

MODULE 09A

FOR B1 & B2 CERTIFICATION

HUMAN FACTORS

Aviation Maintenance Technician Certification Series



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9.1 - GENERAL

INTRODUCTION

Why are human conditions such as fatigue, complacency, and stress, so important in aviation maintenance? These conditions, along with many others, are called human factors. Human factors directly cause or contribute to many aviation accidents. It is universally agreed that at least 80 percent of maintenance related incidents involve human factors. If they are not prevented, and their causes detected, they can cause injuries, wasted time, and even accidents. (*Figure 1-1*)

THE NEED TO TAKE HUMAN FACTORS INTO ACCOUNT

Aviation safety relies heavily on maintenance. When it is not done correctly, it contributes to a significant proportion of accidents and incidents. Some examples of maintenance errors may include; parts installed incorrectly, missing parts, or necessary checks not being performed. In comparison to many other threats to aviation safety, the mistakes of an Aviation Maintenance Technician (AMT) can be more difficult to detect.

Often times, these mistakes are present but not visible and have the potential to remain latent, affecting the safe operation of aircraft for long periods of time. AMTs are confronted with a set of human factors unique within aviation. Often times, AMTs are working in the evening or early morning hours, in confined spaces,

on platforms that are up high, or in a variety of adverse temperature/humidity conditions. The work can be physically strenuous, yet also requiring a high degree of attention to detail. (*Figure 1-2*)

Because of the nature of maintenance tasks, AMTs commonly spend more time preparing for a task than actually carrying it out. Proper documentation of all maintenance work is a key element, and AMTs also typically spend as much time updating maintenance logs as they do performing the work.

Human factors and how they affect people are very important to aviation maintenance. Such awareness can lead to improved quality, an environment that ensures continuing worker and aircraft safety, and a more involved and responsible work force. More specifically, the reduction of even minor errors can provide measurable benefits including cost reductions, fewer missed deadlines, reduction in work related injuries, reduction of warranty claims, and reduction in more significant events that can be traced back to maintenance error.

It is apparent that anticipated or abnormal medical conditions influence the AMTs work. Reduction in vision is a signpost of aging that is anticipated in all AMTs over the age of 50 years. It compromises the visual

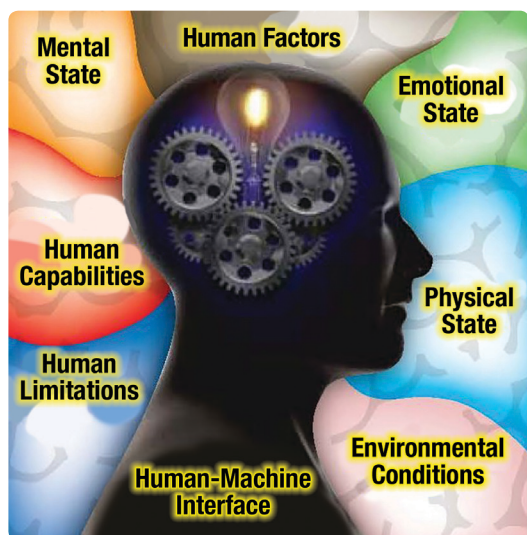


Figure 1-1. The above human factors and how they affect people are very important. Awareness of their influence can help control possible accidents



Figure 1-2. Aviation maintenance technicians have many distractions and must focus on detail.

inspection of aircraft. Obesity is an abnormal medical condition that leads to multiple metabolic changes. It produces behaviors described by The Dirty Dozen of

human factors. These consequences from normal aging or abnormal medical conditions are classified as Latent Medical or Environmental Conditions (LMEC).

THE ORGANIZATIONAL ENVIRONMENT

HOW DOES YOUR ORGANIZATION STACK UP?		
POSITIVE ORGANIZATIONAL CHARACTERISTICS		
There are sufficient staff appropriately licensed to cover the workload.	Yes	No
The organization never encourages shortcuts or procedure violations.	Yes	No
Management acts quickly to fix unsafe situations.	Yes	No
Staff are encouraged to report errors and unsafe situations.	Yes	No
The company has a 'just culture' policy. Incidents are investigated to identify why they occurred, not whom to blame.	Yes	No
Staff receive human factors training.	Yes	No
NEGATIVE ORGANIZATIONAL CHARACTERISTICS		
There is an extreme 'can-do' culture. Staff do whatever it takes to get a job done on time.	Yes	No
Tasks are routinely performed according to 'norms' (informal work practices), rather than documented procedures.	Yes	No
Staff are often required to work excessive hours.	Yes	No
Work is done differently when there is time pressure.	Yes	No
Shortages of spares or equipment often lead to workarounds.	Yes	No
There is rapid staff turnover, or many inexperienced personnel.	Yes	No

INCIDENTS RELATED TO HUMAN FACTORS

The following are major incidents that have been directly attributed to human factors.

