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Facing the Reality of Everyday Maintenance Operations

The aviation maintenance environment is a challenging working place. Mechanics work in physically demanding conditions, such as high above the ground in the aircraft structure, or in small confined surroundings. They can be exposed to high or low temperatures, and to demanding shift work.

There is an increasing workload and time pressure to get the aircraft back into service as quickly as possible after maintenance. Aircraft maintenance requires mechanics to follow procedures by the letter, ensure good communication, diagnose and fix problems under time pressure, read and record various data, and continuously adapt to new technologies.

The Safety First magazine will dedicate a number of articles to the field of maintenance.

The objective is to share the lessons learned and experience reported from the Airbus fleet. It will also raise awareness, and provide recommendations for safe maintenance operations.

1. Introduction

Most maintenance engineers can remember cases where the use of a wrong, or inappropriate tool, has contributed to difficulties in maintenance operations. In most cases, this has lead to additional incurred costs, but on certain occurrences this has even represented a potential threat for the safety of maintenance personnel.

The absence of reliable statistical figures in how often specific maintenance tools have been involved in maintenance errors can be explained by the fact that there are no specific reporting requirements for maintenance events involving tools as being at the origin of the event. The consequences resulting from the use of wrong, or inappropriate tools, are not always immediately evident in terms of aircraft dispatch indicators, and, even when they are, they may not have been reported as the origin of the event.

This article will cover the subject of tooling issues related to engine removal and installation procedures. However, the points raised here are illustrative as well of other maintenance operations.

2. Brief Events Description

The following two events are representative of a number of similar hazardous engine removal/ installation incidents:

- On the first occurrence, one of the bootstraps failed, causing an engine to drop by a distance of three feet (fig. 1).
- On the second event, an engine fell to the ground during its removal. The forward left chain pulley disengaged while the maintenance team was performing Aircraft Maintenance Manual (AMM) subtask 71-00-00-020-053-A(fig. 2).

The reported problems in the use of the engine tools (the bootstrap), are not related to any one particular Airbus type.The majority of these incidents are the consequence of one, or a combination of the following reasons:

- Use of tools not listed in the AMM, and not approved by Airbus.
- Not using appropriately maintained tools.
- A too high pre-load applied to the tool, which can damage the tool.

3. Use of Non Approved Aircraft Maintenance Tools

Figure 1
Consequence of failed bootstrap

Figure 2
consequence of disengaged chain pulley

Depending on the level of the customized maintenance program selected, the investment in the required Ground Support Equipment (GSE) and tools can become significant.

Cheap GSE/tools may be offered from local suppliers, "round the corner", as substitutes for approved or proprietary tools. These may be copied and manufactured by non- approved suppliers, and may therefore not conform to the Airbus technical specifications.

There have been instances where tools have been made from incomplete, or out-of-date drawings, incorrect material, and/or according to wrong protection processes. As a consequence, it is likely that these tools will not be of the appropriate quality, and not perform their intended function in a safe and satisfactory manner.

Such non-approved tools can be categorized into three main groups:

- Airbus and Supplier/Vendor tools manufactured and distributed by non-licensed companies based on non–controlled drawings.
- Copies of Vendor proprietary tools bearing the same part number, but copied from the original by unauthorized companies.
- "Alternate" tool design sold as so-called "equivalents". These tools have a part number different to the one given in the manufacturer's documentation.

Use of any of the above types of non-approved tools for maintenance could lead to aircraft or component damage and/or personnel injury. If non-approved tools are used, the test result may not reflect that of the approved tool.

Airbus therefore recommends that Airlines and Maintenance Centers use only the specific tools called for in the Airbus and/or Vendor documentation, and that users ensure that they are built by the approved manufacturer.

4. Non Appropriately Maintained Tools

Some GSE/tool devices require regular maintenance to be performed, as specified by the GSE/tool manufacturer. Adherence to the GSE/tool maintenance instructions will contribute to a failure-free operation, and reduce the risk of personnel injuries.

As an example, let us consider the bootstrap (fig. 3). It consists of two main parts:

► The bootstrap structure, which is the interface between the pylon and the lifting device. This structure has to be periodically inspected and tested. A visual inspection should be done at each tool use. If any cracks or impacts are identified, the tool should not be further used.

Periodical tests consist of applying a load to the structure (125% of the Working Load Limit for Airbus tooling). Measurements are taken before and after the test, and should provide the same result. If the load test provides different results, the tool is damaged and should be discarded.

► The lifting device (chain hoist), which is the interface between the structure and the assembly to lift (the engine cradle). The lifting device is a device available on the market. The suppliers of the lifting device specify the maintenance recommendations to be applied. Typically, a visual inspection should be done every time the tool is used, and the friction brakes should be inspected at specified intervals.

Investigations of several cases of engine drops have determined that the hoist maintenance had never been done, and that the braking system was either damaged or showed presence of oil.

Figure 3
A380 bootstrap structure

Figure 4
Needle dynamometer

Figure 5
Electric bootstrap tool

5. Too High Pre-Load Applied to the Tool

The engine installation procedure with the bootstrap system consists of two main phases:

► The lifting phase is the operation dedicated to lift up the engine from the ground to the pylon. This phase stops when the engine mounts start to enter in the pylon shear pins.

