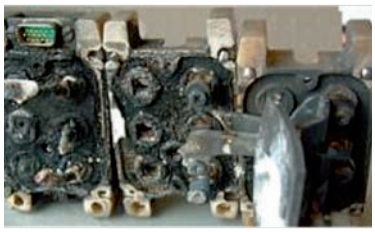

Figure 1
A short circuit caused by a contact pin burnt an A380 power distribution centre

The root cause for the short circuit was a contact pin, which had migrated through the ventilation grid of the equipment (fig. 1).

Here are three examples of different foreign objects that were luckily found before any damage could be created:

- Gloves, earplugs, metal clamps and a plastic cap were discovered in the Auxiliary Power Unit (APU) compartment. It was determined that these objects could have lead to an APU shutdown (fig. 2).

Figure 2
Foreign objects found in an APU compartment

- A wrench was found in the horizontal stabilizer. This FOD could have lead to a blockage of the elevator servo control (Fig. 3 & 4).

Figure 3
A320 horizontal stabilizer

Figure 4
Wrench left in A320 horizontal stabilizer

3. FOD Prevention

Herewith are six recommendations to implement an efficient FOD prevention program:

- **Define FOD risk zones**
- **Introduce housekeeping/ cleanliness rules**
- **Manage hand tools**
- **Introduce FOD declaration, recording and feedback**
- **Train for FOD awareness**
- **Involve the management.**

3.1 Definition of FOD Risk Zones

An aircraft may be divided into three classes of FOD risk zones:

- **Non-sensitive zones:** characterized by a low risk of FOD e.g. primary parts, sections/products without zones closure.
- **Sensitive zones:** characterized by a moderate FOD risk. The zones are closed, but the impact of foreign objects is assessed as limited, notably concerning the migration of these foreign objects to other areas e.g. cabin overhead bins.
- **Critical zones:** characterized by a major FOD risk. The zones are closed and a clear safety impact has been identified. There is a high risk of migration of foreign objects to adjacent areas e.g. avionic or electrical bays, tanks, servo-valves or pipes.

Once the zoning has been defined, decisions have to be taken regarding:

- **The visual identification of these zones,** through standardized FOD logos, ground markings, etc
- **The rules to be applied within these zones,** linked to access rights, work rules, tool usage and carriage of personal objects.
- **The communication channels to be used,** to ensure that the rules are widely known and understood by all stakeholders.

3.2 Introduction of Housekeeping and Cleanliness Rules

Introducing proper housekeeping and cleanliness rules will help minimizing the number of foreign objects. **The 5S standard** (ref A) has been originally developed by the automotive industry. This international standard calls for a reduction of the number of tools and other objects to be used in the work areas and contains simple rules related to housekeeping and cleanliness.

A good practice to avoid FODs, is to install code protected lockers in the vicinity of FOD risky areas, where personnel entering these zones may leave non-useful tools and personal objects like mobile phone, money, keys etc (Fig. 5). A further good practice is to define a dress code including work-wears without pockets, but with a dedicated belt and bag to carry a limited number of personal objects like a pen or handkerchief (Fig. 6).

Figure 5
Code protected l ockers in the vicinity of FOD risky areas

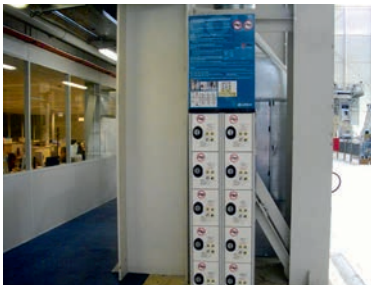

Figure 6
Dedicated dress code against FODs

3.3 Management of Hand Tools

Managing hand tools is key to avoid having screwdrivers, lights, wrenches, drill bits, etc. remain in the aircraft. Several solutions should be considered:

- Equipping tool boxes/cabinets with shadow boards, one form per tool, allows to easily detect missing tools (Fig. 7).
- Introducing inventory rules at the beginning and end of each shift ensures that no missing tool goes undetected.
- Limiting access to tool cabinets by badge ensures that only the authorized user of that cabinet will utilize the enclosed tools.
- Setting RFID chips on individual tools will allow for an efficient tracing.
- Tools kitting consist in having small tools boxes or mallets prepared with only the tools needed for a specified job, not more!
- Means should be put in place to declare lost tools and to analyse the data so as to come up with answers to reduce these occurrences. These solutions should then be promoted to the shop floor. The implementation of a lost tool process highlights the message that leaving a tool in an aircraft is not acceptable. The personnel declaring a loss is expected to do his/her best to relocate the missing effect.
- Tools identification, through laser etching for example, will ease the missing tool list cross-checking when a tool is found. It will also allow to identify the owner of the tool.