CASE STUDY: ALOHA AIRLINES FLIGHT 243

Complacency is identified as one of "The Dirty Dozen" of aircraft maintenance human factors. (Discussed in full detail in Sub-Module 09, along with other error models). The Dirty Dozen are 12 identified human factors that lead to maintenance errors. Complacency is at the top of this list and is the deadliest of the 12 factors. This is demonstrated by the tragic Aloha Flight 243, which took place on April 28, 1988. Complacency with the state of aging aircraft was exposed as the cause of the accident and this event became the watershed accident that would bring much needed change.

Aloha Airlines Flight 243 (AQ 243, AAH 243) was a scheduled Aloha Airlines flight between Hilo and Honolulu in Hawaii. On April 28, 1988, a Boeing 737-297 serving the flight suffered extensive damage after an explosive decompression in flight, but was able to land safely at Kahului Airport on Maui. There was one fatality, a member of the flight crew who was swept overboard from the airplane. Another 65 passengers and crew were injured. The safe landing of the aircraft despite

the substantial damage inflicted by the decompression established Aloha Airlines Flight 243 as a significant event in the history of aviation, with far reaching effects on aviation safety policies and procedures. (*Figure 1-3*)

The flight departed Hilo at 13:25 HST on April 28, 1988 with six crew members and 89 passengers, bound for Honolulu. No unusual occurrences were noticed during the predeparture inspection of the aircraft. The aircraft had previously completed three round trip flights from Honolulu to Hilo, Maui, and Kauai that day, all which were uneventful. Meteorological conditions were checked but no advisories for weather phenomenon occurred along the air route, per Airman's meteorological information or significant meteorological information. The captain was an experienced pilot with 8 500 flight hours; 6 700 of those were in Boeing 737s. The first officer had significant experience flying 737s, having logged 3 500 of her total 8 000 flight hours in them.

No unusual occurrences were reported during the takeoff and ascent. Around 13:48, as the aircraft reached its normal flight altitude of 24 000 feet (7 300 m) about 23 nautical miles (43 km) south southeast of Kahului, Maui, a small section on the left side of the roof ruptured with a "whooshing" sound. The captain felt the aircraft roll left and right, and the controls went



Figure 1-3. Aloha Airlines Flight 243; A watershed moment in aviation maintenance history that brought about much needed change in aviation maintenance. It was recognized that complacency in the state of aging aircraft was the main contributing factor to this accident.

loose. The first officer noticed pieces of gray insulation floating over the cabin. The door to the cockpit was gone so the captain could look behind him and see blue sky. The resulting explosive decompression tore off a large section of the roof, consisting of the entire top half of the aircraft skin extending from just behind the cockpit to the forewing area.

The first officer was flying the plane at the time of the incident. After discovering the damage, the captain took over and steered the plane to the closest airport, on Maui Island. Thirteen minutes later, the crew performed an emergency landing on Kahului Airport's Runway 02. Upon landing, the crew deployed the aircraft's emergency evacuation slides and evacuated passengers from the aircraft quickly. In all, 65 people were reported injured, eight seriously.

Investigation

The main factor was the failure of the Aloha Airlines maintenance program to detect the presence of significant disbonding and fatigue damage.

Contributing causes were the failure of Aloha Airlines management to supervise properly its maintenance forces. The failure of the Federal Aviation Administration (FAA) to properly evaluate the Aloha Airlines maintenance program, and to assess the airlines inspection and quality control deficiencies. The failure of the FAA to require Airworthiness Directive AD 87.21-08 inspection of all

the lap joints proposed by Boeing Alert Service Bulletin SB 737.53A1039; and the lack of a complete terminating action (neither generated by Boeing nor required by the FAA) after the discovery of early production difficulties in the Boeing 737 cold bond lap joint which resulted in low bond durability, corrosion, and premature fatigue cracking.

