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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.

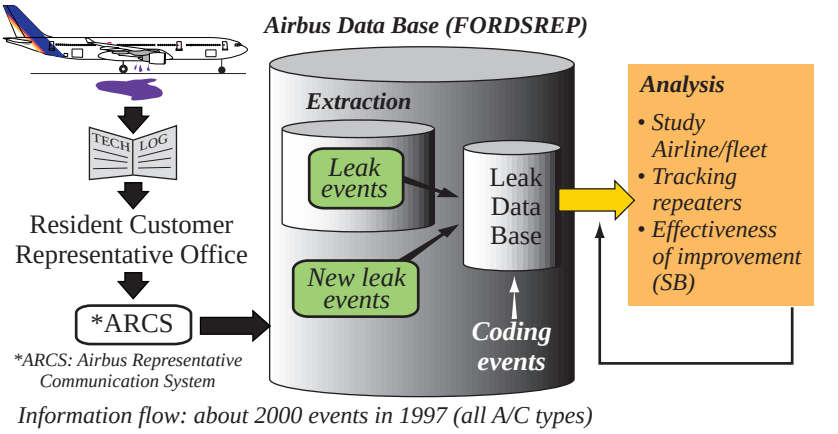
There are three aspects to be considered when looking for the causes of leaks:

- design,
- control of quality in production,
- maintenance.

Only the manufacturer can do something about the first two items andAirbus 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



Information flow: about 2000 events in 1997 (all A/C types)

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

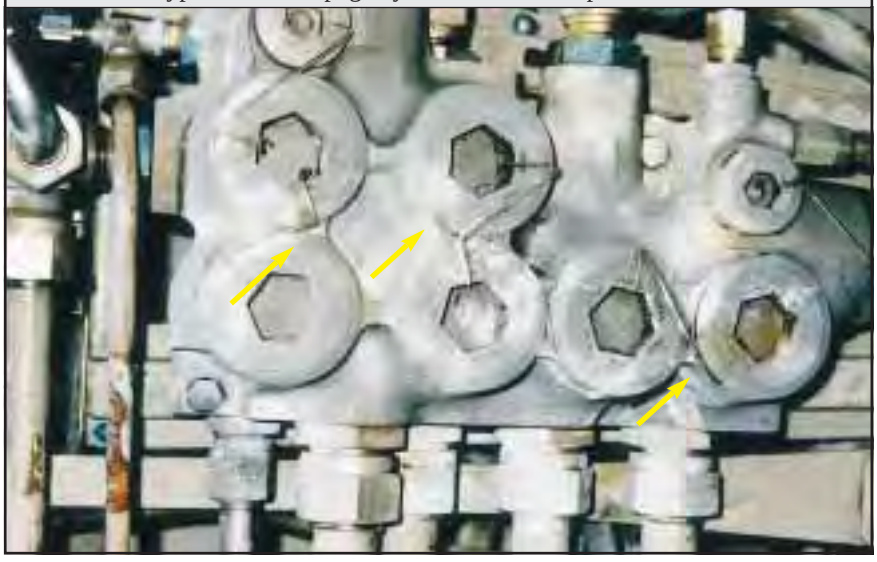


Figure 3

Pipe clamping (spacer) loosening and moving

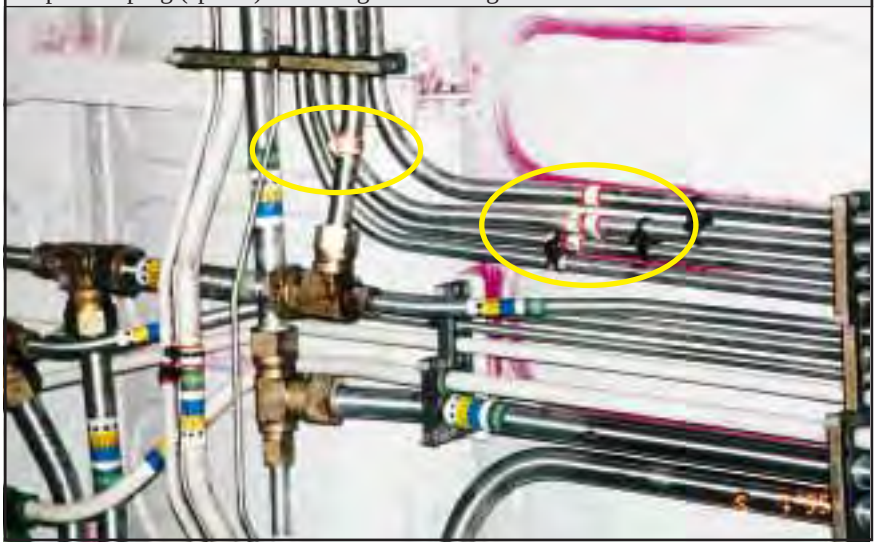
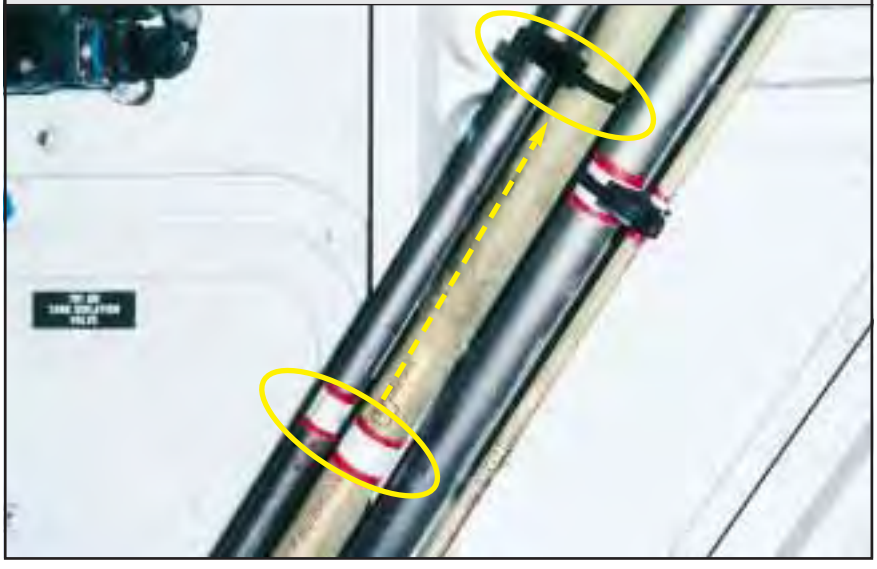


Figure 4

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.

