Japanese Aerospace Quality Group

Guidance Documents for Aviation, Space and Defence Organizations

Appendix-2

- Flight Safety Training -

- April, 2014 Published
- June, 2017 Revised
  (Added English translation for Examples)

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1. Objectives

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- **Aviation and space hardware or instruments are comprised of many parts, and each of them play an important role in flight safety. However, in the respective work sites, there is always a possibility that operator could not keep aware of "the fact that each of the daily work tasks/operations are directly connected to flight safety" is reduced, and that tendency is particularly strong in manufacturing work sites for materials, parts, etc. where it is difficult to imagine the completed aircraft. For that reason, it is extremely important for organizations to actively provide training about flight safety to the personnel and get them to understand its importance.**
- **The objective of this guidance material is to help organizations in the aviation, space and defence industries when they are implementing flight safety training by providing guidelines regarding what perspectives the organizations should take when planning and implementing training, and several examples related to flight safety training materials.**

2. Scope

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■ **This guidance is suitable for use as an training guide when providing flight safety training for the following organizations, personnel, products, and processes.**

(1) The organizations and personnel should be the organizations and personnel in the aviation, space and defence industries.

(2) The products should be for "flight" in the broad sense, and include spacecraft and systems, as well as aircraft.

(3) The processes should be the processes from manufacturing of materials and parts/components to final assembly/maintenance.

(4) The training that is covered here is not only promoting awareness of flight safety that leads to the prevention of harm to persons or property damage during operations, but can also be applied to achieving operational missions, etc.

3. Terms and abbreviations

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(1) Flight safety
The state in which the risk of harm to persons or property damage caused by a flight is reduced to, and maintained at an acceptable level

(2) Approved Organizations
Organizations that have received approval based on the Civil Aeronautics Act, Article 20 to engage in the design, manufacturing or maintenance, etc. of aircraft or components

(3) 2.5 person perspective
This is a perspective for handling the operations which combines the “3rd person perspective" thinking as an expert and the "1st person and 2nd person perspective" thinking what if oneself or one’s family member is a victim of an accident.

(4) Failure Mode and Effects Analysis (FMEA)
This is a method of analyzing the failure modes of constituent elements and their effects of top-ranked items in order to discover imperfections and latent defects in design

(5) Risk map (R-Map)
Map showing the risk tolerance in the figure obtained by multiplying the extent of the damage and the occurrence frequency

4. Flight safety training

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It is important for each organization to repeatedly and regularly provide training in accordance with the guidelines in Section 4.1 and subsequent sections of this guidance material to ensure that the personnel understand the importance of flight safety and the fact that their respective daily work tasks/ operations are directly connected to flight safety.

Note that under the revision* to the Ordinance for Enforcement of the Civil Aeronautics Act, the introduction of a Safety Management System (SMS) is required for Approved Organizations. “Flight safety training“ is included as a part of the introduction of the SMS.

* In relation to the Ordinance for Enforcement of the Civil Aeronautics Act, Article 35, the introduction of a safety management system was added as an approval criterion for these organizations. (Promulgated on November 5, 2010)

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4.1 The objectives of the training

Objective of the training is to ensure that all of the personnel involved in the aviation, space and defence industries understand :

■ **The importance and scariness of flight safety as a problem of their own facing a close-at-hand problem.**

■ **The risk that the level of performance of their work by each and every person" has an effect on flight safety.**

■ **The truth that Flight safety is realized by ensuring that "the quality expected in subsequent processes" from manufacturing of materials and parts/components to aircraft body assembly/ maintenance is "inherited without any interruption."**

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4.2 The commitment of top management

■ **It is necessary for the top management to communicate a clear message to personnel involved in the aviation, space and defence industries that flight safety is important.**

