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HYDRAULIC SYSTEM
Preventing leaks

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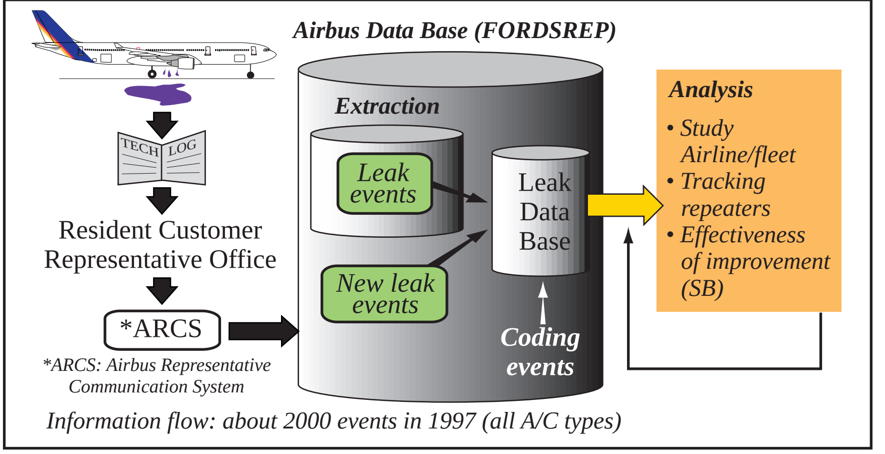
In an earlier article "Hydraulic system - Working practices" (FAST N°13), some fundamental working practices were detailed, aimed to reduce the number of leaks. Since then, a dedicated monitoring programme has been launched and working groups formed to further minimise the occurrence of leaks. The purpose of this article is to provide guidelines for maintenance personnel to reduce the frequency of leaks even further.

There are three aspects to be considered when looking for the causes of leaks:
- design,
- control of quality in production,
- maintenance.

Only the manufacturer can do something about the first two items and Airbus Industrie is continually studying how repetitive defects can be designed out of the system either by changing the design, the supplier and /or the production process (Figure 1).

Figure 1

Hydraulic Leak Monitoring



DESIGN

Part of the designer's work is to make the maintenance interventions, scheduled and unscheduled, as infrequent as possible, and the maintenance practices as simple as possible. The Technical Design Directives for the hydraulic system, written originally for the A300, are largely still applicable, however there have been some changes such as the greater use of titanium piping which is lighter than stainless steel and less prone to pin-hole corrosion; the generalised use of flareless fittings; installation of built-in Hydraulic System Monitoring Units and the qualification of new fluids and methods of repairing pipes.

Further work is being done to enhance the built-in test and monitoring capabilities of the system allowing easier and more accurate maintenance interventions as early as possible in the degradation sequence.

QUALITY IN PRODUCTION

Computer aided design and manufacturing of pipes have greatly improved the quality of the installation of pipe runs particularly in areas having many pipes with multiple bends in close proximity. The improved installation allied with:
- respect of torque values and proper tightening methods,
- stress free installation,
- seal installation with lubricants
- use of dedicated tools,

all lead to trouble free installations.

The Airbus Industrie Process Specification (AIPS) sets the standards for production and installation of the hydraulic systems for all the Airbus aircraft.

One area where manufacturer and operator have to be particularly vigilant is in the inadvertent acquisition of "bogus" parts that do not always conform with basic quality standards. Hydraulic systems have been known to suffer from the installation of these parts, particularly seals, which has led to reinforced audits at vendors and information being transmitted to the operators through the Service Information Letter (SIL 29-064).

MAINTENANCE

Maintenance can be divided into two groups - preventive and corrective.

Preventive maintenance

In the Maintenance Planning Documents (MPD) there are scheduled tasks which are defined to ensure hydraulic system integrity and avoid leaks. These tasks are found in the Zonal Inspection Programme under System checks (typical defects are shown in Figures 2 to 6).

Zonal inspection programme

The zonal programme asks for visual inspection of various aircraft systems including the hydraulic system, at various locations (wheel well bay, under floor, engine pylons, wing trailing edge etc). It is during the visual inspections that anomalies can be identified and corrected, such as:
- presence of seepage (Figure 2)
- loose or missing ties, spacers or clamp blocks, (Figures 3, 4, 6)
- damaged pipe-lines
- loose connections
- line chafing (Figure 6 and 7).