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 5

Effect of lubricant on plug-in union threads

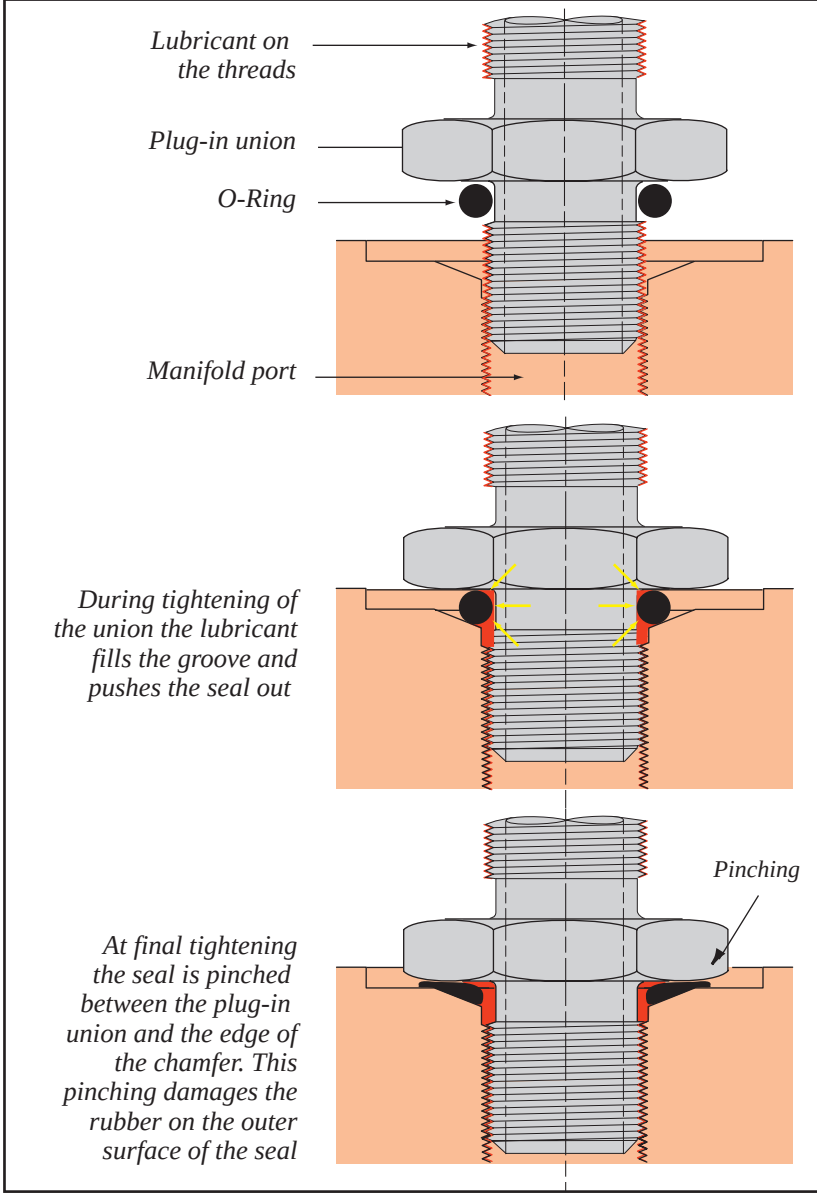


Figure 6

Risk of chafing due to loose clamping

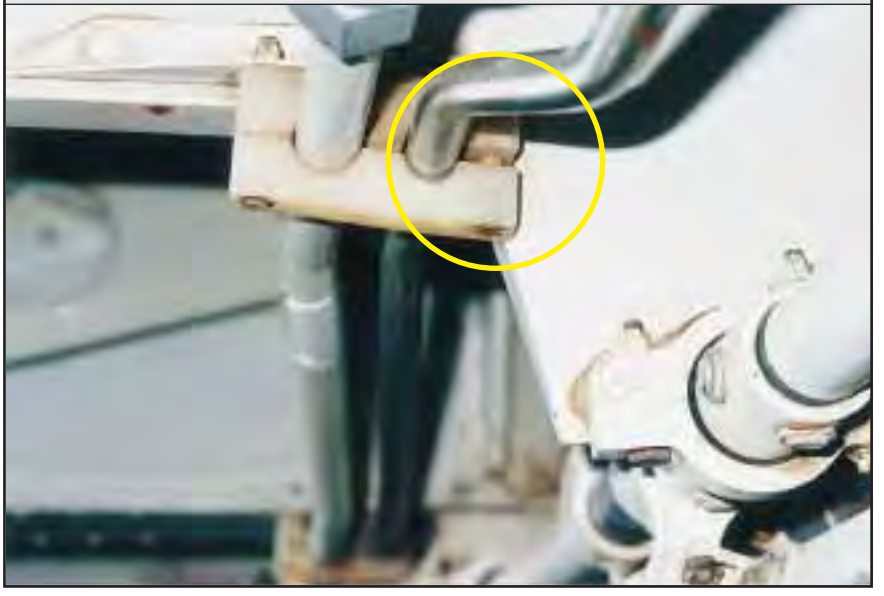


Figure 7

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.

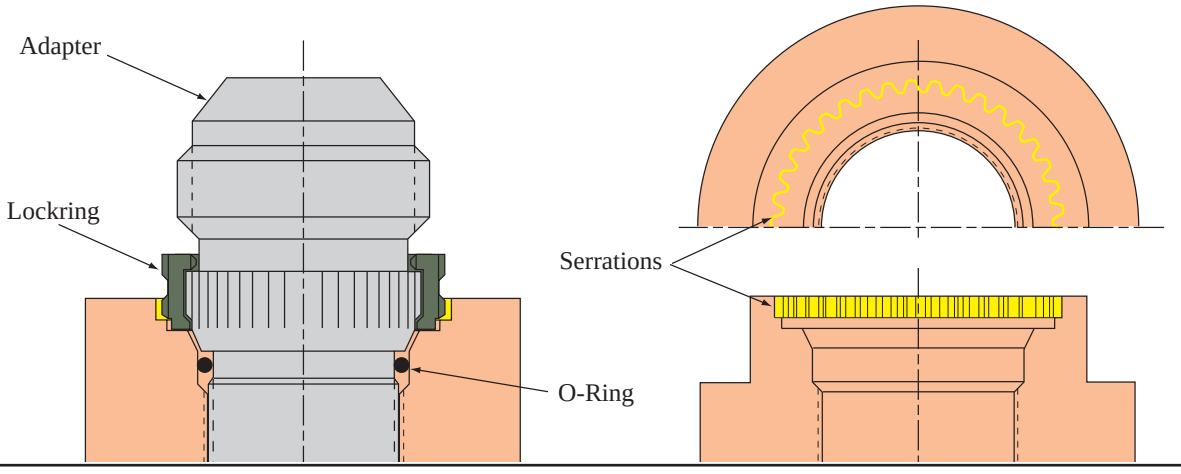
Pipe fittings

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

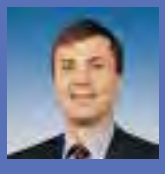
Lubricant MCS-352 should not be used on the threads of the plug-in unions. Although the hydraulic leak rate on a fleet-wide basis is approaching a satisfactory level it can and will be improved. Further efforts by Airbus Industrie and the vendors to improve hydraulic system reliability together with 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%. ■

For further information please contact:
AIRBUS INDUSTRIE Engineering Services, Engineer Hydraulic Systems, Mr TORBJÖRN KETTEL

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

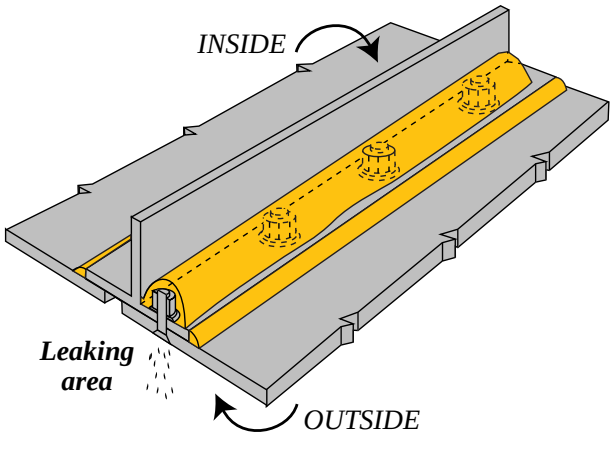
Airbus Industrie investigated several leak path detection methods and has selected and developed a new detection technique using helium as a tracer gas to allow easier detection of the source of the leak (Figure 2b).