4. Flight safety training

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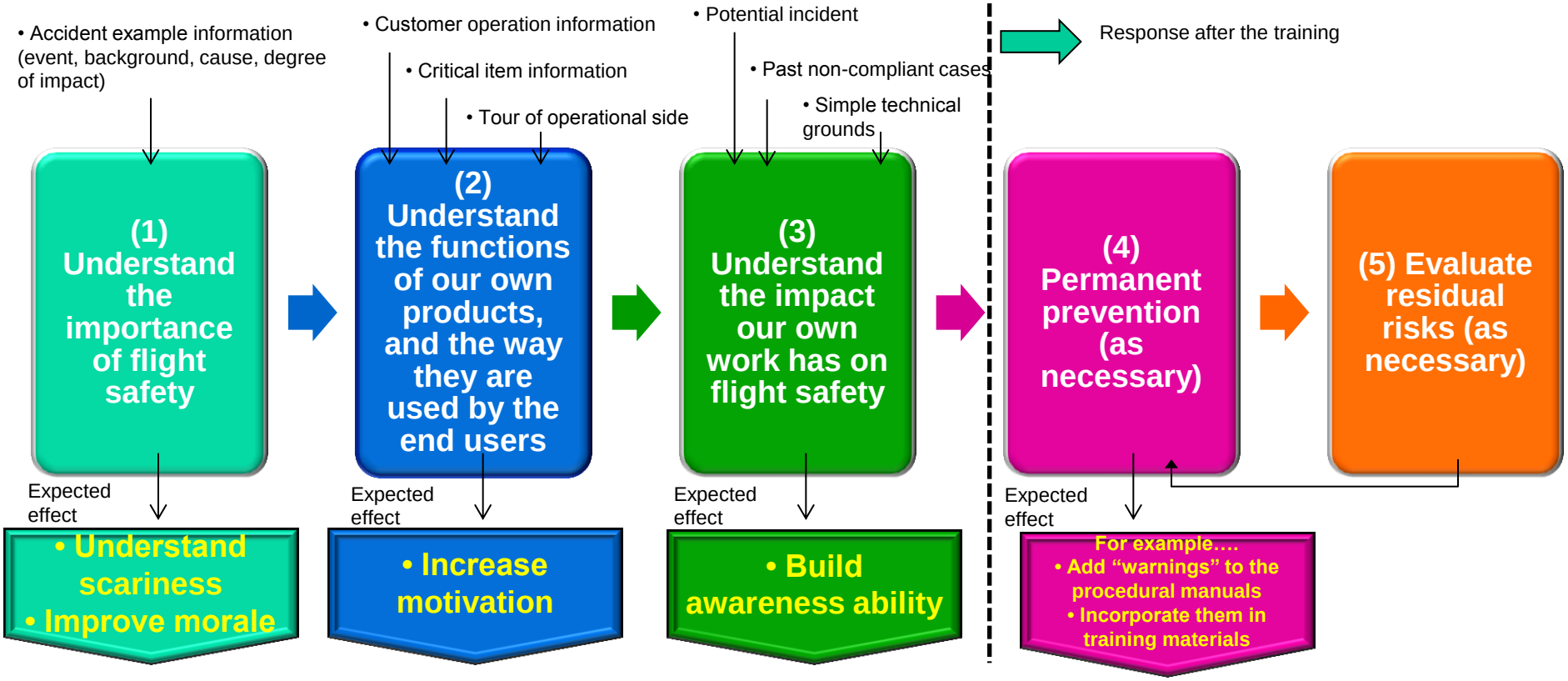
4.3 Training content

4.3.1 The flow and content of the training

It is preferable to implement training related to "flight safety" in accordance with the following flow. *)



*) It is acceptable to implement these steps separately but it is necessary to implement them repeatedly and regularly.

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4.3.1 The flow and content of the training

(1) Understand the importance of flight safety

- Understand that deliberate corner-cutting, violations, near miss in our own work lead to major accidents -

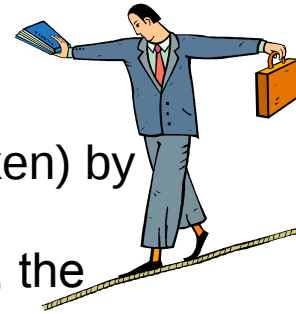
■ **It is desirable to include the following in the information that is necessary for the training**

(i) Present examples of accidents

(ii) Explanations of the background and causes

Against what background and due to what action that was taken (or not taken) by what person did the incident or accident occur?

