Aviation Occurrence Report

ASC-AOR-09-09-001, Publication Date: Sep, 2009

A 30 in (77 cm) cracked through fuselage skin was found during transit check

CHINA AIRLINES FLIGHT CI7552

BOEING 737-800

SAGA AIRPORT, JAPAN

SEPTEMBER 20, 2007

Aviation Safety Council

Taiwan, THE REPUBLIC OF CHINA

According to Article 5 of the Aviation Occurrence Investigation Act of The Republic of China:

The objective of the ASC ‘s investigation of aviation occurrence is to prevent recurrence of similar occurrences. It is not the purpose of such investigation to apportion blame or liability.

Further, the Section 3.1, Chapter 3, Annex 13 of International Civil Aviation Organization (ICAO):

The sole purpose of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Thus, based on both the ICAO Annex 13, as well as the Aviation Occurrence Investigation Act of the Republic of China, this aviation occurrence investigation report shall not be used for any other purpose than to improve safety of the aviation community.

The aviation occurence reports were written in both Chinese and English. The Chinese version of the report is official report.

Executive Summary

September 20th, 2007, a Boeing 737-800 aircraft, registration number B-16805, operated by China Airlines, flight number CI7552, from Taoyuan International Airport, Taiwan to Saga Airport, Japan. At Taoyuan Intenational Airport, the copilot and mechanic performed a 360 degree preflight check, found aircraft condition normal. The aircraft's take off, climb, cruise, descent and landing were all normal. There was no experience of inflight turbulence.

At 1326 Japan local time, the aircraft landed in Saga. During transit check, a 30 in (77 cm) through crack located at lower belly below the after cargo door of fuselage skin was found by a mechanic. The aircraft ceased the return flight after communicated with Taipei maintenance base.

Since the state of occurrence was Japan, the investigative authority was under Japan's jurisdiction. After Aviation Safety Council (ASC), Taiwan negotiated with ARAIC, Japan, in accordance with ICAO annex 13, the investigative authority was delegated to ASC, Taiwan.

It took 8 monthes to collect the factual data information. A factual data confirmation meeting was called on June 19, 2008 and the analysis task was proceeded. A technical review meeting was called on October 03, 2008. The comments from investigation parties were collected and reviewed. After the adoption of reply comments from CAA, CAL and NTSB, a final draft report was finished. The draft report was approved on August, 25, 2009 by the Board meeting and published on September 25, 2009.

This final report follows the format of ICAO Annex 13 with a few minor modifications. Firstly, in Chapter 3, Conclusions, the Safety Council decided in their 74th Board meeting that to further emphasize the importance that the purpose of the investigation report is to enhance aviation safety, and not to apportion blame and responsibility, the final report does not directly state the "Probable Causes and Contributing Factors", rather, it will present the findings in three categories: findings related to the probable causes of the occurrence, findings related to risks, and other findings. Secondly, in Chapter 4, in addition to the safety recommendations, the Safety Council also includes the safety actions already taken or in progress by the stakeholders. This modification follows the practices by both the Australian Transport Safety Bureau (ATSB) and Transportation Safety Board (TSB) Canada, as well as follows the guidelines of ICAO Annex 13. The Safety Council decided that this modification would better serve its purpose for the improvement of aviation safety.

Therefore, based upon the analysis by ASC, the followings are the key findings of the CI7552 occurrence investigation.

The findings related to the probable causes identify elements that have been shown to have operated in the occurrence, or almost certainly operated in the occurrence.

These findings are associated with unsafe acts, unsafe conditions, or safety deficiencies that are associated with safety significant events that played a major role in the circumstances leading to the occurrence.

1. The plastic waste tank outlet flanges could not resist complex stresses resulting from the installation of coupling tubes of waste water system. (2.3.2)

2. The consistence leakage of waste tank fluid was trapped in the lower level of affected area, and the concentration of Chlorine was increased by evaporating of water. It induced corrosion to the detriment of the fuselage skin. The residual strength of the skin was not of sufficient to endure the hoop-wise stress resulted from flight operation. Finally the fuselage skin fractured to a 30 in (77 cm) crack due to the overstress. (2.1) (2.2)

The findings related to risk identify elements of risk that have the potential to degrade aviation safety. Some of the findings in this category identify unsafe acts, unsafe conditions, and safety deficiencies that made this occurrence more likely; however, they can not be clearly shown to have operated in the occurrence. They also identify risks that increase the possibility of property damage and personnel injury and death. Further, some of the findings in this category identify risks that are unrelated to the occurrence, but nonetheless were safety deficiencies that may warrant future safety actions.