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*

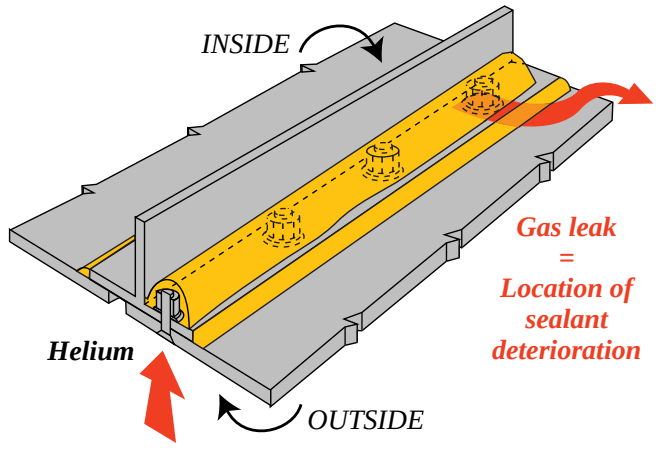
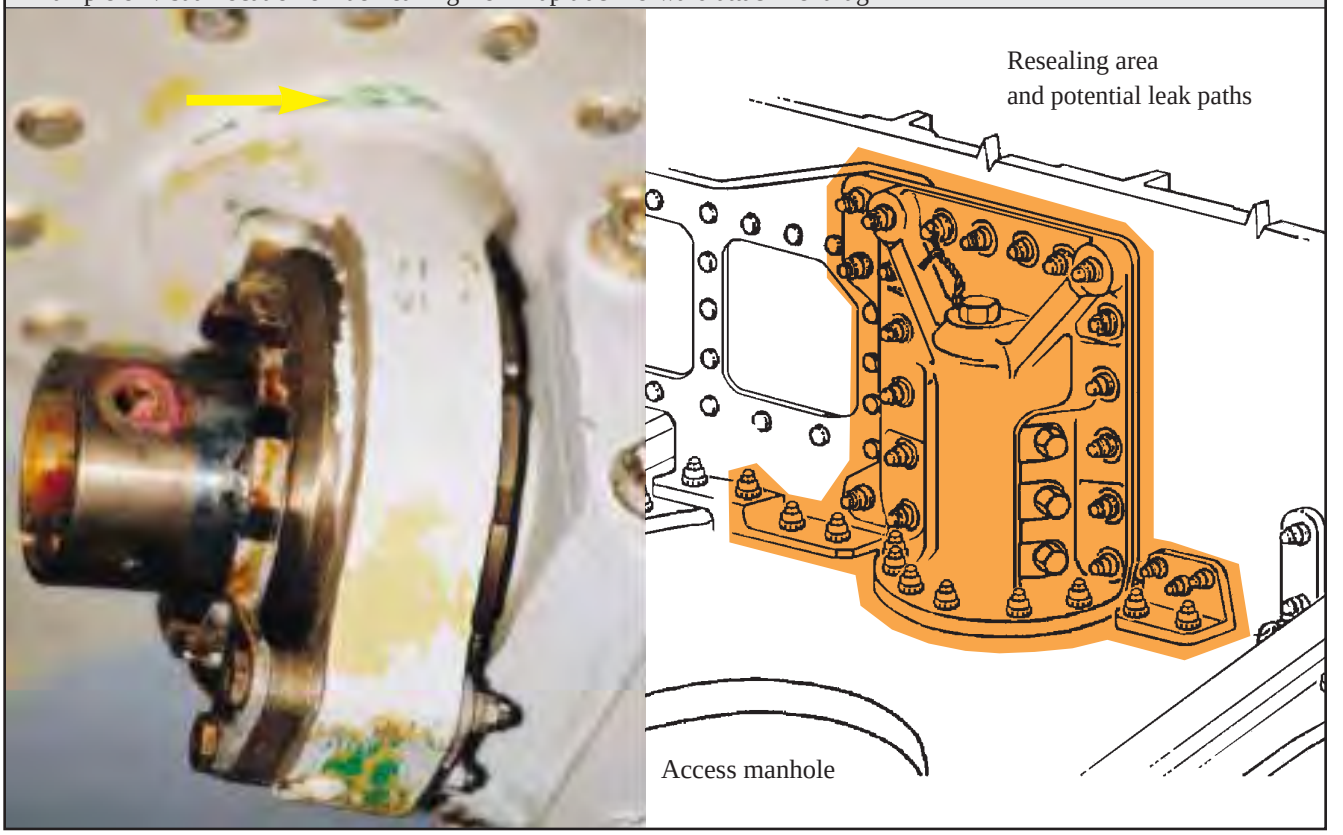


Figure 3

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.

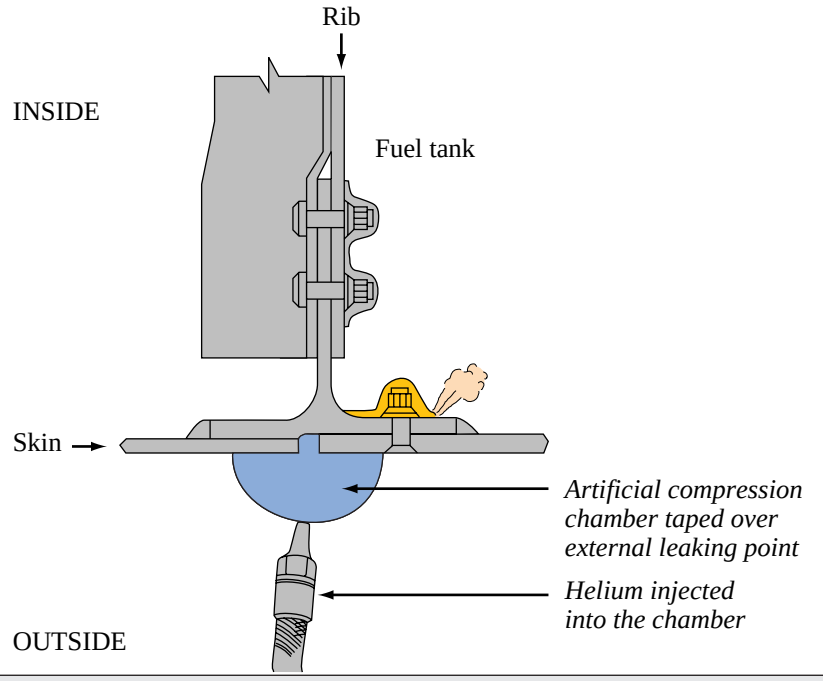
Figure 4

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

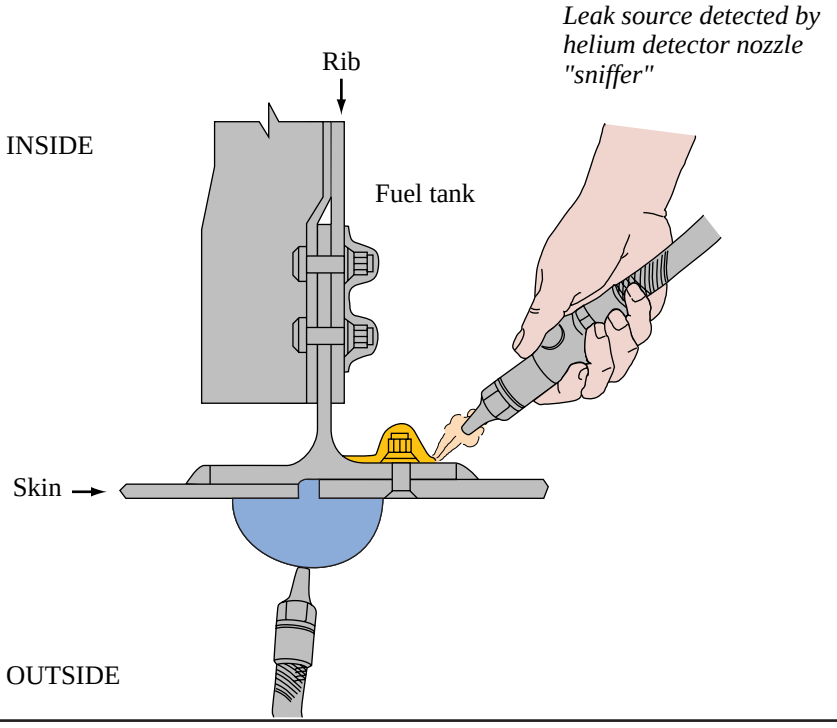
Figure 5

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.

THE INTERNATIONAL REGULATORY CLIMATE

Andrew S. McClymont, Director Certification Strategies, Product Integrity , Airbus Industrie

International cooperation on civil aircraft regulations and certification has been in existence to some extent, initially a small extent, for more than 50 years. It has been increasing in recent years as Europe slowly draws together many diverse national bodies to create a single Joint Aviation Authority to act on behalf of each European country member. At the same time, the level of cooperation on both sides of the Atlantic and with other regions of the world is also increasing in a manner which should - in the long term - achieve a practical worldwide certification process and an improved overall safety regulation system.

That ideal is some way ahead, but is becoming a possibility for aircraft airworthiness certification, if political restraints and perceived sovereignty protection policies can be avoided. It may take longer for operational "control" to reach such a common goal.

We need to persuade the politicians to support our justifiable intentions for the overall benefit of all. See the following article on JAR-OPS.