(iii) The resultant effects — on the crew/passengers, their families, society, the company



■ **What if the victim was you or your family? Get the employee to think from the 2.5 person perspective.**

■ **Videos, books, movies, theater plays, etc. of the aircraft accident are also effective**

■ **Raise morale and quality awareness by understanding the scariness of the fact that deliberate corner-cutting, violations, and near miss can lead to a serious accident and prevent these behaviors by ourselves.**

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4.3.1 The flow and content of the training

(2) Understand the functions of our own products, and the way they are used by the end users

■ **It is desirable to include the following in the information that is necessary for the training**

(i) Operational information of end users and customers

(ii) Critical item information

■ **Tours, etc. of the customers and end users are also effective**

■ **The information of the customers and end users can be obtained from the following and other sources**

(i) Contract documents

(ii) The training by the ordering party

(iii) Appropriate handling by the ordering party with respect to the demands from the supplying party

■ **Normally the customers (the ordering party) have the responsibility of transmitting these types of information, but it is also important for the people receiving the orders to have the attitude of obtaining the information and getting their suppliers to understand it.**

■ **The employees can gain a strong sense of the aircraft body composition which cannot be understood from individual parts, etc., which leads to improved motivation.**

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4.3.1 The flow and content of the training

(3) Understand the impact that our own work has on flight safety

— Understand how the output of our own work is involved with flight safety —

■ It is desirable to include the following in the information that is necessary for the training

(i) Potential incident in the related industries

(ii) Past potential incident of alarm and non-compliant cases that occurred inside the organization

(iii) Explain the grounds for the technical requirements using simple words, diagrams, and videos

Why the narrow tolerance of precision bore holes is necessary, what would happen if the heat treatment condition of the material changed, the scariness of improper material, stress concentration with respect to damage, fastening with incorrect torque/contact pressure, preventing loosening, the direction in which bolts are inserted, film thickness requirements, etc.

■ Anticipate (identify) the risks that could have an impact on flight safety, and aim to improve awareness ability

■ It is important for each and every individual to participate in thinking as a group about the risks, rather than only relying on unilateral presentations from superiors and the bureau of training, etc.

■ For the anticipation of risks use of techniques such as “Failure Mode and Effects Analysis" (FMEA)/"Risk Map" (R-Map), etc. is effective

4. Flight safety training

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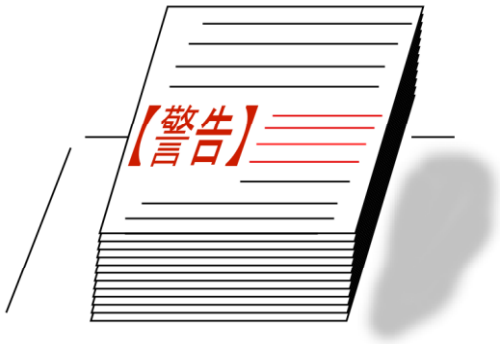
4.3.1 The flow and content of the training

(4) Permanent prevention

— Transmit to the following successor in charge, etc., and visualize —

■ Examples of permanent prevention

- Add "[Warnings]", etc. to operating procedure, work book etc.
- Add to training materials as “things which must not be done", etc.



(5) Evaluate residual risks (as necessary)

■ **Conduct evaluations of the residual risks after implementation of the measures and as necessary permanent prevention again**

4. Flight safety training

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4.3.2 Training Method

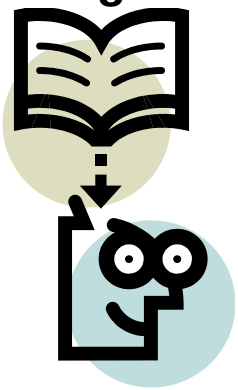
(1) Instructors

■ **Select personnel who are appropriate as person who understand flight safety and can evaluate the effectiveness of the implemented training.**

(2) Training material

■ **It is necessary to use the following tools, etc. to implement the training repeatedly and regularly.**

• Classroom training (OFF-JT), e-learning, posting of teaching materials on LAN, provision of training within some meeting formats (tool box meeting is also possible) and in OJT



(3) Effectiveness evaluations

■ **It is necessary to not only provide the training but also evaluate the level of understanding of the students and provide the training again when needed.**

• Evaluation tools: tests, oral questions by the instructors, questionnaires, ordinary behavior, etc.