1. In accordance with the current FAA MRBR and Boeing MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether the damage on structure was existed or not is unknown. Therefore, either structural inspection program or zonal inspection program can not detect and make prevention of similar structural corrosion. (2.4.3)

2. CAL developed its AMP completely referring to FAA MRBR and Boeing MPD together with FAA issued MRBR and ADs to form a fully workable Aircraft Maintenance Program. However, CAL did not have any similar experience before the occurrence. As a result, CAL's AMP could not detect and prevent similar failure from happening.

3. The AMP number of the inspection of waste tank compartment is AMP 53-838-00. This task is performed in zone number 141. The AMP number of the inspection of area below aft cargo compartment is AMP 53-840-00. This task is performed in zone number 143. These two works are performed neither at the same zone nor at the same time. Unusual situations occurred

due to leveling difference and curved structure surface when these two tasks were performed. The structure at higher place (zone 141) where waste water leakage occurred was not corroded. Corrosion came into existence due to the leaked waste water accumulated at lower place (zone 143) which located at right and front side to the adjacent compartment. Since the insulation blankets needed not to be removed during general zonal visual inspection, structural abnormality could not be detected either. (2.4.1.2)

Other findings identify elements that have the potential to enhance aviation safety, resolve an issue of controversy, or clarify an issue of unresolved ambiguity. Some of these findings are of general interest and are not necessarily analytical, but they are often included in ICAO format occurrence reports for informational, and safety awareness, education, and improvement purposes.

1. An installation quality check of 737-800 fleet on the coupling showed that there were unmatched centerlines, skewed centerlines between waste tank outlet and its adjacent short tube. (2.3.1)

2. There were no definite modes or relations between the damaged locations and conditions on the flanges of three damaged waste tanks. This indicates the failures of waste tank outlet flanges were affected by the combination of multiple stresses. (2.3.1.3)

3. On site measurement revealed that some of the gap dimensions between the waste tank outlet and the connecting tube satisfied the specification: “as long as the clamp can be installed in fixed position,” but not satisfy Boeing’s document. There are no evidences that the crack on the flanges were resulted from the contradiction. (2.3.1.4)

4. The Ion Chromatography test results show that the leaked fluid from waste water tank is the main effective factor that induced corrosion fracture to the detriment of the fuselage skin. (2.4.4)

5. The compromised belly skin panel was chemically milled by the manufacturer, which resulted in the removal of the pure Aluminum cladding and inherent deficiency of corrosion resistance. Though corrosion protection coating and anti-corrosion treatment were applied, these countermeasures to corrosion did not eliminate the effect of long time soaking of leaked waste tank fluid at the lower portion of the aft cargo compartment structure, in addition, the concentration of the waste tank fluid was further increased as water vaporized over time, resulted in the high concentration of Chlorine Ion penetrating all the corrosion protection measurements and heavy corrosion of the base material thereafter. (2.4.4)

6. ASC could not measure the amount and the consistency of the leaked fluid from waste tank, and the information for the amount of vaporization of

leaked fluid and the variation of Chlorine Ionic during the period of leakage of waste tank are not achieved. As a result, it is difficult to estimate the corrosion rate of the skin, and determine the possible timeline while the waste tank leaked. (2.4.4)

7. There were no abnormal maintenance records. Scheduled zonal inspections were all finished within intervals. (1.6.3)(1.6.3.3)

8. After the flight occurrence happened, CAL didn't comply with the regulation to ensure the CVR power off procedure performed to preserve the integrity of the CVR data. (2.5)

9. The flight crew were properly certificated and qualified in accordance with applicable CAA regulations. (2.6)

10. This occurrence bears no relationship with flight operations and weather. (2.7)

11. There was no evidence from ground video recording to prove that the aircraft's crack was caused by the ramp operation of the Taoyuan international airport. (1.10.1)

Recommendations

Interim Flight Safety Bulletin

Reference No.：ASC-IFSB-07-12-002

Date : December 26, 2007

1. Make sure that leakage of the waste water system is properly controlled, and aircraft structural integrity is well maintained at locations where the possible leakage fluid from waste-tank system flows over and/or accumulates.