The International Regulatory Climate is a continually changing environment but there is an overall major purpose to promote an enhanced air safety environment for the travelling public, without unreasonably increasing the regulatory burden on the Authorities, the manufacturers and the operators.

The main theme to be remembered, and from time to time we need to be reminded, is that we are all aiming at the same target - safe, reliable, cost effective air transport.

Associated with this theme is an essential need to create a working environment of confidence, and positive technical relationships between all involved parties.

The A330 concurrent JAA and FAA Type Certification Ceremony, 21st October 1993.

Seated left to right: Mr B. Ziegler (SVP Engineering Airbus Industrie), Mr C. Frantzen (DGAC France), Mr V. von Tein (Chief Operating Officer Airbus Industrie), Mr M. Dambaek (JAA Executive Board Chairman) and Mr D. Curtis (FAA Transport Airplane Directorate representative) plus other participants from France, Germany, Italy, The Netherlands, United Kingdom, Austria, Belgium, Portugal, JAA and FAA.

HISTORY

It was through the principles and activities of the International Civil Aviation Organization (I.C.A.O.) that guidelines were produced in an attempt to create common technical standards in all aspects of air transport regulation. These internationally accepted guidelines, defined in the technical ICAO Annexes, provide the basic principles to enable the air transport industry to operate safely, reliably, regularly and legally.

The broad objectives from the December 1944 Chicago Convention on International Civil Aviation were :

- Safe and orderly development of International Civil Aviation
- Sound and economical operation for International Air Transport Services, and equality of opportunity.

These objectives remain valid today, providing the background to the defined rules, regulations and requirements which are the basic roots of the flight safety levels achieved in the air transport industry.

There are more than 180 contracting states associated with ICAO, and its Air Navigation Commission, and there are 18 ICAO Annexes covering the relevant Standards and Recommended Practices (SARPS).

It is the word "recommended", however, which creates some of the long term problems associated with the implementation of these ICAO SARPS - these "International Standards".

Each participating country defines its own "legal" standards and notifies ICAO, and all other participating countries, how they enable (or accept) compliance to be achieved with the International Standards. In fact, the normal process is to formally notify defined non adherence or non compliance with specific ICAO recommendations in each countries' internal legal "package" of regulations. But this "flexible" way of behaving creates the possibility of varying interpretations of regulations, because many countries are not prepared to give up sovereignty, or legal control of their own regulations. Some of the ICAO-SARPS are quite general in content and leave some room for national interpretations.

There is also a problem to be addressed because a few countries claiming that they comply with the ICAO SARPS have in fact no structured aviation authority and no related national regulations.

AIRCRAFT CERTIFICATION

There are, or have been, two normal types of aircraft certification exercises - the basic domestic certification under the general control of the Authority of the State of Design and Manufacture and then the validation of that basic certification by other countries.

The validations have tended to look at acknowledged differences in the regulatory standard between the domestic Type Certification Basis and the required Certification Basis of the validating or importing country.

The validation team, apart from necessary aircraft design familiarisation and getting an informative grounding in the basic certification of the aircraft, generally concentrates on how certification can be found with the defined regulatory differences.

This additional certification/validation work programme, with the implication of possible design changes to the aeroplane, can be a major burden to the manufacturer, particularly when a number of countries have significant national differences. Regulatory differences have in the past caused some expensive design changes with questionable cost effective safety benefit.

HARMONISATION OF REGULATIONS AND PROCEDURES

Harmonisation of regulations and procedures has been a major target of joint work both in Europe and across the Atlantic.

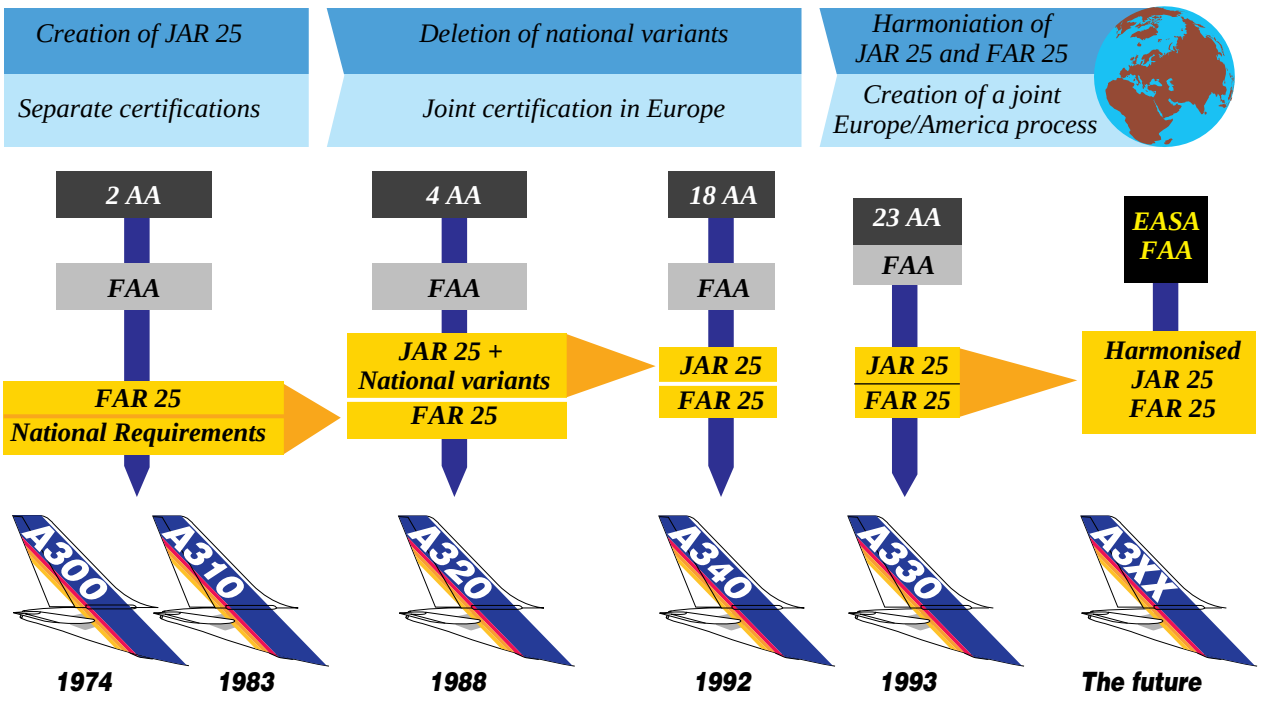
As a result of strong Industry pressure both in Europe and in North America, it has been possible to make progress in harmonising the various airworthiness standards in order to reduce significant differences in regulations and interpretations (Figure 1).

Taking the European scene as an example, this problem of national differences was behind the early attempts to create Joint Aviation Requirements (JAR) as a common set of regulations. Unfortunately, they were in the beginning, not very common, because a large number of National Variants were included, to meet long held basic certification standards which some countries were not initially prepared to give up. Although the JAR 25 large transport aeroplane design regulations were originally based on the FAR 25 North American format, all the National Variants raised defined differences.

Following the experience with real joint certification and validation projects in Europe on the Airbus A320 and Saab 340 during the 1980s, the National Aviation Authorities (NAA) in Europe were required to review each of their National Variants to confirm whether there was still a justifiable

Figure 1

Harmonising regulations and procedures - The Airbus experience



need to retain them. If they still felt there was a justifiable need, then they had to be reviewed with the other European NAAs to try and reach a common agreement to justify a requirement different from the basic JAR 25.

If agreement or justification regarding a National Variant could not be reached within the NAAs then the originating NAA was required to drop that regulation. A difficult and sometimes time consuming process to find justifiable legal means to remove a previously well considered, and possibly long time applied, design requirement.

The Airbus A320 type certification experience (1983-1988) was fundamental in promoting the removal of all JAR 25 National Variants. This was achieved at JAR 25 Change 13 in 1989, which was used for the European Joint Certification of the Airbus A340.

However, it is well worth remembering that no Authority should be implementing a regulation which cannot be sensibly and acceptably justified. That point should of course be part of every new rule proposal justification. It is more difficult later to remove a regulation which might no longer be justifiable for the original reasons.