4. Flight safety training

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4.3.3 Utilization of examples

Utilize the following examples, the cited documents/related web sites in Chapter 6, etc. to provide training materials suited to the business format and needs of the organization.

(i) Understand the importance (scariness) of flight safety

- Emergency landing - British Airways Flight #5390 (Section 5.1)
- China Airlines Flight 120 fire (Section 5.2)
- Japan Self-Defence Forces jet crash into a riverbed (Section 5.3)

(ii) Understand the impact that our own work has on flight safety

- Handling of ultra-high tensile strength steel leading to damage of parts (Section 5.4)

-- Discussion based on F-111 crash caused by damage to the aircraft's wings --

- Engine stoppage during a flight caused by material defect (Section 5.5)

5. Example

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5.1 Emergency landing - British Airways Flight 5390

[1] Accident Summary

■During the stable ascending at the altitude of 17,300 ft. Flight No.5390 for Spain from Birmingham airport on June 1990 with 87 passengers including the crew, the windscreen of the commander's side blew off with a sudden blast .

■The commander was sucked out from his head with his upper part of the body ejected through the opening, and with his knees caught on the control lever.
His body was bent over the outer ceiling panel of the cockpit under the air flow of 630 km/h at -17° C. His face was banged repeatedly on the window frame to shed blood from his nose and the side of his face.

Checking broken window after landing

■The cabin crew held and secured the commander's body at once when coming in here by chance. While fighting in a cold and fatigue, the commander was pulled back inside with help of the other crew.

■Fortunately, the copilot was secured with the seat belt. He was controlling the craft desperately and made an emergency landing 18 minute after.

■This accident had got away with a mere injury to the commander and some crews, but it was only one step away from a catastrophe (for example, if two pilots should have been ejected from the cockpit…).

[2] Root Cause（1）

■The cockpit's windscreen was replaced 27 hours ago for the flight. Non-engineering required bolts (incorrect diameter) were installed.

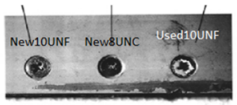
	Part No	Shank Length (inch)	Diameter (inch)	Thread Size
Specified Parts per Maintenance Manual	A211-8D	0.8	0.1865-0.1895	10UNF(Fine Thread)
Actual installed part for the Craft	A211-8C	0.8	0.1605-0.1639	8UNC(Coarse Thread)

■During selection of bolts (90ea) to install the windscreen, the night shift maintenance manager had selected them via his experience with visual check between the original bolts before replacement and the ones stored at the shop. He did not confirm the maintenance manual (The removed bolts had no engraved P/N).

[3] Lessons Learned

■Why an error was made by the maintenance manager for the night shift:

(1) Judged just by visual oversight without confirming the procedure or the manual.
(2) Did not listen to the store manager who told him that the bolts of A211-8D should be applied.
(3) If the bolt with the wrong diameter of the hole was used, its flat head sunk and the countersink became exposed. He did not feel strange even after installation check.



4)Another windscreen was replaced with the bolt of A211-8D during his next night shift. The manager did not feel strange this time in using the different ones for the last night shift..

Even a small doing of "snap judgment" and "distraction" will directly impact on flight safety to endanger lives of people. Keep in mind that their lives are in your hand and ensure to work by following the procedure firmly.

[4] Other Circumstances

■Incorrectly installed A211-8C (8UNC) was 0.026 inch (about 0.7mm) smaller in diameter, but it was applicable to 10UNF nut due to different screw type. (However, the torque was 1/2 to 1/10 of the correct one):

■In this company's system, the judgment(selection) of night shift maintenance manager would not be determined by the third party.