2. Review and draw up a policy in order to prevent the same type of event from recurring.

Safety Recommendations

To China Airlines

1. When performing AMP 53-838-00, general visual inspection of waste tank compartment at zone 141, once dirty stains were found on the insulation

blanket right below waste tank outlet, the structural inspection of the area below aft cargo compartment at zone 143 should be performed immediately. To perform AMP 53-840-00, general visual inspection of area below aft cargo compartment at zone 143, a direct visual inspection of the skin structure located on the lower surface should be applied. (ASC-ASR-09-09-001)

2. In accordance with FAA MRBR and Boeing MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. CAL developed its AMP completely referring to FAA MRBR and Boeing MPD to form a fully workable Aircraft Maintenance Program. As a result, CAL's AMP could not detect and prevent similar failure from happening. Based on the experience of the occurrence, CAL should initiate a strategy to make up the deficiency of current AMP. (ASC-ASR-09-09-002)

   The operator responded to this Recommendation by stating:

   'Perform leakage test for 737-800 waste tank at every RE (500 Flight Hours) check. (refer to Appendix 10); Revise the interval of 737-800 AMP 53-838-00 from 24 months to 12 months and require the removal of insulation blankets to gain the access to the structure. (refer to Appendix 11); Revise the interval of 737-800 AMP 53-840-00 from 60 months to 24 months and require the removal of insulation blankets to gain the access to the structure. (refer to Appendix 11)'(translated text)

3. Amend the Article 12 of Aviation Occurrence Investigation Act and the Article 111 of Aircraft Flight Operation Regulation to ensure the CVR power off procedure performed when flight occurrence happened. (ASC-ASR-09-09-003)

To Taiwan Civil Aeronautics Administration

1. In accordance with FAA MRBR and Boeing MPD, structure inspection requires the removal of the insulation blankets and maintenance personnel can detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal

inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. CAL developed its AMP completely referring to FAA MRBR and Boeing MPD to form a fully workable Aircraft Maintenance Program. As a result, CAL's AMP could not detect and prevent similar failure from happening. Based on the experience of the occurrence, CAA should supervise CAL to initiate a strategy to make up the deficiency of current AMP. (ASC-ASR-09-09-004)

Taiwan Civil Aeronautics Administration responded to this Recommendation by stating:

'CAA approved the modifications of CAL's Aircraft Maintenance Program on February 12, 2008. Time interval of AMP 53-838-00 has changed from 24 months to 12 months, and insulation blankets need to be removed for inspection. Time interval of AMP 53-840-00 has changed from 60 months to 24 months, and insulation blankets need to be removed for inspection. CAL has executed the revised inspections since then.'(translated text)

2. Supervise CAL to ensure the CVR power off procedure performed when flight occurrence happened. (ASC-ASR-09-09-005)

Taiwan Civil Aeronautics Administration responded to this Recommendation by stating:

'CAA requested the operation of Flight Data Recorder by following the standards specified in Regulation 111-2 of Aircraft Flight Operational Rule. Flight Data Recorder needs to be turned on before flight and can not be turned off during flight. After aircraft accident, serious incident or incident, Flight Data Recorder needs to be turned off after the termination of flight operation. Flight Data Recorder can not be turned on again before it is removed from aircraft. CAL also asked his flight crews to comply with the rules specified on the Enterprise Safety Manual 8.2.2 and Flight Operation Manual Chapter 10.2.'(translated text)

To The Boeing Company

1. Require to improve the material of waste tank outlet flanges to sustain pre-stress resulting from the installation of coupling tubes. Before final fix the material, require to make sure to correct the unmatched and skewed centerlines problem during the installation of the waste tank outlet and the short tube to reduce pre-stress and to avoid the resultant damage to the waste tank outlet flanges. The AMM should use a practical instruction and specific tolerance to install the flanges of waste tank outlets instead of using the theoretical 0.1500 in gap dimension between the flanges of waste tank outlet and the short tub. (ASC-ASR-09-09-006)

2. In accordance with the current MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. Based on the experience of the occurrence, Boeing company should initiate a strategy to make up the deficiency of current MPD. (ASC-ASR-09-09-007)

   Prior to this recommendation, the aircraft manufacturer released a Multi Operator Message, MOM no. 1-725906264-1, on January 03, 2008, with subject: Vacuum Waste Tank Drain Fitting Inspection. This message provided a timely advisory all 737 -600/700/800/900 operators for one time inspection and recommended temporary action. Detailed contents referred to Appendix 12.