System checks

Some system checks are fundamental to ensure the system integrity and to prevent future damage. For instance, regular hydraulic fluid sampling to allow the operator to maintain the fluid quality within given limits (acidity level, chlorine and water content) and therefore avoid component erosion or corrosion. Moreover, as soon as components become eroded, internal leakage rates increase, fluid is laminated,

Figure 2

Detection of typical fluid seepage by stains on talcum powder

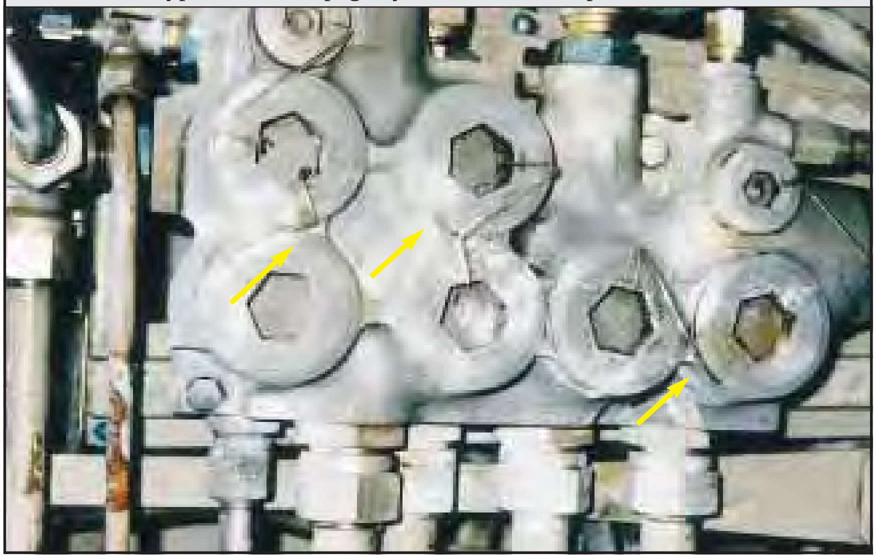


Figure 3

Pipe clamping (spacer) loosening and moving

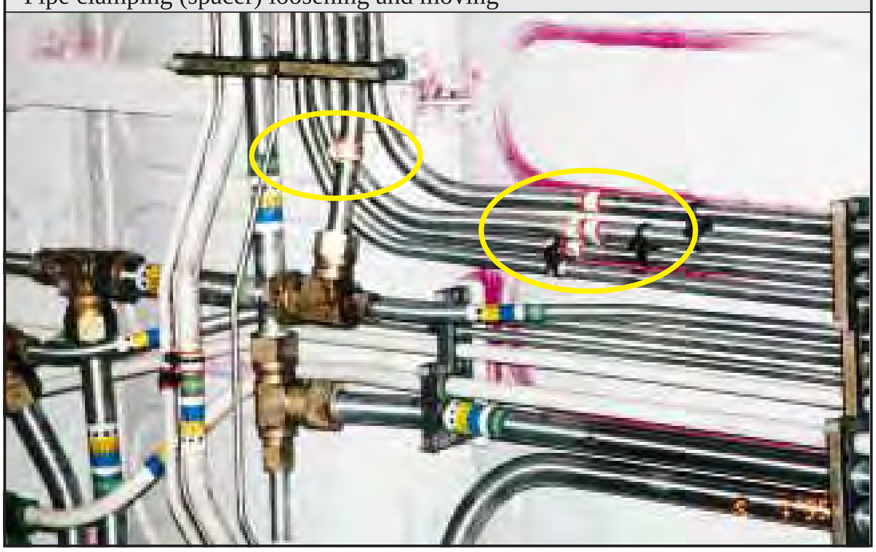


Figure 4

Detail of spacer loosening and moving

system operating temperature increases which further degrades the fluid, increasing its acidity level. This never ending process will continue until affected components and fluid are changed as necessary. This example shows the prevention role of the systems checks required by the MPD both for mandatory tasks such as internal leak checks and economic tasks such as fluid sampling.