Figure 7
Tool box with shadow boards to easily detect missing tools

3.4 FOD Declaration, Recording and Feedback

- The declaration, recording and communication about lost tools should be broadened to encompass all families of foreign objects. All foreign objects should be declared and recorded. FOD trends should be analysed to identify why they are left in the aircraft and pertinent mitigation means should be defined. Last but not least, these mitigation means should then be actively promoted to all stakeholders to ensure a good implementation.

3.5 Training for FOD Awareness

The training allows to:

- Make people aware that foreign objects left in an aircraft may impact safety, thereby obtaining their adherence to FOD mitigation procedures.
- Inform personnel on how to follow these procedures.

That training should be given to all the people working on the aircraft, whether direct employees or external staff, as well as to their managers. It would be advisable as well to give people working in support functions, on the ground floor, a basic FOD awareness course.

3.6 Involvement of the Management

The implementation of an efficient FOD prevention program needs the active involvement of the management at all levels of the hierarchy. This requires a constant effort over time to ensure that habits change durably. It is up to the management to clearly indicate that fighting FODs is a priority, and to put in place the needed mitigation measures.

4. Conclusion

Internal foreign objects may take many forms, but they all potentially represent a threat to safe aircraft operation.

This threat should be mitigated by implementing a sound Foreign Object Damage (FOD) program, which calls for:

- **The definition of FOD risk zones**
- **The introduction of housekeeping and cleanliness rules**
- **The management of hand tools**
- **The declaration, analysis of recordings and feedback of mitigation means against FODs**
- **The training for FOD awareness**
- **The involvement of the management.**

All above recommendations are currently being implemented by Airbus on its manufacturing sites.

References A:

- *"5S for operators: 5 pillars of the visual workplace"*
  Writer: Hiroyuki HIRANO
  Editions: B&T – ISBN: 978-1563271236

Safety First

The Airbus Safety Magazine
For the enhancement of safe flight through increased knowledge and communications

Safety First is published by the Flight Safety Department of Airbus. It is a source of specialist safety information for the restricted use of flight and ground crew members who fly and maintain Airbus aircraft. It is also distributed to other selected organisations.

Material for publication is obtained from multiple sources and includes selected information from the Airbus Flight Safety Confidential Reporting System, incident and accident investigation reports, system tests and flight tests. Material is also obtained from sources within the airline industry, studies and reports from government agencies and other aviation sources.

All articles in Safety First are presented for information only and are not intended to replace ICAO guidelines, standards or recommended practices, operator-mandated requirements or technical orders. The contents do not supersede any requirements mandated by the State of Registry of the Operator's aircraft or supersede or amend any Airbus type-specific AFM, AMM, FCOM, MEL documentation or any other approved documentation.

Articles may be reprinted without permission, except where copyright source is indicated, but with acknowledgement to Airbus. Where Airbus is not the author, the contents of the article do not necessarily reflect the views of Airbus, neither do they indicate Company policy.

Contributions, comment and feedback are welcome. For technical reasons the editors may be required to make editorial changes to manuscripts, however every effort will be made to preserve the intended meaning of the original. Enquiries related to this publication should be addressed to:

Airbus
Product Safety department (GS)
1, rond point Maurice Bellonte
31707 Blagnac Cedex - France
Fax: +33(0)5 61 93 44 29
safetycommunication@airbus.com

A320
Winter operation in Yakutsk, Siberia

Safety First, #15 February 2013. Safety First is published by Airbus S.A.S. - 1, rond point Maurice Bellonte - 31707 Blagnac Cedex/ France. Editor: Yannick Malinge, Chief Product Safety Officer, Nils Fayaud, Director Product Safety Information. Concept Design by Airbus Multi Media Support Ref. 20130248. Computer Graphic by Quat'coul. Copyright: GS 420.1329 Issue 15. Photos copyright Airbus. Photos by ExM Company, Baldur Sveinsson. Printed in France by Airbus Print Centre.

© Airbus S.A.S. 2013 – All rights reserved. Proprietary documents.

By taking delivery of this Brochure (hereafter "Brochure"), you accept on behalf of your company to comply with the following guidelines:

► No other intellectual property rights are granted by the delivery of this Brochure than the right to read it, for the sole purpose of information.

► This Brochure and its content shall not be modified and its illustrations and photos shall not be reproduced without prior written consent of Airbus.

► This Brochure and the materials it contains shall not, in whole or in part, be sold, rented, or licensed to any third party subject to payment.

This Brochure contains sensitive information that is correct at the time of going to press.

This information involves a number of factors that could change over time, effecting the true public representation. Airbus assumes no obligation to update any information contained in this document or with respect to the information described herein.

Airbus S.A.S. shall assume no liability for any damage in connection with the use of this Brochure and of the materials it contains, even if Airbus S.A.S. has been advised of the likelihood of such damages.