THE PRESENT DAY STATUS

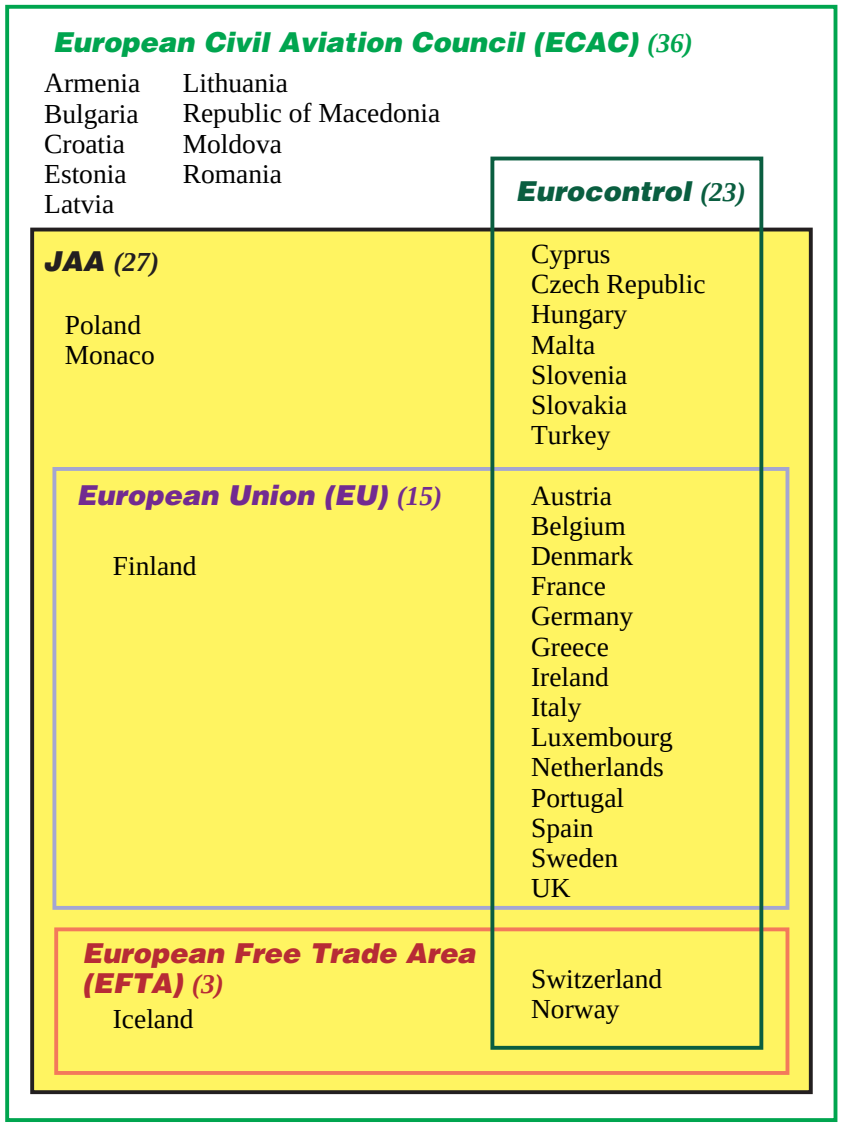
Work has also been going on for more than 10 years to reduce the number of differences between the basic requirement standards on each side of the Atlantic with a major attempt at harmonisation of JAR 25 and FAR 25. There has also been an attempt to cater for appropriate regulatory evolution during the life of a long production model of an aircraft.

This latter case was addressed in the International Certification Procedures Task Force during the last 8 years, set up to produce a "harmonised" jointly agreed means to handle derivative aircraft, i.e. basic model evolution over many years of continuous production, in an attempt to enhance the safety certification levels during the life of such type designs. Derivatives of aircraft which originally went into service in 1968 are being designed, developed and certificated up to 30 years later.

European harmonisation has been slowly progressing since the late 1960's, through the certification of Concorde, Airbus A300 and later models, BAe146, Jetstream 41, Saab 340/2000, Dassault, Dornier, ATR 42/72, CASA 235, etc... The certification procedures, and regulations, have evolved with experience such that nowadays a single JAA Team carries out the Type Certification investigation and agreement of findings of compliance on behalf of all the NAAs in the JAA. However, this process, which does work, is only by "gentleman's agreement" in the JAA "Club of Authorities". The creation of a single European Aviation Safety Authority will greatly improve the present

Figure 2

JAA and European organisations



"heavy" process. The relationship between the JAA and other European organisations is shown in Figure 2.

The harmonisation between Europe and the Western side of the Atlantic is taking its time also. In 1989, a target was declared at the annual JAA /FAA/Transport Canada and Industry joint meeting in Bordeaux, to go for major harmonisation of the FAR 25 and JAR 25 regulations. At about the same time, the US Government, through the FAA, set up their Aviation Rulemaking Advisory Committee (ARAC) structure and invited participation from Canadian and European Authorities and Industry.

After a slow and difficult start, at least in the tasking of the ARAC Transport Aeroplane and Engines Issues Group, the review work and the attempts to reach consensus conclusions have produced some productive results, notably in flight and structures regulations. In other subjects such as cabin safety, there has been little or no consensus and some difficult decisions will have to be taken eventually by the Authorities.

There is a general concern that in spite of all the significant resources put into the ARAC process by both Industry and Authorities, the lack of productive agreed output in many areas will reduce Industry commitment, and may eventually fail to achieve the original good harmonisation ideal.

But by including Industry at a suitable early stage of the review , and in the drafting process, there ought to be less Industry opposition to the final proposed regulatory product.

The regulations do need to be harmonised to an acceptable level before the implementation of joint procedures agreed across the Atlantic, can really result in the easing of the certification burden on manufacturers, by having one single certification process on behalf of all Authorities.

THE FUTURE PROSPECTS

The International Regulatory Climate is a variable environment. The principles of harmonised regulation and harmonised joint certification processes, acceptable to all, are a proper ideal to strive for in the civil aviation safety scene. We need to maintain the effort to reach the ideal in spite of some unexpected set backs. The main way to continue to make progress is to talk together and work together in a cooperative and open manner.

The "getting together" in Europe is being promoted both by Industry (manufacturers and now gradually the operators) and most of the NAAs of the JAA. The major problem is how to create a single legal entity with the relevant powers to act on behalf of all the members. The main feature to resolve is the formal handing over of sovereignty for aviation safety matters by the members governments, or safety bodies. There is also the question of covering the costs of a European Aviation Safety Authority.

Recent discussions reviewed a possible legal treaty or convention with relevant connection to the European Union; the EU being the appropriate European political body overseeing the administration by the European Commission.

There are legal difficulties to be resolved but generally there is a growing intent to see it happen and eventually the political will to make it happen will be there. The first signs of political commitment were seen at the European Council of Ministers in December 1996.

The Type Certificates for the A330

The Industry wishes to see the new European Aviation Safety Authority in place by the year 2000.

Meanwhile there is a continuing need to maintain dialogue and improve working arrangements between the major aviation safety control organisations across the world. There are signs of progress in this field with the conclusions and actions coming from the 13th and 14th Annual FAA/JAA/TCA and Industry Harmonisation Conferences held respectively in San Diego in June 1996 and in Berlin in June 1997.

The Industry and the Authorities have looked into a major problem which has arisen regarding the depth of involvement expected to be undertaken by an Authority when validating the certification of an already type certificated aircraft, and have proposed a new concept regarding this problem which is worthy of serious consideration.

The Safety Regulation Codes of FAR 25 and JAR 25 provide generally equivalent levels of safety. The large Regulatory Harmonisation programme which started 5 or 6 years ago, under ARAC, was a good principle to follow, but it has become very costly and time consuming in terms of Industry and Authority manpower resources. A more efficient way to meet the general need for harmonisation has to be found.

A new idea on how to handle this growing concern emerged, after some hard talking between and within the Authority and Industry group. It starts from the general view that the two codes are similar in concept although not necessarily identical in regulation or interpretation in all aspects. It should therefore be possible to consider each code "equivalent", and a Type Certification based on one code

should in principle be acceptable to countries normally using the other code. With that principle in mind we can concentrate the harmonisation work on key subjects where known differences in regulatory implementation are causing undue burden to industry, without any relevant safety benefit.