■The procedure specified that the structural elements of which damage directly impact on Flight Safety shall be designated as the critical items and duplicate inspection shall be implemented. However, the subject item was not designated as the "critical item".

■When the windscreen is fastened from outside, the fastened section is loaded heavier than fastened from inside. This is incorrect design for aircrafts.

■Note that the bolts installed 4 years ago were also the wrong items with the shorter shank length of 2.5mm(A211-7D). The aircraft was owned by a different owner. Therefore, replacement details are unclear.

Reference:"Report of the Air Accidents Investigation Branch"(AAIB)
http://www.aaib.gov.uk/cms_resources.cfm?file=/1-1992%20G-BJRT[2].pdf
http://www.aaib.gov.uk/cms_resources.cfm?file=/1-1992%20G-BJRT%20Append.pdf

5. Example

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5.2 China Airlines Flight 120 fire

[Accident]

■The flight landed in Naha airport of Okinawa, Japan from Taipei and fired on leaked fuel from the second engine immediately upon completion of taxi to the apron. The fire spread on the flowing oil on the ground and extended to the first engine downwind to blast the craft.

■The fire was extinguished one hour after but the craft was a complete loss.

■All the passengers evacuated outside of the craft safely. But the last two crew members were remained. One of them was the Commander, who tried to evacuate from the left window of the cockpit under the strong fire flame extending over the right window, shrunk and fell onto the ground by the blast shock. Fortunately, the cockpit was exempted from the direct blast shock and the copilot jumped down immediately after the blast.

■If the passengers evacuated too late (or if the fire too quickly spread), this would have ended up a catastrophe.
The 3 newspaper scripts and 1 illustration of the fire

[Root Cause]

During maintenance, the washer was forgotten to be installed on the moving section of Slat track of the right main wing one month before the accident.

↓

■Falling apart of the Down stop assembly from the moving section of the right main wing with no washer installed.

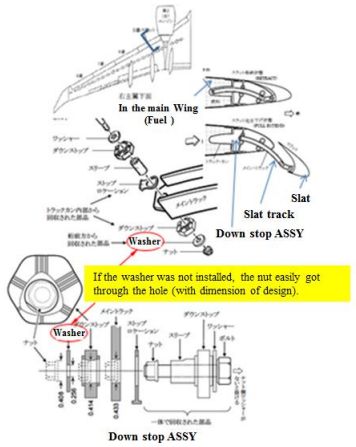
↓

■By moving the slat, the bolt of the assembly stuck to open the fuel tank.

↓

■The leaked fuel oil was fired by intense heat of the engine.

The bolt was installed in a narrow area, which induced maintenance error easily.



[Lessons Leaned]

Even a small parts (a washer) will endanger the lives of people if you forgot to install it.
Some people on board may be you or your love ones.
It is the mission to ensure to implement the established rules for us engaging in assembling aircrafts. That is professional.

[Other backgrounds]

■The design was not correct to stop the fall of the Down stop assembly when the washer was not installed.

■The work instructions such as the service bulletin did not draw enough attention to the disadvantageous section to work for installation.
There was no report of difficulties to work there from the workers or the inspector to the work instructor.

Reference:
"Report of the Air Accidents"(AA Jul. 2009)
Japan Transport Safety Board
http://www.mlit.go.jp/jtsb/aircraft/rep-acci/AA2009-7-2-B18616.pdf