► The approaching phase is the operation dedicated to engage the pylon shear pins in the engine mount and to have contact between engine mount and the pylon.

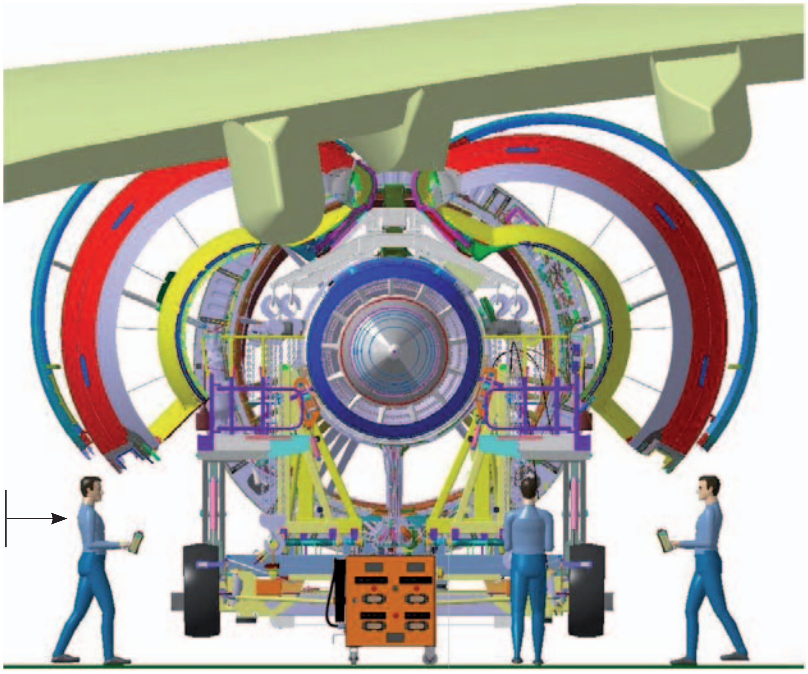

Figure 6
Operation of electric bootstrap

The bootstrap system is equipped with needle dynamometers (fig. 4) indicating the applied loads. The approaching phase is sensitive because the technicians have to continuously monitor the loads applied on the bootstrap system. Several mechanics, working as a unit, are required to perform this operation. They have to ensure proper communication amongst the team in order to ensure a balanced bootstrap movement and an adequate load monitoring at all times. An overload may cause a life threatening structural failure of the bootstrap.

The AMM provides the references for the standard tool, which in combination with the described procedures ensures a safe operation during engine removal and installation.

6. Electric Bootstrap Tool

In addition to the standard tool required by the AMM, Airbus has developed a new "electrical bootstrap" tool (fig. 5).

It offers a number of enhancements, including easier handling and improved load monitoring, and requires less mechanics. It is therefore safer to operate.

The main features of this new GSE are:

- Wireless electrical hoists
- Integrated dynamometers
- A load supervision system.

The lifting control achieved for the right and left hand side, as well as for the forward and aft hoists is performed by remote control devices (fig. 6), which include integrated load control displays. A warning system prevents any risks of overload.

7. CONCLUSION

The use of non approved, non appropriately maintained or improperly used aircraft maintenance tools represent safety hazards that need to be properly addressed.

Airbus therefore recommends to:

- Use only GSE/tools specified in the Airbus and/or Vendor documentation and to ensure that they are built by the approved manufacturer.
- Adhere to the GSE/tool manufacturers maintenance instructions.
- Closely follow the procedures described in the Aircraft Maintenance Manual.

References

Document	Title	Recommendations
OIT 999.0063/96	A300/A310/A300-600 - ATA 54/71 - Engine dropping during removal/installation.	Failure of hoist fittings or bolts, caused by static overload. This will occur when stirrups of the rear bootstrap beam cable jam in pulleys. AMM tasks modified to provide cautions associated to jamming.
OIT 999.0114/97	A340 ATA 71, engine removal installation AMM procedure.	Operators reported during engine removal engine/cradle assembly rotated around forward bootstrap hoisting point. Forward is heavier than aft, and if not cranked correctly can end up being in a nose down position. AMM procedure revised.
OIT 999.0042/00	A319/A320/A321 -ATA 71- Consequences of utilizing non-certified Airbus tooling for engine change.	Use of another manufacture tooling, during which one winch failed, causing the engine to drop, causing minor damage. Recommendations to use approved Airbus tooling.
SIL 71-020	Engine removal/installation procedure with "bootstrap system".	Attachment bolt failure due to excessive shear load, due to asymmetrical loading configuration created by blockage of bootstrap cable. Best practice recommendations provided to prevent dropping of engine.
TEB number: 340A3009-2	98F71201000 021 A340 200/300 bootstrap modification	The previous lift from YALE is no longer procurable for the bootstrap application, it was replaced by a new AERO ref from YALE. The TEB also remind the basic maintenance to perform on a YALE hoist.
TEB number: 340A3162-2	98F71201006036 A340 500/600 bootstrap modification	
TEB number: 330A3036-2	98F71201006034 A330 GE bootstrap modification	
TEB number: 330A3037-2	98F71201006030 A330 RR bootstrap modification	
TEB number: 330A3038-2	98F71201006032A330 PW bootstrap modification	
TEB number: 320A3197-2	98D71203501001 Single Aisle bootstrap modification	

Safety First

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