Corrective maintenance

For corrective maintenance to be effective and long lasting a certain level of basic maintenance training and knowledge of the specific aircraft are required. These requirements were detailed in the article in FAST 13. A video, poster and related documentation are available from the address at the end of this article.

Most leaks are discovered during line maintenance - on the walk-around, night stop or pre-flight checks - and they have to be corrected as quickly as possible. This may require the installation of a temporary repair kit rather than a permanent hydraulic tube repair requiring pipe manufacturing capability. In this case SIL 29-069 "Pipe repair kit" and SIL 29-067 "Hydraulic tubing repairs" provide useful information.

Other SILs providing related information on the various leak sources are :
- 29-032 for A300/A300-600/A310,
- 29-064 for A319/A320/A321,
- 29-066 for A330/A340.

LEAK SOURCES

Components

A list of available and essential component improvements is provided in the dedicated SILs listed above. The embodiment of those product improvements on an attrition basis or through dedicated retrofit should provide a significant increase in system reliability.

Tracking of component reliability is necessary to meet on-condition/condition-monitoring maintenance requirements. For hydraulic systems it concerns the main components such as the engine driven pumps (EDP) and power transfer units.

There is evidence that those components, even when a proper overhaul has been performed, do not recover their full potential after the overhaul, which affects their long term reliability. Also, if a part such as an EDP valve block is not changed at the overhaul of the EDP, then it will accumulate many years of operation which may lead to natural damage, fatigue or corrosion.

This is an example of why tracking of component reliability may justify a need for a fixed time between overhaul (TBO), replacement of a part, or embodiment of a modification.

Seals

The keys issues for seal reliability are product manufacturing quality and proper installation.

Manufacturing quality

The product manufacturing quality has been recently at the focal point of in-service failures on the A330/A340 programs. (Refer to SIL 29-064). As a result, two vendors have been removed from the approved list of suppliers because of identified quality deficiency on some of their products. Three other vendors (Le Joint Francais, Dowty U.K, and Parker) have been audited and their standard of manufacturing quality judged satisfactory.

Installation

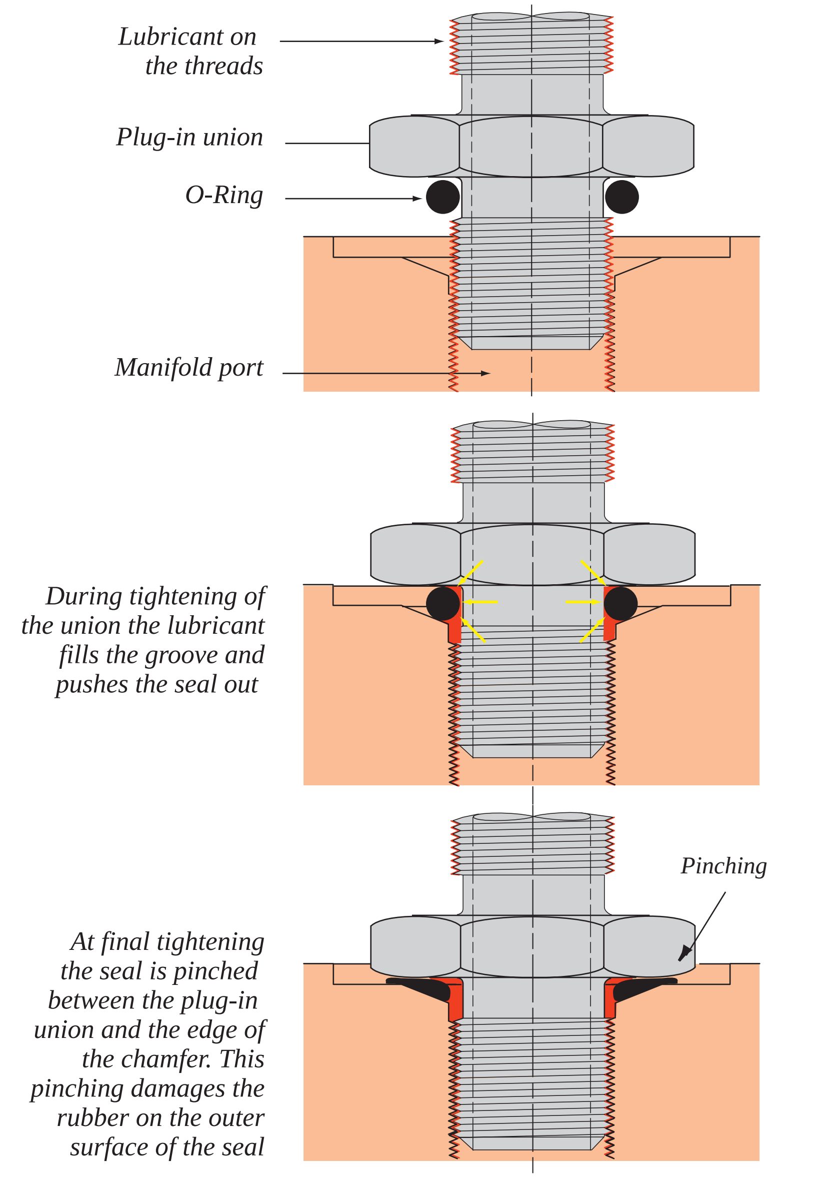
Chapter 20 of the Aircraft Maintenance Manual recommends use of certain tools and provides other advice for proper installation of seals.