5. Example

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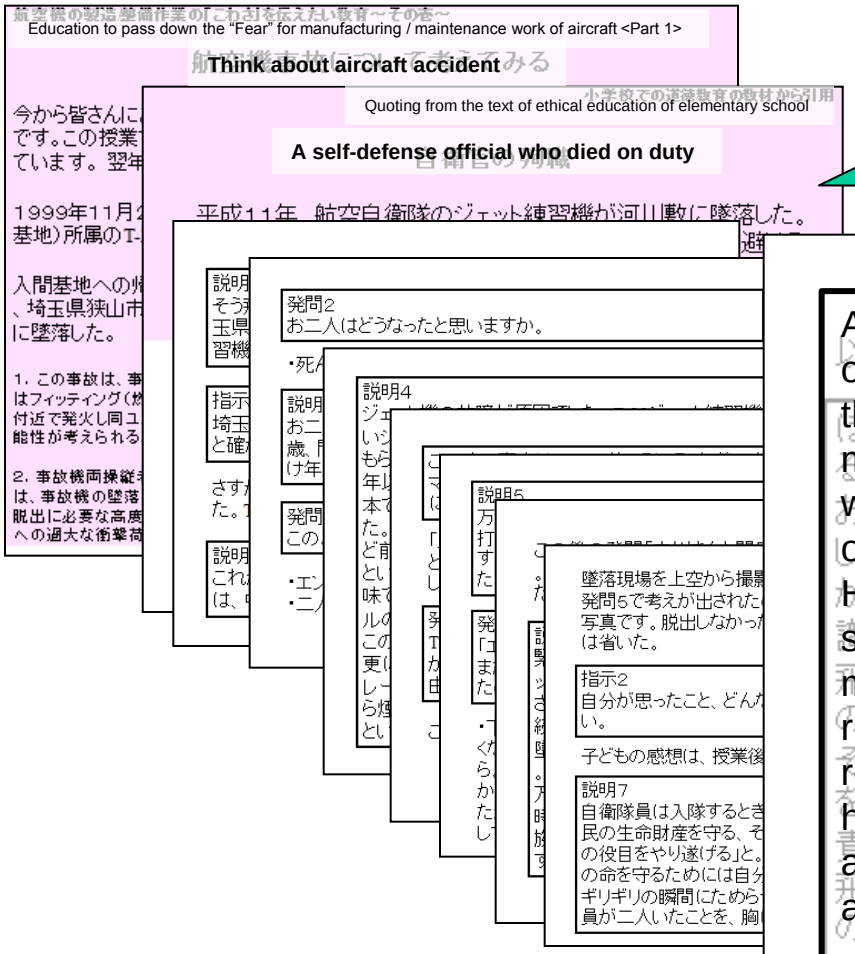
5.3 Japan Self-Defence Forces jet crash into a riverbed



This material quotes the ethical education of elementary school which deals with a subject that the Japan Self-Defense Force jet crashed into river bed but the pilot didn't eject and continued to fly the aircraft to avoid crashing on private houses.

A small mistake might become a threat to the safety of aircraft used over many years. It should be realized that the quality level required by customer is maintained. Moreover we shall realize a mistake which occurs at the rate of the one of thousand, the one of ten thousand may lead to a serious accident. Humankind that invented aircraft and can fly in the sky have learned a lot with numerous casualties by many accidents. The most important thing is follow rules and do our works perfectly. That is our responsibilities and pride. A person who does not have the confidence with this, does not fit for the aircraft manufacturing work. Never forget that there are persons who put their lives in our works.

Reference:
http://www.sanjo.nct9.ne.jp/yocchaki/kigai/junshoku/junshoku.html

5. Example

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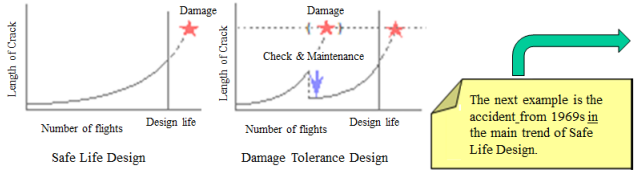
5.4 Handling of ultra-high tensile strength steel leading to damage of parts

[Introduction] Do you know "Safe Life Design"?