This proposal needs careful consideration by all parties before implementation. A very tight time schedule was proposed in 1996 to review and implement the details, and real progress was achieved in June 1997, with the joint agreement to two principle documents defining the future way ahead.

SAFETY OVERSIGHT

The interests of a growing number of countries, or groups of countries, in the world aviation safety scene are also being addressed. This fact, and the recent aggressive FAA policy regarding safety oversight, demonstrate the need to promote further aviation safety initiatives in a coordinated global fashion. Increasing interaction between ICAO and Member States is required, and is happening, to achieve such progress in a practical and controlled manner.

A number of regional aviation safety seminars have been, and are being, organised in various parts of the world, supported by the recognised safety bodies, and by manufacturers and operators and authorities. These initiatives and events provide opportunities for improving safety awareness by communication and dialogue within and between all involved parties.

As a model for the creation of a regional aviation safety organisation meeting the intent of the ICAO principles, the example of the European JAA, and its future evolution into a single authority acting on behalf of all European countries, can be offered. It shows how large and small countries can work together for a common cause. There is already a large body of recently harmonised regulatory material covering all aspects of safety regulation, which will soon also be available in different languages.

Positive progress, using the European example, is taking place among the countries of South Asia, and also in the Caribbean and in South America. Recent increases in ICAO activity and influence in these matters are welcomed.

CONCLUSION

Enhancement of the present aviation safety levels must be achieved in the coming years to meet the increasing volume of air transport traffic with a reduction in the actual accident numbers, in order to maintain public confidence in this major productive industry. Continuing worldwide cooperation to ameliorate the International Regulatory climate is essential to improve safety. Airbus Industrie is an active participant with the airworthiness authorities in the effort to achieve that aim. ■

Implementing JAR-OPS with Airbus Industrie Operational Documentation

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All major aviation countries have a regulatory system for applying and monitoring the safety standards of their civil aviation industry (see article *"THE INTERNATIONAL REGULATORY CLIMATE"* on page 11). The International Civil Aviation Organisation (ICAO), sets minimum standards for international air transport but the national standards of many countries exceed these.

The Joint Aviation Authorities (JAA) are an associated body of the European Civil Aviation Conference (ECAC) representing the civil aviation regulatory authorities of 27 European States (*) who have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. This co-operation is intended to provide high and consistent standards of safety based on the ICAO standards. Much emphasis is also placed on harmonising JAA requirements (JARs) with the regulations of the USA (FARs).

The JAA undertook a major harmonisation task to produce common operating regulation acceptable to all participating countries.
The result, called JAR-OPS, defines the Joint Aviation Requirements in the fields of aircraft operation. ICAO Annex 6 has been selected to provide the basic structure of JAR-OPS, but with additional sub-divisions where considered appropriate. The content of Annex 6 has been used and added to where necessary by making use of existing European regulations and the Federal Aviation Requirements of the United States of America where acceptable.

JAR-OPS Part 1 covering Commercial Air Transportation by aeroplanes was adopted by the JAA Committee at the end of March 1995, the first issue being published on 22 May 1995.

A Notice of Proposed Amendment (NPA) was issued in December 1996 to include new material which could not be developed before the first issue and to take into account some amendments made to ICAO Annex 6.

(*) Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom

APPLICABILITY

JAR-OPS 1 requirements are "applicable to the operation of any civil aeroplane for the purpose of commercial air transportation by any operator whose principal place of business is in a JAA member State". Therefore in the JAA Member States, JAR-OPS 1 applies to all airplanes regardless of date of manufacture. In addition some non-European states are adopting JAR-OPS 1.

JAR-OPS must be implemented no later than 1 April 1998 and this will occur, initially, under national legislation.

JAR-OPS 1 will be subject to "phased implementation" with the operators of large aeroplanes (those over 10 tonnes MTOW or with 20 or more passenger seats) and mixed fleets of large and small aeroplane being affected first, followed one year later (1 April 1999) by those Air Operator Certificate (AOC) holders operating small aeroplanes only. Some of the provisions in JAR-OPS have later compliance dates to alleviate the practical difficulties for the industry of implementing certain requirements.

JAR-OPS 1 CONTENT

The JAR-OPS 1 consists of the 19 subparts containing requirements for Air Operator Certificate holders below:

JAR-OPS 1 subparts:

A. Applicability
B. General
C. Operator certification and supervision
D. Operational procedures
E. All weather operations
F. Performance general
G. Performance class A (*Multi-engined aeroplanes powered by turbopropeller engines with a maximum approved passenger seating configuration of more than 9 or a maximum takeoff mass exceeding 5700 kg, and* ***all multi-engine turbojet powered aeroplanes****.)*
H. Performance class B (*Propeller driven aeroplanes with a maximum approved passenger seating configuration of 9 or less, and a maximum takeoff mass of 5700 kg or less.)*
I. Performance class C (*Aeroplanes powered by reciprocating engines with a maximum approved passenger seating configuration of more than 9 or a maximum takeoff mass exceeding 5700 kg)*
J. Mass and balance
K. Instruments and equipment
L. Communication and navigation equipment
M. Aeroplane maintenance
N. Flight crew
O. Cabin crew
P. Manuals, logs and records
Q. Flight and duty time limitations and rest requirements *(not published in the first version of the JAR-OPS).*
R. Transport of dangerous goods by air
S. Security

IMPLEMENTATION OF JAR-OPS 1

There are areas where the JAR-OPS formalizes requirements more than or which differ from or are in addition to FAR 121. For the operational documentation, Airbus Industrie already took these requirements into account and most of the associated information is already available.

The areas concerned are described below under:

- ❍ Aircraft Performance
- ❍ Operations manual
- ❍ Miscellaneous

Aircraft performance

JAR-OPS formally requests the operators to take into account the following items.

- ***One-engine inoperative cruising speed - JAR-OPS 1.295***
  Selection of aerodrome

For takeoff alternate airport selection, JAR-OPS requires the operator to take into account the one-engine inoperative cruising speed according to the Airplane Flight Manual (AFM). This speed (green dot speed / drift down speed) is given in the Flight Crew Operating Manual (FCOM), and in the performance chapter of the AFM or in the OCTOPUS performance computation program where AFM refers to this software (A319/A321/A330/A340). This speed has to be used to adopt obstacle strategy.

When obstacles are not a concern, any other one engine-out speed published in the FCOM or computed through the In Flight Performance (IFP) program may be used.

- ***Operation from / to contaminated runways***
  JAR-OPS 1.490 (c)(3) - takeoff
  1.520 (b) - landing

Airbus Industrie has published data on performance on contaminated runways since the beginning of A300B2 operations.

Associated performance may be obtained using appropriate takeoff performance computation programs (TCP, TLC or OCTOPUS) or using data published in the FCOM:

- ❍ for takeoff: special Operations chapter and fluid contaminated runways section
- ❍ for landing: Landing chapter.

For JAR 25 certified aircraft (A319/A320/A321/A330/A340), these performance are certified. Therefore they are also published in the AFM by reference to TLC for A320 and OCTOPUS for the other models.

- ***Takeoff line-up distance***
  JAR-OPS 1.490 (c)(6)

As per JAR-OPS, the operator must take into account lineup corrections when computing takeoff performance data when the access to the runway does not permit positioning of the aircraft at the threshold.

The NPA published in December 1996 proposes a calculation method when the aircraft manufacturer does not provide the appropriate data. However Airbus Industrie published minimum lineup distance corrections in its Takeoff Safety Training Aid and in the Performance Programs Manual (PPM).

Regarding takeoff performance computation, TCP, TLC or OCTOPUS programs have all the options to take into account any line-up distance chosen by the operator.

- ***Takeoff obstacle clearance in turn***
  JAR-OPS 1.495 (c)

During takeoff, aircraft may be banked by no more than 15° up to 400ft, then up to 25° when above 400ft. The NPA published in December 1996 proposes to allow, under specific circumstances, bank angles of 20° above 200ft and 30° above 400ft.

In any case JAR-OPS requires adequate allowance to be made for the effect of bank angle on flight path and operating speeds. Furthermore, when the aircraft is banked by more than 15°, the net flight path must clear the obstacles by 50ft (instead of 35ft).