In the previous article in FAST it was stated that "Seals, O-rings and packing washers should be smeared with MCS-352 lubricant or hydraulic fluid". It has recently been discovered that the application of MCS-352 on the threads of plug-in unions can have a negative effect, causing the seal to be squeezed and damaged (Figure 5).

For plug-in unions hydraulic fluid should be used as a lubricant.

Figure 5

Effect of lubricant on plug-in union threads



Pipes

There are generally three origins of pipe failure:

- chafing,
- installation under stress,
- corrosion.

High quality of manufacture of the pipes allowing good installation can largely prevent these types of failures. A recent audit performed on all Airbus pipe production centres revealed that manufacturing processes and techniques are well adapted and controlled, with the use of :

- numerical controlled bending machines and improved knowledge of spring back effect,
- laser dimensional check for every individual manufactured pipe,
- chlorine free pipe cleaning,
- laser marking.

Compliance with installation rules will avoid chafing and pre-stressed installations. Design will also help

Figure 6

Risk of chafing due to loose clamping

Figure 7

Risk of chafing due to small clearance

with improved clamping definition (adjustable brackets) and dampening of pressure pulsation of pumps.

Ageing affects the integrity of pipe installations (Figures 3 to 7) justifying the importance of periodic inspection checks such as in the zonal inspection. Typical ageing effects are:

- reduced efficiency of clamp blocks due to loosening, wear or damage,
- corrosion development (exposure to contaminants such as saline atmosphere, spillage from toilets),
- damage to pipe surfaces during maintenance.