To United States Federal Aviation Administration

1. Require the MRB to review the B737 series aircrafts MRBR and modify as necessary to ensure that leaks from the waste water system are detected before similar structural corrosion can occur. The review should include an analysis of the inspection intervals, the need for changes to inspection procedures (i.e. removal of insulation blankets), and the need for more detailed description of inspection criteria (i.e. task cards). (ASC-ASR-09-09-008)

Contents

Tables

Figures

Abbreviations

AD	Airworthiness Directives
AMP	Aircraft Maintenance Program
ARAIC	Aircraft and Railway Accidents Investigation Commission
ASC	Aviation Safety Council
ATSB	Australia Transportation Safety Board
BS	Body Station
EDS	Energy Dispersive System
EO	Engineering Order
FAA	US Federal Aviation Administration
JCAB	Japan Civil Aviation Bureau
MPD	Maintenance Planning Document
MRBR	Maintenance Review Board Report
MRB	Maintenance Review Board
NTSB	US National Transportation Safety Board
SEM	Scanning Electron Microscope
SSCVR	Solid-State Cockpit Voice Recorder
SSFDR	Solid-State Flight Data Recorder
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time

1. Factual Infromation

1.1 History of Flight

September 20th, 2007, a Boeing 737-800 aircraft, registration number B-16805, operated by China Airlines, flight number CI7552, from Taoyuan International Airport, Taiwan to Saga Airport, Japan. At Taoyuan Intenational Airport, the copilot and mechanic performed a 360 degree preflight check, found aircraft condition normal. The aircraft's take off, climb, cruise, descent and landing were all normal. There was no experience of inflight turbulence.

At 1326 Japan local time, the aircraft landed in Saga. During transit check, a 30 in (77 cm) through crack located at lower belly below the after cargo door of fuselage skin was found by a mechanic. The aircraft ceased the return flight after communicated with Taipei maintenance base.

1.2 Injuries to Persons

None

1.3 Damage to The Airplane

A substantial damage of a through crack of 77 centemeters long was found on the belly skin of the airplane.

1.4 Other Damage

None

1.5 Personnel Information

1.5.1 Pilot's Basic Information

Basic information of the pilots is shown in Table 1.5-1.

Table 1.5-1Basic Information of The Pilots

ITEM	CM-1	CM-2
Gender	Male	Male
Age	44	34
Date Joined CAL	May-21-1993	Feb-10-2005
License Type and Number	ATPL 102078	CPL 302239

Type Rating Expire date	B737-800 CAPT Sep-28-2010	B737-800 F/O Aug-20-2010
Medical Class Expire date	Class 1 Oct-31-2007	Class I Aug-31-2008
Total Flight Time (H:M)	8,486:06	1,733:39
Flight Time (H:M) in Last 12 Months	789:29	690:44
Flight Time (H:M) in Last 90 Days	191:11	148:12
Flight Time (H:M) in Last 30 Days	61:11	39:13
Flight Time (H:M) in Last 7 Days	13:58	7:18
Flight Time (H:M) on B737-800	4,706:55	1,456:20
Flight Time on the Day of Occurrence	2:14	2:14

1.5.2 Pilot's Health Conditions

1.5.2.1 CM-1

The medical certificate issued by the Aviation Medical Center reveals that CM-1 may perform flight with status post "Medical waiver for heart disease".

1.5.2.2 CM-2

The medical certificate issued by the Aviation Medical Center reveals that CM-2 may perform flight with status post "Refractive surgery for eye".

1.6 Airplane Information

1.6.1 Airplane Basic Information

The airplane basic information is shown in Table 1.6-1.