Even if a crack occurs and grows by fatigue during flights, it does not damage a structure during the expected number of flights. This is the design concept of Safe life design.
On the other hand, even if a crack occurs and grows possibly to deteriorate within a life cycle, by finding it with the proper regular check and by repairing to recover it, a structure sustains the flaw safely during its service life. Such design concept is called "Damage Tolerant Design".
Safe life design is to design not to damage a structure and is to make it tough and heavy. This design concept had prevailed for the aircrafts until the mid-70s. But increasing demand for fuel efficiency shifted this main trend to the Damage Tolerant Design.
However, up until now, Safe life design is used for the sections unable to inspect and secure redundancy (covering the damaged part by the other part to function) during operation.



[Accident Example] F111 Airplane Crash by the Main Wing Damage

F-111 is the first Variable Geometry wing in the world and was designed to endure 16,000 flights, 4 times more than the expected life. It passed strength test smoothly to be put into mass production.

However, after only107 operations, the bolt at the neck of the main wing became fatigue failure to break off the wing, causing crashes one after another.

The bolt in use was made of the newest steel at that time, ultra-high tensile strength steel (D6-AC). Investigation was carried out to find the reason why the parts passed the fatigue failure test broke.

It was found that there was the initial process flaw on the craft mass-produced to expedite the damage. The flaw was not found in the testing piece.

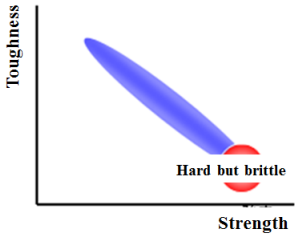
As a matter of fact, the higher the tensile strength is, the more brittle and susceptible to the process flaw.

After this experience in development of aircrafts, safe life designing must take into account the fact that the initial flaw does exist on crafts. However, we are required to follow the rules in handling this steel.

[Summary - what is Ultra-high tensile strength steel?]

■It is used as the material for the aircraft parts.
The heat-treated steel material with increased strength of more than 220 ksi (kilo-force per square inch) (HRC46 (Rockwell hardness scale))

■ The material is characterized by increased strength required for ultra-high tensile strength steel but it is too brittle. It needs appropriate attention in handling and processing.



What kind of attention is needed?

[Specific Attention-Points]

■Attention required for ultra-high tensile strength steel

①Shock resistance
When contacted with other metals, heat is caused locally to change the metallographic structure affecting fatigue limit.

②Level of tooling mark
The tooling mark caused by the process will be the initial cause of fatigue failure depending on its shape and heat treatment outcome will also be affected.

③Flaw or Damage
Protect UHTS steel not to hit or fall to give a flaw when handling.
If such things happened, ensure to report even when a mark is not clearly visible.

(This is not only limited to ultra-high tensile strength steel, but it is fatal for the UHTS steel.)

■Identification of Ultra-high tensile strength steel

For the parts process, the material processed must be identified as the UHTS steel by the documents attached to the item processed.

Reference:
"Changes of design concept of aircraft structures" by Kouichi Hiraoka
Journal of the Japan Society of Aeronautical & Space Sciences: Vol.55, No.63, 2007.1

5. Example

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5. 5 Engine stoppage during a flight caused by material defect

Commercial Airline Accident

Underlying Issue – Material Defect

Problem – Engine gear failure due to raw material contamination

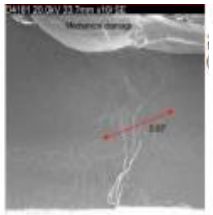
Impact – Engine failure, but because dual engine aircraft no loss of life or injury

Why – Contamination of raw stock not detected before gear manufacturing

Lessons Learned –

- Ensure there is a robust inspection process to eliminate contamination of the raw material.
- The importance of a heightened awareness and oversight of inspection processes required of raw material suppliers.
- It is impossible to find material defects in post-process (e.g. assy. line). Quality assurance of material is important (critical). Therefore, it is mandated to manage supplier quality.
- Ensure that the raw stock supplier understands the importance of their material as it relates to the criticality of the product usage.

Impurity[FOD] in material (0.8mm length)



Causing the engine-shaft fractured during take-off climb.

Pilot stopped one of 2 engines, and landed as emergency landing.