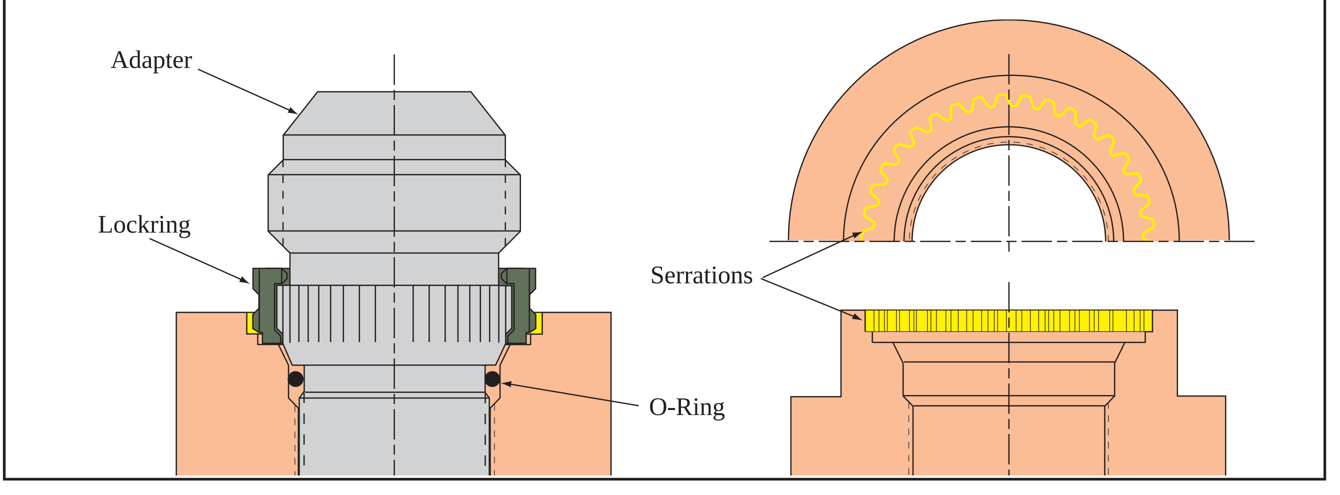
Pipe fittings

Maintenance is a common source of leakage when loosening is due to under-tightening (often found on large fittings) and damage is due to over-tightening, generally found on aluminium fittings or small fittings and due to cracking from frequent loosening and tightening. The main development in fitting technology has been the introduction of more reliable flareless unions. However experience has shown that there is no substitute for systematic compliance with correct tightening procedures and use of the correct tools.

Airbus Industrie is studying more "damage tolerant" fitting designs such as Rosan (Figure 8) and alternative tightening techniques which can cope with vibration and a maintenance environment where use of torque wrenches is not common practice.

Figure 8

Rosan fitting definition: union and port



CONCLUSION

Lubricant MCS-352 should not be used on the threads of the plug-in unions. Although the hydraulic leak rate on a fleet-wide basis is approaching a satisfactory level it can and will be improved. Further efforts by Airbus Industrie and the vendors to improve hydraulic system reliability together with preventive maintenance actions applied by operators when necessary and proper application of procedures, will keep the hydraulic leak rates within an acceptable level. For this purpose, customers' feedback on in-service experience is vital.

Airbus Industrie will assist any operator suffering from a perceived excessive leak rate to initiate a leak preventive programme. This programme has been successfully implemented by a number of operators one of whom experienced a reduction in leak rates by 50%.

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FUEL SYSTEM

Detecting leaks using helium

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Until now curing fuel leaks has been a relatively difficult operation for operators and manufacturers alike. The methods available to identify the leak paths have been air blowing associated with soapy water to detect bubbles (a method as old as aviation itself), and suction associated with dye penetrant, neither method being very successful.
This article describes a new detecting technique using helium gas developed by Airbus Industrie.

Figure 1

Wing structure (typical)

Fuel tanks in modern commercial airliners are housed principally in the wings, and the wing structure is also the fuel tank structure; there are no rubber tanks or other forms of inner walls within the wings. Wing structures are composed of large skin panels, dozens of ribs and stringers, and thousands of bolts and rivets covered with a sealant to prevent fuel seepage (Figure 1). This structure is flexible, as anyone who has flown in turbulent weather will have noticed, as they watch the wing tips moving up and down. Eventually fuel seepage does occur and the leaks become evident on the outer surface of the skin. The visible point of seepage is at the end of the leak path (Figure 2a) and an efficient repair requires that the origin of the leak path (or paths) is identified and properly sealed. If not, there is a high risk that the leak will appear again, and quite often it does.

THE INNOVATIVE APPROACH

Airbus Industrie investigated several leak path detection methods and has selected and developed a new detection technique using helium as a tracer gas to allow easier detection of the source of the leak (Figure 2b).