Table 1.6-1Airplane Basic Information

Airplane Basic Information (Data Accumulated up to Sep. 20, 2007)	
Nationality	Republic of China
Airplane Registration Number	B-16805

Airplane Type	737-809
Manufacturer	Boeing Company, USA
Serial Number	30636
Manufacturing Date	Feb. 23, 2001
Delivering Date	Feb. 23, 2001
Owner	International Lease Finance Corporation
Operator	Mandarin Airlines Ltd.
Registration Number	90-807
Airworthiness Certificate Number	96-02-025
Effective Date of Airworthiness Certificate	Feb. 16, 2007
Airworthy until	Feb. 15, 2008
Total Flight Hours	15,890 : 36
Total Landing Cycles	6385
Type and Date of Latest Periodic Inspection	RE10 Check Aug. 29, 2007
Accumulated Flight Hours After Latest Periodic Inspection	125 : 05
Landing Cycles After Latest Periodic Inspection	62
Maximum Takeoff Weight	172,500 Pounds

The airplane installed two engines which were manufactured by the GE Company. The related basic information of the engines is shown in Table 1.6-2.

Table 1.6-2Engine Basic Information

Engine Basic Information (Data Accumulated up to Sep. 20, 2007)		
Manufacturer	GE Company, USA	
Number/Location	No. 1/Left	No. 2/Right
Type	CFM 56-7B26	CFM 56-7B26
Serial Number	889190	888203
Total Accumulating Hours	15,890 : 36	15,890 : 36

1.6.2 Weight and Balance

The aircraft's maximum takeoff weight is 172,497 pounds, maximum landing weight is 143,998 pounds, and zero fuel weight is 135,997 pounds. Takeoff and landing C.G. were both within the allowable range. Weight and balance data is shown in Table 1.6-3.

Table 1.6-3Weight and Balance Data

Zero Fuel Weight	111,006 lbs.
Takeoff Fuel	18,600 lbs.
Takeoff Weight	129,606 lbs.
Takeoff C.G.	26.7% M.A.C.
Trip Fuel	10,900 lbs.
Landing Weight	118,706 lbs.
Landing C.G.	12.6% M.A.C.

1.6.3 Maintenance Information

ASC investigators check the maintenance records which include AV Check, Ground Log Book, Technical Log Book and Cabin Log Book covering from the last time zonal inspection(AV6 check, Nov. 24, 2006) on the waste tank compartment to the date of occurrence, no abnormal was found. There were no replacement of insulation blanket during that period. The check of waste tank compartment on Nov. 24, 2006 was the only inspection that the region was accessed and checked.

1.6.3.1 Airplane Maintenance Programs

According to FAA Maintenance Review Board Report(MRBR) on Boeing's 737 series aircrafts, Boeing 737 series MAINTENANCE PLANNING DOCUMENT (MPD) and China Airlines 737-800 type AIRCRAFT MAINTENANCE PROGRAM (AMP), a STRUCTURE INSPECTION PROGRAM and a ZONAL INSPECTION PROGRAM, need to be carried out on the aft cargo compartment area which contains the failed structure.

1.6.3.2 Structure Inspection Programs and Execution

The structure inspection program contains one job card to inspect the failed structure stated as follows.

According to FAA MRBR 53-250-00, Boeing MPD 53-250-00 and CAL AMP 53-250-00, a general visual inspection of skins, frames, stringers and splices needs to be carried out on the aft bilge. The threshold of the inspection is 8 years, and the repeated interval after the threshold is 6 years. Detail working periods and contents refer to Appendix 1, 1-1, 1-2 and 1-3. The item number and its contents of China Airlines' AMP are identical to those of Boeing' s and

FAA' s documents. The total time from the date of delivery of the airplane, Feb. 23, 2001, to the date of occurrence, Sep. 20, 2007, is about 6 years and 7 months (79 months). Therefore, the threshold to perform the first inspection had not yet reached, and the task was not yet carried out by China Airlines.

In FAA MRBR 53-250-00, Boeing MPD 53-250-00 and CAL AMP 53-250-00, the access notes stated:

Remove cargo floor panels and scuff plates, Remove/Displace insulation blankets as required.

To perform the task, CAL removes the insulation blankets to carry out a visual inspection.

1.6.3.3 Zonal Inspection Programs and Execution

The zonal inspection program contains two job cards to inspect the structural failure region stated as follows.