Data source for specific JAR-OPS performance requirements

		A300B2 / B4	A310 / A300-600	A320	A319 / A321 / A330 / A340
One-engine inoperative cruising speed		AFM/FCOM/IFP			OCTOPUS/FCOM/IFP
Operation from/to contaminated runways		FCOM	TLC/FCOM	TAB/TLC/FCOM	OCTOPUS/FCOM
Takeoff line-up distance		TSTA/TCP/PPM	TSTA/TLC/PPM		TSTA/OCTOPUS/PPM
Takeoff obstacle clearance in turn	Gradient correction	AFM			OCTOPUS/PPM
	Speed correction	PPM			
Go-around gradient for decision heights below 200ft		FCOM		AFM/FCOM	OCTOPUS/FCOM

AFM: Airplane Flight Manual
FCOM: Flight Crew Operating Manual
IFP: In Flight Performance computation program
OCTOPUS: Operational and Certified Take-Off and landing Performance Universal Software
TAB: Tabulation and Interpolation Program
TCP: Takeoff Chart Computation program (A300 B2/B4)
TLC: Takeoff and Landing Chart program (A310/A300-600/A320)
TSTA: Takeoff Safety Training Aid
PPM: Performance Programs Manual

Regarding allowance on the flight path:
❍ Climb gradient corrections due to bank angles are given in the AFM Performance chapter.
❍ the OCTOPUS program can compute real takeoff performance taking the turn into account. No further climb gradient correction needs to be introduced.

Regarding allowance on the operating speeds, JAR-OPS proposes that unless otherwise specified in the Aeroplane Flight Manual or other performance or operating manuals from the manufacturer, an acceptable means of compliance to this requirement, is to add a 5kt increment on V2 minimum speed for bank angles above 15° and 10kt for bank angles above 25° to assure adequate stall margin.

Studies show that there is no need to add any speed increment on V2 minimum for any Airbus aircraft for any bank angle up to 20° and even up to 25° for most of Airbus aircraft. Therefore this information will be published in the Performance Programs Manual (PPM).

Airbus Industrie Flight Operations Support can assist any customer to determine operational procedure and takeoff performance when high bank angles are required at takeoff.

- ***Go-around gradient for decision heights below 200 ft JAR-OPS 1.510 (b)***

For instrument approaches with decision height below 200 ft, JAR-OPS requires a minimum go-around climb gradient of 2.5%, or the published gradient, whichever is the greater.
Relevant information is already available in the AFM of the A320, as well as for some A310s and for A319/A321/A330/A340 through the OCTOPUS program. It will be introduced in the FCOM as soon as possible.

For the A300 and remaining A310s, the information will be available in the FCOM by 1st April 1998.

A summary of the various data sources for specific JAR-OPS requirements is shown on the table above.

Operations Manual

JAR-OPS 1.200 Operations Manual: *"An operator shall provide an Operations Manual in accordance with Subpart P for the use and guidance of operations personnel."*

JAR-OPS 1.1040 General Rules for Operations Manuals: *"An operator shall ensure that the Operations Manual contains all instructions and information necessary for operations personnel to perform their duties."*

- ***Structure and contents***

JAR-OPS 1 Subpart P "Manuals, logs and records" defines the general rules, structure and contents for Operations Manuals produced by the airlines.

JAR-OPS prescribes the structure of the Operations Manual in four part:
❍ Part A: General/Basic
❍ Part B: Airplane Operating Matters
❍ Part C: Route and Aerodrome Instructions and Information
❍ Part D. Training

Appendix 1 to JAR-OPS 1.1045 contains a comprehensively detailed and structured list of all items to be covered in the Operations Manual.

Since it is believed that a high degree of standardisation of Operations Manuals within the JAA will lead to improved overall flight safety, JAR-OPS strongly recommends that the structure described in the JAR-OPS Subpart P should be used by operators as far as possible. Manuals which do not comply with the recommended structure may require a longer time to be accepted/approved by the authority.

To facilitate comparability and usability of Operations Manuals by new personnel, formerly employed by another operator, JAR-OPS recommends operators not to deviate from the numbering system used in Appendix 1 to JAR-OPS 1.1045. If there are sections which, because of the nature of the operation, do not apply, it is recommended that operators maintain the numbering system described in JAR-OPS and insert "Not applicable" or "Intentionally blank" where appropriate.

- ***Part A: General / Basic***

"This part shall comprise all non type-related operational policies, instructions and procedures needed for a safe operation and shall comply with all relevant regulations."

Airbus Industrie developed an Operations Policy Manual that may be used by Airbus operators as a guide to produce this Part A of their own Operations Manual. It was issued to all Airbus customers in Malaga during the 9th Performance and Operations Conference in June 96. It is also available on diskette from the auhor.

The structure and the technical content of the Operations Policy Manual developed by Airbus Industrie aimed to fulfil the requirements of the JAR-OPS as much as possible.

With the evolution of JAR-OPS, a second issue is now under preparation.

The Airbus Industrie Operations Policy Manual is made of the following chapters as prescribed by JAR-OPS:

0. *Administration and control of Operations Manual*
1. *Organisation and responsibilities*
2. *Operational control and supervision*

3. Quality system
4. Crew composition
5. Qualifications requirements
6. Crew health precautions
7. Flight time limitations
8. Operating procedures
9. Dangerous goods and weapons
10. Security
11. Handling of accidents and occurrences
12. Rules of the air

The technical content of the Airbus Industrie Operations Policy Manual is given for information only and is not approved by any authority. The information mentioned in it represents in some parts a strict application of requirements, elsewhere it includes guidelines or examples.

Although many parts of the Airbus manual may be used as they are or with minor amendments by an operator, it has to be customised to include specific airline policies, special organisation, area of operations and some detailed compliance and interpretative information which some Civil Aviation Authorities and industrie organisations would like to see.

● ***Part B: Aeroplane operating matters***

"This part shall comprise all type-related instructions and procedures needed for a safe operation. It shall take account of the different types of aeroplanes or variants used by the operator". The Flight Crew Operating Manual (FCOM) and Quick Reference Handbook (QRH) produced by Airbus Industrie may be used to fulfil most of the requirements of this part. However Part B should also include other items given in other Airbus Industrie documentations such as Aircraft Flight Manual (AFM), Performance Programs, Weight and Balance Manual (WBM) and any other type related operational manuals as Aircraft Characteristic (AC), Noise Definition Manual (NDM) / Octoper, Cargo loading System Manual (CLS).

The following paragraphs of Appendix 1 to JAR-OPS 1.1045 Part B which are not or are only partially addressed in FCOM and QRH, are addressed in other Airbus Industrie documents as mentioned below:

• ***1.1.(b)*** Passenger seating configuration: WBM.
• ***2.1.(e)*** Noise abatement: NDM or Octoper
• ***3.(e)*** Exceeding cosmic radiation limits: Not applicable
• ***4.1.*** Performance data: AFM and Airbus performance programs
• ***4.1.(d)*** Gradient losses for banked climbouts: AFM or Octopus
• ***4.1.1.*** Icing condition: Values are given in the FCOM but in addition specific performance can be established by computation with Airbus performance programs.
• ***4.2.(f)*** Performance under CDL (Configuration Deviation List): Chapter 6 of AFM
• ***6.*** Mass and Balance: Covered by Weight and Balance Manual and FCOM. Airbus customises Load and Trim sheets on operator request.
• ***7.*** Loading: WBM and CLS
• ***8.*** CDL: Chapter 6 of the AFM.
• ***9.*** MEL:- Minimum Equipment List is established by the operator using the Airbus MMEL.
• ***10.1.*** The list of survival equipment is a function of the operation and is not indicated in the Airbus FCOM.

● ***Part C: Route and aerodrome instructions and information***

"This part shall comprise all instructions and information needed for area of operation". The Jeppesen Airway manuals or equivalent may be used to cover this part.

● ***Part D: Training***

"This part shall comprise all training instructions for personnel required for a safe operation". The Airbus Industrie Flight Crew Training Manual (FCTM) and the Flight Crew Training Reference Manual (FCTRM) may be used to cover most of the requirements of this part dealing with flight crew training.