This technique, which was developed

Figure 2

Different phases of detection method

2a *Identification of a leak* **2b** *Use of helium gas as tracer gas*

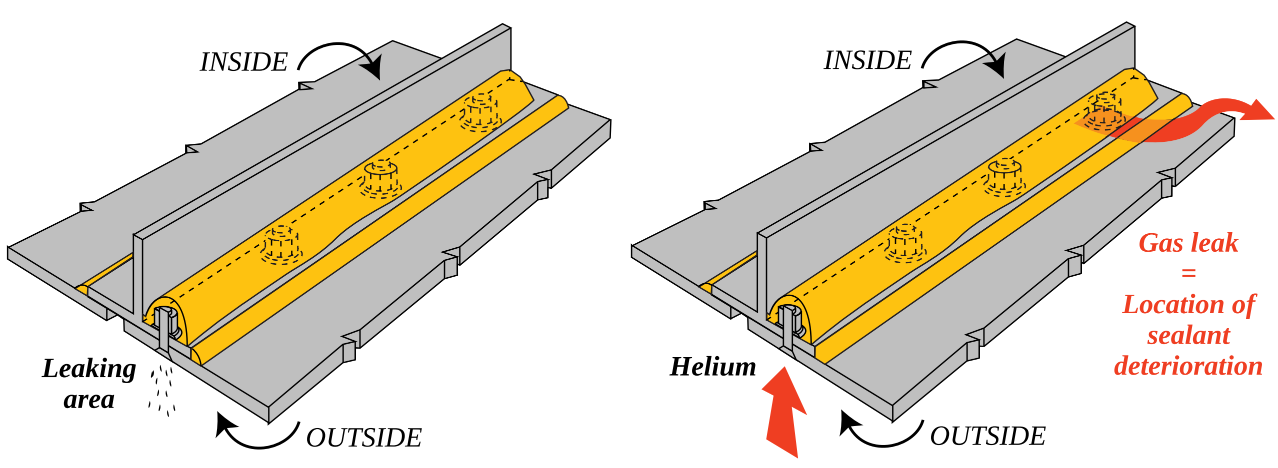
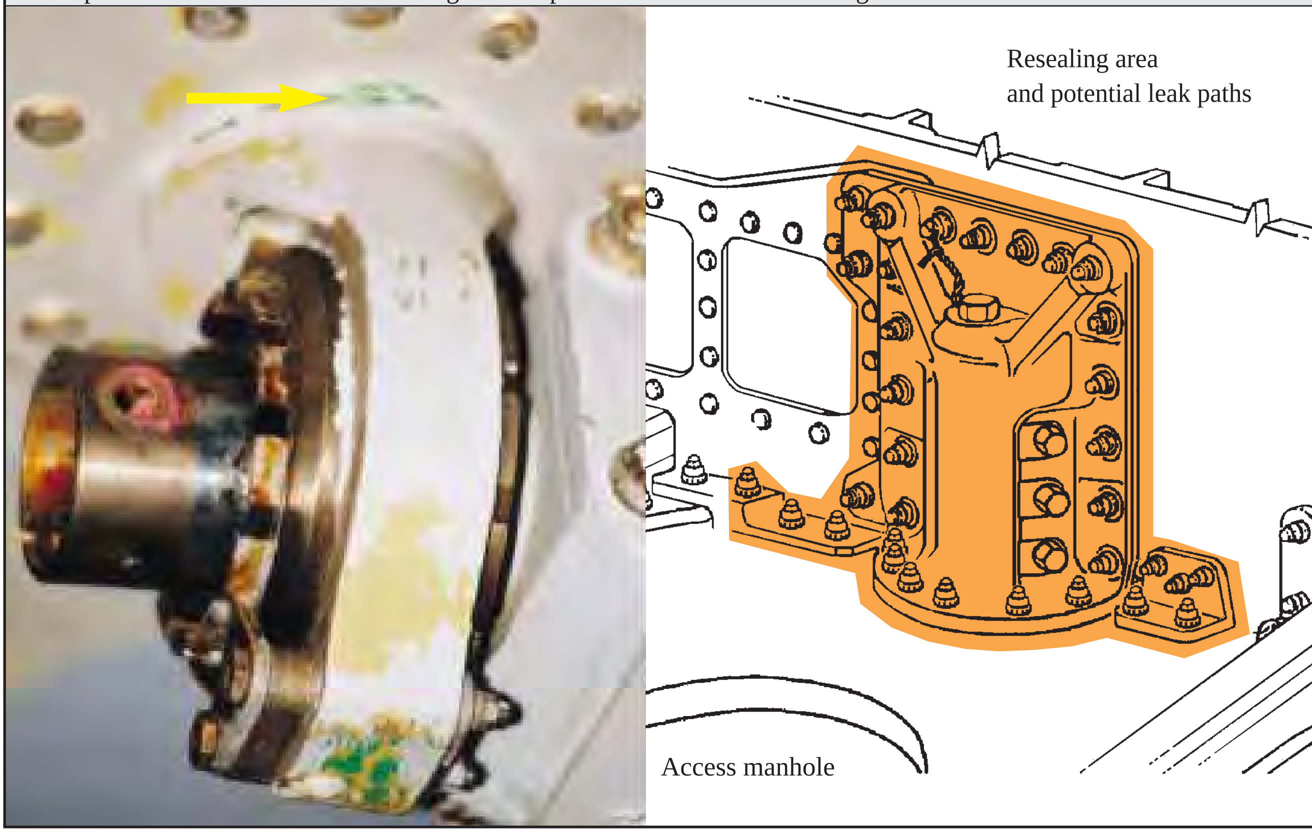