Safety Recommendations

Investigator's made eighteen *Safety Recommendations*.

FAA Recommendations

- Provide specific guidance and proper engineering support to principal maintenance inspectors to evaluate modifications of airline maintenance programs and operations specifications, which propose segmenting major maintenance inspections.
- Revise the regulation governing the certification of aviation maintenance technical schools and licensing of airframe and power plant mechanics to require that curriculum and testing requirements include modern aviation industry technology.
- Require formal certification and recurrent training of aviation maintenance inspectors performing nondestructive inspection functions. Formal training should include apprenticeship and periodic skill demonstration.

- Develop a continuing inspection program for those Boeing 737 airplanes that have incorporated lap joint termination action (protruding head solid fasteners installed in the upper row of all lap splices) to detect any fatigue cracking that may develop in the middle or lower rows of fuselage lap joint fasteners holes (for both the inner and outer skin panels) or the adjacent tear strap fastener holes. Additionally, to define the types of inspections, inspection intervals, and corrective actions needed for continuing airworthiness.
- Develop a model program for a comprehensive corrosion control program to be included in each operator's approved maintenance program.
- Issue an airworthiness directive for Boeing 737 airplanes equipped with carbon steel control cables to inspect the cables for evidence of corrosion and if there is evidence, to accomplish the actions set forth in Boeing Service letter 737-SL-76.2-A.
- Enhance stature and performance of the principal inspectors through; (1) formal management training and guidance, (2) Greater encouragement and backing by headquarters of efforts by principal inspectors to secure the implementation by carriers of levels of safety above the regulatory minimums, (3) Improve accountability for quality of the surveillance; (4) Additional headquarters assistance in standardizing surveillance activities.
- Discontinue classification of fuselage skin as "malfunction evident" or "damage obvious" on supplemental structurally significant items in the damage obvious category for possible inclusion in the supplementary inspection program.
- Issue an air carrier operations bulletin for all air carrier flight training departments to review the accident scenario and reiterate the need to assess airplane airworthiness as stated in the operators manual before taking action that may cause further damage or breakup of a damaged airframe.
- Revise and upgrade the technical division manpower and organization to provide the necessary management, quality assurance, engineering, technical training and production personnel to maintain high level of airworthiness of the fleet.
- Assist member air carriers to establish maintenance department engineering services to evaluate maintenance practices including structural repair, compliance with airworthiness directives and service bulletins, performance of inspection and quality assurance sections, and overall effectiveness of continuing airworthiness programs.

Related to "The Dirty Dozen"

- Complacency with the state of aging aircraft – **Complacency**
- Working under pressure – **Pressure**
- Inspections done at night; circadian rhythm upset – **Fatigue**
- Inspectors suspended by safety harnesses – **Lack of Resources**
- Required to inspect 1 300 rivets – **Pressure**
- Documentation is complicated and subject to interpretation – **Lack of Knowledge**
- Engineering Dept was outsourced – **Lack of Communication, Lack of Teamwork**
- Hangar lighting designed for DC-3's – **Lack of Resources**
- Lack of adequate manpower – **Fatigue**
- Lack of knowledge – just two hours of NDT training – **Lack of Knowledge**

CASE STUDY: BRITISH AIRWAYS BAC-111; WINDSCREEN BLOWOUT

The aircraft, captained by 42 year old, who had logged 11 050 flight hours, and copiloted by 39 year old, who had logged 7 500 flight hours, was a BAC One Eleven Series. The aircraft took off at 7:20am local time, with 81 passengers, four cabin crew and two flight crew. Copilot handled a routine takeoff, and relinquished control as the plane established itself in its climb. Both pilots subsequently released their shoulder harnesses, while the pilot loosened his lap belt as well.

The plane had climbed to 17 300 feet (5 270 m) over Didcot, Oxfordshire. Suddenly, there was a loud bang, and the fuselage quickly filled with condensation. The left windscreen, on the captain's side of the cockpit, had separated from the forward fuselage. The Captain

Aloha Airlines Recommendations

- Revise the maintenance program to recognize the high time high cycles nature of the fleet operations and initiate maintenance inspection and overhaul concepts based on realistic and acceptable calendar and flight cycle intervals.
- Initiate a corrosion prevention and control program designed to afford maximum protection from the effects of harsh operating environments.

was jerked out of his seat by the rushing air and forced head first out of the cockpit, his knees snagging onto the flight controls.