Miscellaneous

● ***Mass and balance (Subpart J)***

The present Weight and Balance Manual provided by Airbus Industrie is not affected by JAR-OPS requirements.

JAR-OPS gives a method to make statistical evaluation of passenger and baggage mass to be used for aircraft weight and CG determination. However, JAR-OPS also gives standard passenger mass values including hand baggage as follows:

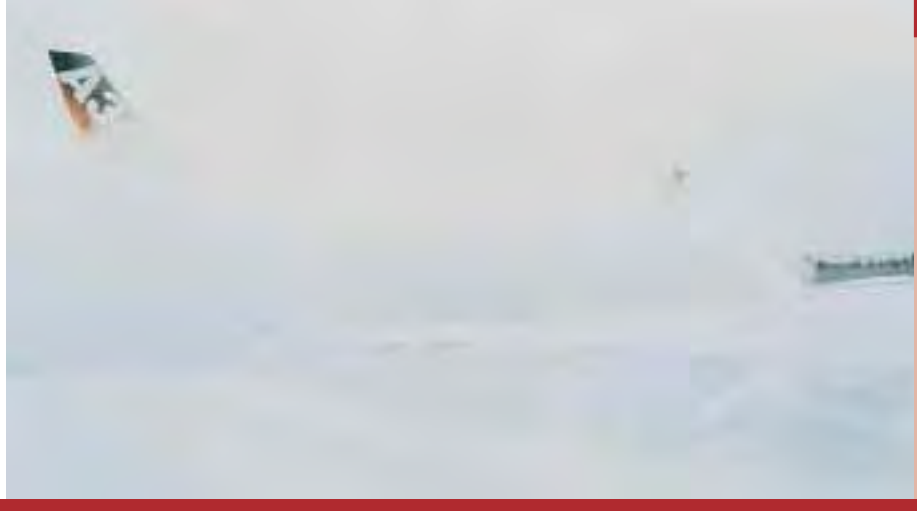
	All flights except charters	*Holiday charters*
Adult	84 kg	76 kg
Children	35 kg	35 kg
or:		
Male	88 kg	83 kg
Female	70 kg	69 kg
Children	35 kg	35 kg

The Load and Trim sheet provided on request by Airbus Industrie is customised taking into account the passenger weight value decided by the airline.

● ***Instruments and equipment (Subpart K)***

There are small differences in terms of instruments and equipment requirements between JAR-OPS and FAR. This greatly depends on equipment defined by the operator which are responsible for determining compliance with the regulation.

Airbus Industrie can provide assistance to operators in determining on a case by case basis, compliance of their aircraft instruments and equipment with JAR-OPS.



CONCLUSION

The operational documentation provided by Airbus Industrie to its customers already meets most of the JAR-OPS requirements. Airbus Industrie went even further by the production of an Operations Policy Manual which should help Airbus operators to build their own Operations Manual. This is another example of the continuous safety and support improvement that Airbus Industrie offers to its customers ■

THE PORTABLE WATER DETECTION TOOL FOR A300/A300-600/A310

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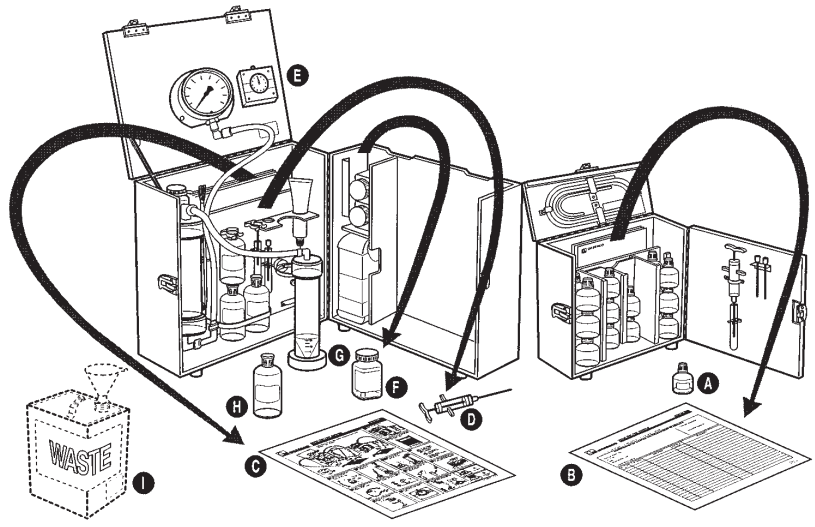
The consequence of water ingress into the gearboxes in slat and flap actuation system is well known to aircraft operators. In the event of seal damage and because of the decrease in air pressure after take-off, air can escape from a gearbox. Then as the aircraft descends to land, humid air is sucked into the gearbox and condenses. This action is known as "breathing"and with time can cause a build-up of water content in the gearbox. Until recently it has been difficult to carry out an analysis of the oil in the gearboxes to determine the degree of water ingress. It required a specialised person and a laboratory with specific equipment.

Figure 1

The Preciwatertest - *some elements from the water measurement unit:*



A - Sample
B - Identification and record card
C - Directions for use for water measurement
D - Syringe 20cm3 with the 8 cm long metal tube
E - Stop watch
F - Flask containing the capsules
G - Test tube (reaction flask)
H - Solvent flask for cleaning
I - Receptacle for the waste

FLAP AND SLAT JAMMING

The presence of more than 5% of water in the oil quantity in gearboxes can be disturbing because the water can freeze, causing increased torque in the drive system and perhaps causing it to jam. Water ingress also degrades the quality of the oil and can cause corrosion of the components. To date there has been a procedure to take a sample of the suspect oil but no practical tool to allow the mechanic to determine quickly the percentage of water. The analysis had to be done by a specialist in a laboratory, which was a time consuming process.

THE SOLUTION

Geserco and Airbus Industrie have developed a tool called the Preciwatertest which allows the mechanic to get a direct reading of the water percentage at the aircraft. The Trouble Shooting Manuals(TSM) for the A300-600 (Chapter 27-50-02) and A310 (Chapters 27-50-02 and 27-80-02) are being modified to incorporate the new method, as is the FIM Chapter 27-50-00 for the A300. In addition modifications to the seals are available (Mod 06551 for A300, Mod 10796 for A300-600 and Mod 10961 for the A310).

Figure 2

The sampling

THE WATER DETECTION TOOL

The Preciwatertest contains two kits, one for sampling the oil, the other for measuring the water content. Both are transported in a single small suitcase (38 x 33 x 27.5 cm) (see page 21) but can be carried independently if required. For example if the sampling and the measurement were to be done at the aircraft then both would be carried.

However if the analysis is not urgent then the sampling kit may be taken to the aircraft and the measurement done later.

SAMPLING

The sampling procedure depends on the gearbox from which the oil has to be extracted.

The oil can be extracted from some gearboxes without a syringe. For the other gearboxes there are three different nozzles for the syringe: one in metal, one curved in plastic and the third, a flexible plastic tube (Figure 2). In the sampling kit one bottle is provided for each gearbox.

The samples must be taken no later than 40 minutes after operation of the flap or slat system. Within this time the oil and water will still be mixed otherwise they will be separated and false results would be obtained.

MEASUREMENT

Measurement of the water content can be done at the aircraft or in a workshop by a non specialist. The oil sample is poured into a reaction flask (Figure 3) which is linked to an expansion vessel and manometer which ***gives a direct reading of the percentage of the water in the oil*** (Figure 4 on the following page).

The function is based on a chemical reaction. The cap of the reaction flask has housings in which capsules containing a reactive powder are placed. When the powder and oil are mixed a foam will form if there is water in the oil (Figure 3). The mixture gives off oxygen in direct ratio to the amount of water contained in the oil sample. Pressure in the expansion vessel is measured by the manometer.

The water detection tool is calibrated for a 10cm3 sample. Therefore ***only 10 cm3 of oil should be placed in the reaction flask and the reading of the manometer should be taken five minutes after all the powder has entered the sample***. If these conditions cannot be respected a formula and chart are provided with the kit to allow calculation of the correct result.

Figure 3

The foam in the reaction flask