Figure 3

Example of visual location of fuel leaking from flap track forward attachment lug



in cooperation with two companies, Helitech and Varian, and with the support of different maintenance centres and airlines, was the only one which offered the required sensitivity and reliability, and is a great step forward compared to the methods used previously.

THE HELIUM TECHNIQUE

Helium is a non-toxic inert gas which does not react chemically with any other element, making it intrinsically safe. In addition, due to its small relative molecular mass, it has a high penetration capability allowing it to pass through the smallest gaps. Helium is particularly interesting for this leak detection task because of its low concentration in the atmosphere (five particles per million) which allows easy detection of any small increase in this proportion. Finally it is an industrial gas available anywhere in the world.

Pressurised helium is already used in Airbus production lines to test for leaks. The leak is visually located externally (Figure 3) and the source is identified internally by creating a compression chamber around the leak point (Figure 4) and filling it with helium under pressure thereby forcing the helium back up the leak channel into the fuel tank.

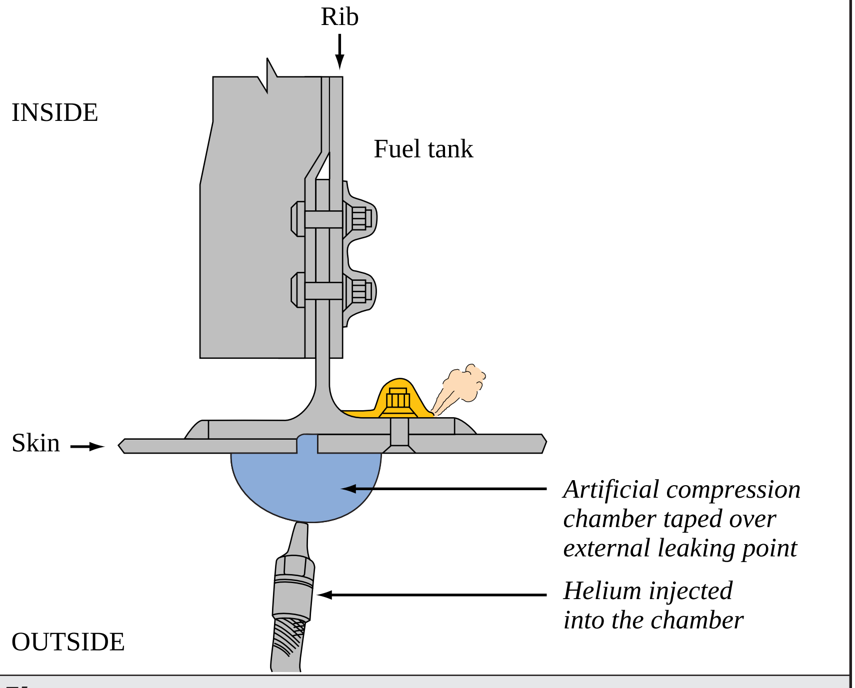
Figure 4

Example of artificial compression chamber around the lug shown on Figure 3

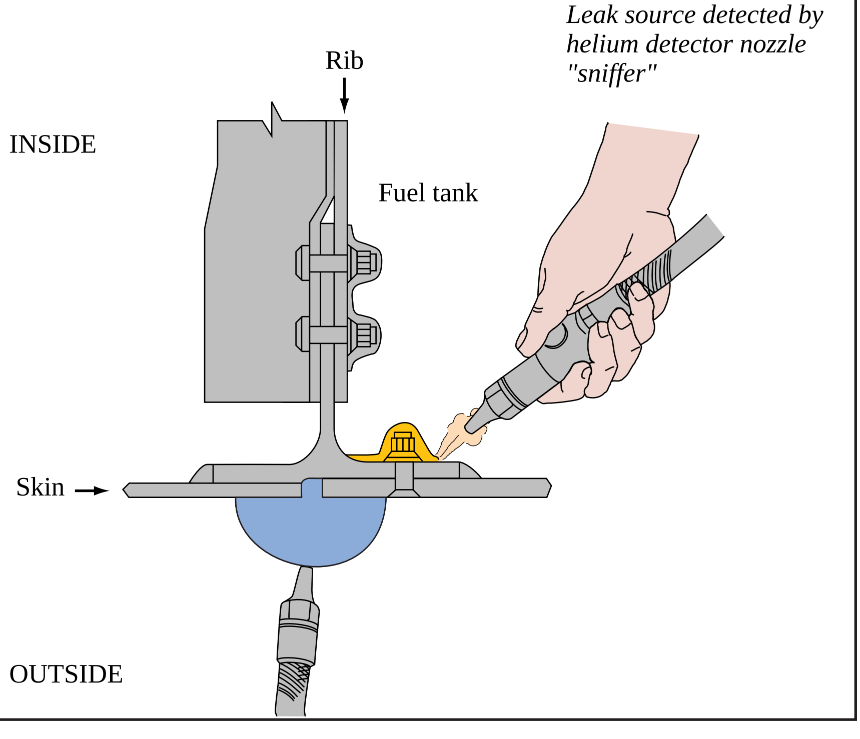
Figure 5

Detection phases

5a *Injection*



5b *Detection*



The procedure must start with a clear mapping of the fuel leak on the outer surface of the tank (precise leak location and approximate leak rate) then the tank can be defuelled, drained and vented until it becomes completely dry. Before entering the tank, all the safety checks have to be performed to ensure adequate ventilation and acceptable fuel vapour concentration.