The door to the flight deck was blown out onto the radio and navigation console, blocking the throttle control which caused the plane to continue gaining speed as they descended, while papers and other debris in the passenger cabin began blowing towards the cockpit. On the flight deck, the flight attendant quickly latched his hands onto the captain's belt; another flight attendant began to reassure passengers, secure loose objects, and take up emergency positions.

The copilot eventually received clearance from air traffic control to land at Southampton. The aircraft had landed safely on Runway 02, where the passengers immediately disembarked from the front and rear stairs, and emergency crews retrieved the captain.

Investigation

Accident investigators found that a replacement windscreen had been installed 27 hours before the flight, and that the procedure had been approved by the shift maintenance manager. However, 84 of the 90 windscreen retention bolts were 0.026 inches (0.66 mm) too small in diameter, while the remaining six were 0.1 inches (2.5 mm) too short. (*Figure 1-4*)

The investigation revealed that the previous windscreen had been fitted with incorrect bolts. Because the plane was due to take off soon and there was a tight schedule, in order to save time, the shift maintenance manager replaced the bolts on a "like for like" basis without referencing the maintenance documentation. The air pressure

difference between the cabin and the outside during the flight proved to be too much, leading to the failure of the windscreen. The incident also brought to attention a design flaw in the aircraft. Securing the windscreen from the outside of the aircraft put a greater pressure on the bolts than if they were secured from the inside.

Investigators found the British Airways Birmingham Airport shift maintenance manager responsible for installing the incorrect bolts during the windscreen replacement, and for failing to follow official British Airways' policies. They also found fault with British Airways' policies, which should have required testing or verification by another individual for this critical task. Finally, investigators found the local Birmingham Airport management responsible for not directly monitoring the shift maintenance manager's working practices.

Safety Recommendations

Investigators made eight safety recommendations in the final accident report.

British Airways Recommendations

- Review their quality assurance system and encourage technicians to provide feedback.
- Review the need to introduce job descriptions and terms of reference for different grades Shift Maintenance Manager and above.
- Review their product sample procedure to achieve independent assessment of standards and to conduct an indepth audit into the work practices at Birmingham Airport.

Civil Aviation Authority Recommendations

- Examine the continued viability of self certification with regards to safety critical tasks on aircraft.
- Review the purpose and scope of the FOI 7 Supervisory Visit.
- Consider the need for the periodic training and testing of technicians.
- Recognize the need for the use of corrective glasses, if prescribed, in association with aircraft engineering tasks.
- Ensure that, prior to the issue of an air traffic control rating, a candidate shall undergo an approved course including training in both the theoretical and practical handling of emergency situations.



Figure 1-4. Incorrect windscreen retention bolts; (too small) led to the windshield blowout.

Related to "The Dirty Dozen"

- There were staff shortages – **Lack of Resources**
- Time pressures existed – **Pressure/Fatigue**
- All the errors occurred at night – **Fatigue**
- Shift or task hand overs were involved
– **Lack of Communication**
- All involved supervisors doing long hands on tasks
– **Lack of Teamwork**
- There was an element of a "can do" attitude
– **Complacency**
- Interruptions occurred – **Distraction**
- There was some failure to use approved data or company procedures
– **Lack of Knowledge, Lack of Resources**
- Manuals were confusing – **Lack of Resources**
- There was inadequate planning, equipment or spares
– **Lack of Resources**

CASE STUDY: NOSE WHEEL JAMMED ON DASH-8

While preparing a Dash-8 (DHS-8) aircraft to return to service after major repairs, maintenance technicians noticed that the nose gear was missing a cover plate designed to protect micro switches from dust and stone damage, no spare was available. To help the company meet a deadline, maintenance personnel decided to

manufacture a substitute cover plate, without waiting to get engineering approval. The plate was only a protective cover, not a structural component, and this probably led them to believe that manufacturing a similar replacement part would not affect safety.