Source: Japanese Ministry of Land, Infrastructure, Transport & Tourism

6. Reference documents /related websites

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- AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT (AI2010-6) <JAPANESE ONLY>
  http://jtsb.mlit.go.jp/jtsb/aircraft/download/pdf/AI10-6-1-JA847C.pdf

- Air Accident Information (Ministry of Land, Infrastructure, Transport and Tourism: Japan Transport Safety Board)
  http://www.mlit.go.jp/jtsb/english.html

- Safety Management Manual (SMM) Doc 9859 International Civil Aviation Organization (ICAO)
  The concept of Safety (Section 2.1)
  Safety Culture (Section 2.6)
  http://www.icao.int/SAM/Documents/RST-SMSSSP-13/SMM_3rd_Ed_Advance.pdf

- The Human Contribution – Unsafe Acts, Accidents, and Heroic Recoveries - James Reason (Author)

6. Reference documents /related web sites(continued)

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- Implementation of the Construction of a Safety Culture in the JAL Group and Future Issues <JAPANESE ONLY>
  http://www.atec.or.jp/Forum__09__PNL_JAL.pdf
- Yotaro Hatamura: Failure Knowledge Database
  http://www.sozogaku.com/fkd/en/index.html
- NTSB AVIATION ACCIDENT DATABASE
  http://www.ntsb.gov/aviationquery/index.aspx
- National Diet Library AIRCRAFT ACCIDENTS IN JAPAN <JAPANESE ONLY>
  http://www.eonet.ne.jp/~accident/
- Wikipedia: Aviation accidents and incidents by subcategory
  http://en.wikipedia.org/wiki/Aviation_accidents_and_incidents
- On-Duty Deaths of Japan Self-Defence Force Officials by Yoshinori Kobayashi <JAPANESE ONLY>
  http://www.sanjo.nct9.ne.jp/yocchaki/kigai/junshoku/junshoku.html
- Play: Charlie Victor Romeo [CVR = Cockpit Voice Recorder].

7. Editor's Note

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We commenced writing this guidance on the instruction of JAQG Strategy WG that keenly realized the necessity of ensuring that the personnel understand the importance of flight safety in order to prevent the recurrence of quality problems that have been occurring in the aviation, space and defence industries in recent years.

At the stage of making a draft form, the issue we directly encountered was people saying that "even if you talk about flight safety, the further upstream you go, to materials manufacturers, etc. the more cases there are where individual workers are not even aware of whether or not the materials are used in aircraft, etc., and they do not really know what you mean when you talk about flight safety training."

Of course the people working in the upstream sectors probably do not think about where the parts they have made themselves are used in aircrafts, what functions the parts have, or what would happen if the parts failed to fulfill their functions, etc.
However, it is a fact that due to parts processing mistakes, etc. human lives are directly threatened, and a significant number of accidents related to flight safety has been occurring.

Near miss and errors in our own work affect the lives of people close to us; moreover once an accident has occurred, it does not only lead to misfortune for those people close to us; but also the company, etc. which caused the accident may have to pay compensation and be held socially responsible, etc. for what happened, and as a result may not be able to continue existing as a company and could be pushed out of business.

We think that there are a variety of ways of investing the time and effort and emphasizing points in each process, but in any case, it is necessary at the least to ensure that workers understand that "manufacturing of aircraft is directly connected to the safety of human lives", so we included as much of the content necessary for awareness of flight safety to penetrate in upstream sectors in this text as possible. We hope that these materials will be used effectively for that purpose.

Furthermore, regarding the maintenance sector and assembly sector, we think there are probably already many cases of flight safety training being implemented, but as the technologies come to mature awareness of doing "work that involves being responsible for lives" tends to weaken because even when there are potential incidents or small instances of non-compliance, there is no experience of serious accidents in which people die. For that reason, these materials can also be utilized in training aimed at continuing to reaffirm the importance of flight safety.

Finally, we would like to emphasize that in order to provide flight safety training effectively, not only the supplier who provides the training but also the people who orders the contracts have an important role. For example, the contractee should explain how the products are used, what is important, etc.