According to FAA MRBR 53-838-00, Boeing MPD 53-838-00 and CAL AMP 53-838-00 (Job Card P-1410-30-11, issued date Feb. 10, 2006), the content of this job card is to carry out general visual inspection of waste tank compartment. This job needs to be carried out every 5500 flight cycles or 24 months whichever come first. Detail working periods and contents refer to Appendix 1, 2-1, 2-2 and 2-3. The item number and its contents of China Airlines' AMP are identical to those of Boeing' s and FAA's documents. The total time from the date of delivery of the airplane, Feb. 23, 2001, to the date of occurrence, Sep. 20, 2007, is about 6 years and 7 months (79 months). In accordance with 24 calendar months' period, CAL finished the inspection 4 times on Jul. 9, 2002, Jan. 5, 2004, Jan. 3, 2005 and Nov. 24, 2006. No abnormality was found. The records of compliance refer to Appendix 1, 2-4.

According to FAA MRBR 53-840-00, Boeing MPD 53-840-00 and CAL AMP 53-840-00 (Job Card P-1400-30-06, issued date Jul. 12, 2006), the content of this job card is to carry out general visual inspection of the area below floor of the aft cargo compartment which is located on section 46 and part of section 47, from station 727 to station 947.5. This job needs to be carried out every 13,000 flight cycles or 60 months whichever come first. Detail working periods and contents refer to Appendix 1, 3-1 3-2 and 3-3. The item number and its contents of China Airlines' AMP are identical to those of Boeing's and FAA's documents. The total time from the date of delivery of the airplane, Feb. 23, 2001, to the date of occurrence, Sep. 20, 2007, is about 6 years and 7 months (79 months). In accordance with 60 calendar months' period (5 years), CAL finished the inspection 1 times on Jan. 4, 2005 (47 months after delivery of airplane). No abnormality was found. The record of compliance refers to Appendix 1, 3-4.

On Oct. 3, 2008, CAL submitted a mail to ASC during technical review of the draft investigation report. In the mail, CAL service request ID 1-631858151 dated Sep. 26, 2007, queried about 737-800 MPD. CAL would like to know if it is necessary to remove the insulation blankets when performing tasks MPD 53-838-00, MPD 53-840-00 and etc. On Sep. 27, 2007, Boeing replied with service request ID number 1-631858151-3 as follows.

> *For the Reference /A/ thru /D/ tasks, it is not required to remove the insulation Blankets, unless during CHI examination they find degradation of an items against a specific standard, detect irregularities or discrepancies such as wear, deterioration, damage, corrosion, cracking, etc.*

Boeing's response stated that it is not required to remove the insulation blankets when performing the listed MPDs, unless quality degradation, irregularities or discrepancies are found. When performing the tasks, CAL did not remove the insulation blankets unless quality degradation, irregularities or discrepancies are found. A visual inspeciton was performed. CAL said that CAL's inspection method is the same as Boeing's recommendation.

1.6.3.4 Waste Drain Operation on Apron

The waste drain operations of China Airlines' 737-800 airplanes on apron are all done by the Taoyuan International Airport Service Company (TIAS). The waste drain operation is carried out by following its standard operational procedures specified in RS-W-01 Section 3-2. According to the contract, all scheduled flights must carry out waste drain operation after landing. Every morning, service operators of the TIAS acquire schedules about landing time and parking gate during dispatching briefing. The TIAS has four service cars in Taoyuan Airport to do waste drain service everyday. A foreman of the TIAS assigns work persons to designated apron on south and north side of Taoyuan airport. The assigned work persons carry out waste drain operations in accordance with their standard operational procedures during the airplane parking on the apron.

Waste water drain out route is shown in Fig. 1.18-1. The sequence of the waste water drain out starts from the waste tank outlet, and then the short tube, ball valve, elbow tube, and then to the TIAS's service car through an adapter on the waste tank service panel.