The original plate was shaped to provide clearance between it and the micro switches and was secured using countersunk screws. Because of the limited manufacturing capability at this maintenance facility, the replacement cover was manufactured from a flat plate and spacers were used to provide similar clearance. The holes in the replacement plate were not drilled to accept countersunk screws and it was secured using washers and hexagonal head bolts. The bolt heads protruded beyond the normal position of the counter sunk screw heads. The difference was sufficient to cause the landing gear to jam in the up position during a test flight following the repairs. (*Figure 1-5*) A retraction test that might have detected the problem was successfully completed before the replacement plate was fitted.

Investigation

Positive gravity maneuvers and a touch and go landing failed to shake the nose gear free. The crew decided to land once all other traffic was clear and emergency



Figure 1-5. A retraction test done after the plate was fitted as opposed to prior, would have prevented damage from this accident.

services were in place. A landing was completed with the aircraft sliding to a stop on its main wheels and nose. The accident investigator noted that a culture of "getting the job done" existed in the company and there was a strong sense of loyalty and motivation among the maintenance staff. The report concluded, "Staff excelled themselves in order to meet deadlines. While this approach is laudable, research and investigation has shown that it can lead to incorrect practices if the appropriate balance is not found".

As described in this example, an awareness of how the physical and organizational environment influences maintenance tasks is an essential part of human factors. If you can identify error producing conditions in your work environment, you will be better prepared to change those things you can change, and deal with those things that are beyond your control.

Related to "The Dirty Dozen"

- Corporate culture – get the job done at all costs
 - **Pressure**
- Time saving short cuts – **Pressure**
- Lack of spare parts – **Lack of Resources**
- Retraction test done before replacement part fitted
 - **Lack of Knowledge, Complacency**

CASE STUDY: FAILURE TO PRESSURIZE AFTER OUTFLOW VALVE LEFT IN OPEN POSITION

Early on the morning of August 14, 2005, a Boeing 737-300 aircraft departed Cyprus for Prague via Athens. About five minutes after takeoff, at an altitude of 12 040 ft. and at a cabin pressure that corresponded to an altitude of 10 000 ft., an aural warning horn sounded. On this type of aircraft, the same aural tone is used to indicate two conditions: Take-off Configuration Warning and Cabin Altitude Warning.

A minute and a half later, with the aircraft still climbing, the captain contacted the company operations center on the company radio frequency and reported that the crew had a takeoff configuration warning. The operations center put a ground technician on the line to communicate with the captain. The technician later reported a confusing conversation in which the captain mentioned a problem with the ventilation cooling fan lights.

Since the message from the captain did not make any sense to the technician, he asked the captain to "confirm that the pressurization panel was selected to AUTO." The captain responded "where are my equipment cooling circuit breakers?" The technician replied "behind the captain's seat".

During the conversation with the company operations center, the passenger oxygen masks deployed as they were designed to do when the cabin altitude exceeded 14 000 ft. The communication between the ground technician and the captain ended as the aircraft climbed through 28 900 ft.

Shortly after, the flight crew is believed to have lost useful consciousness as a result of hypoxia, the aircraft leveled off at 34 000 and continued on its programmed route, eventually entering a programmed holding pattern near Athens. There was no response to radio calls to the aircraft.

F-16 fighters were scrambled to intercept the 737. One of the F-16 pilots observed the aircraft at close range and reported that the captain's seat was vacant, the first officer's seat was occupied by someone who was slumped over the controls, the passenger oxygen masks were dangling, and motionless passengers were seen seated wearing oxygen masks in the cabin. A person who appeared to be a flight attendant was then seen to enter the cockpit and sit in the captain's seat. At around 9:00am, the engines flamed out due to fuel exhaustion and the aircraft crashed into hilly terrain northwest of Athens airport. All the 115 passengers and six crew died.

Investigation

During the previous flight, cabin crew had noticed frozen door seals and noises around the right aft service door, and the flight crew wrote up an entry in the aircraft tech log 'aft service door requires full inspection'.

Between 1:30am and 3:15am, technicians performed a visual inspection of the aft service door and carried out a cabin pressurization leak check. During the leak check, the technician who would later speak with the captain during the flight went to the cockpit to pressurize the aircraft, while another technician stayed in the rear of the aircraft near the R2 door. No defects were found and the log entry was signed off.