An artificial compression chamber (Figure 5a) over the leaking area has to be created. This is simply done by penetrating one corner of a plastic bag with the rubber hose from the helium supply and sealing the join with sealant and aluminium tape. The open end of the plastic bag is attached to the skin of the wing around the leak, also by aluminium tape. This simple method can be easily adapted to awkward situations as shown on page 7 where the leak is from a flap track attachment fitting. This artificial chamber must be able to withstand a maximum internal pressure of 200 mbar. When this has been done, the helium injection can start at a constant pressure.The initial pressure choice depends on the kind of leak (rate, location) and must be based on knowledge of the structure and potential leak paths. Then the jet of helium being forced into the tank has to be found. By moving the detection "sniffer" (Figure 5b) probe inside the tank, there will be various sound frequencies emitted by the detection device depending on how far the probe is from the jet of helium (and the origin of the leakage). During this operation, it could be necessary to increase the injection pressure. It should not be forgotten that more than one leak may exist in the same area. Therefore it could be necessary to repeat this operation several times. In this case it is recommended to vent the area between two detection operations.

The artificial compression chamber should not be removed, because when the repair has been performed it can be used to check, in the same way, the quality of the repair. This will prevent refuelling and de-fuelling of the tank if the quality of the repair is not acceptable.

CONCLUSION

Conventional methods for detecting fuel leaks are now becoming obsolete. This helium technique has been tested and fine tuned on several aircraft. It is now the most efficient and reliable method of identifying fuel leak sources. It is cost effective as a much lower number of manhours are required to cure fuel leaks and it reduces significantly the aircraft downtime. In addition it also confirms the integrity of the repair, avoiding the use of fuel. This operation alone can easily save four days of ground time.

Airbus Industrie highly recommends that operators apply this procedure, which is described in SIL. 57-091 applicable to all Airbus aircraft types.