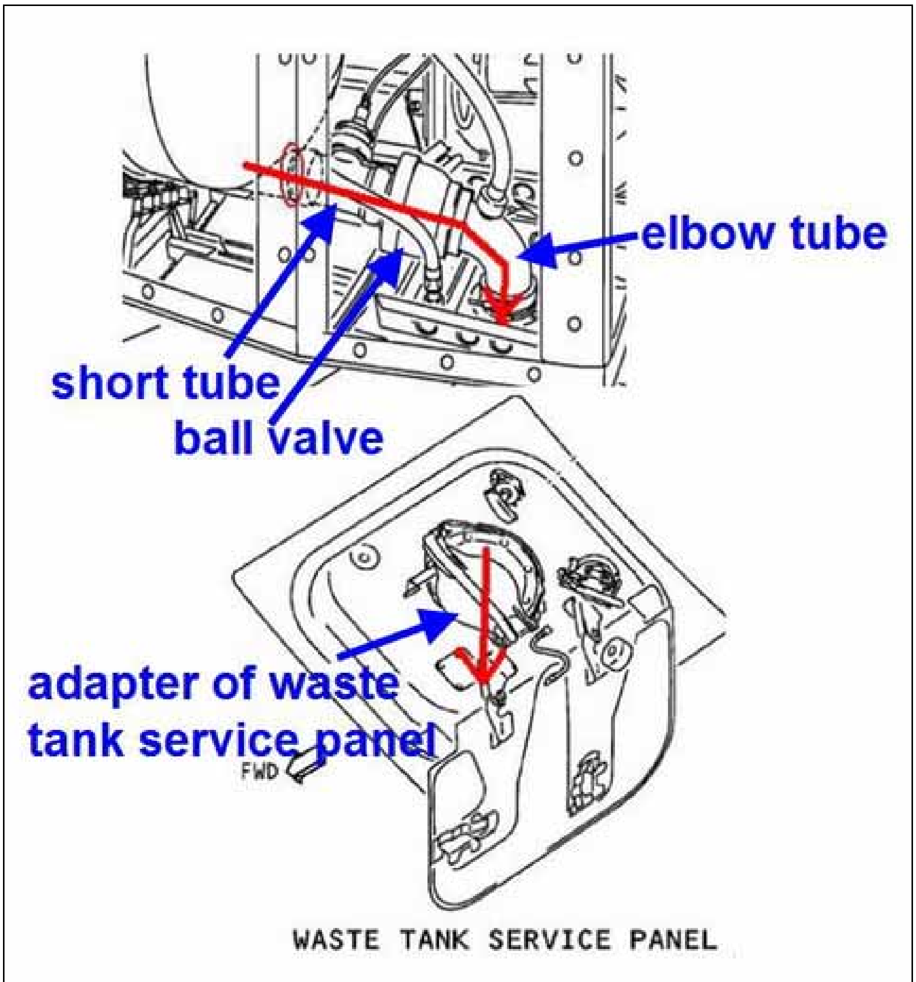


Figure 1.6-1 Waste Water Drain Out Routes

1.6.3.5 Waste Line Cleaning Operation

The cabin cleaning of China Airlines' 737-800 airplanes are all done by the Hwa Hsia Company. According to the contract, the Hwa Hsia Company arranges the work sheets and approved by the China Airlines. The Hwa Hsia Company carried out cabin cleaning by following the work sheets being approved. The time to do airplane cabin cleaning was during over night staying in hanger. All necessary cleaning agents such as detergents and cleaners were all provided by China Airlines. The maintenance and clean of waste line system needed to be carried out at the same time during cabin cleaning operations. There were only working subject, without detail procedures of waste line cleaning on the work sheets.

The operation of waste line cleaning is based on Boeing 737-600/700/800/900 AIRCRAFT MAINTENANCE MANUAL, Periodic Flush – Vacuum Waste System Cleaning (Page 701, Task 38-32-00-100-801, Jun. 10, 2006), step E, partial procedures of waste line cleaning are extracted as follows.

Method I (Crushed Ice and Acid).

Do these steps for each toilet on the airplane, one toilet at a time ∶

(a) …

(b) Add approximately one-half gallon of the Honey Bee 60 cleaner, B00638 (recommended) or 5 to 10% acetic acid, B00636 (optional).

(c) Flush the toilet to put the toilet system cleaner into the waste line.

(d) Flush approximately 1 gal (4 l) of fresh water through the toilet to remove the toilet system cleaner from the toilet.

(e) Let the toilet system cleaner stay in the waste lines as long as practical.

There are four toilets inside 737-800 airplane. All waste water from toilets drain out through waste line system to the waste tank located on tail section of airplane. According to the method of waste line cleaning stated above, the maintenance manual suggested using ice cubes and Honey Bee 60 cleaner to carry out the cleaning task. The Acetic Acid with 5%~10% in concentration is an optional substitute. Each toilet requires 0.5 gallon of cleaner. Two gallons of cleaner are required to clean four toilets each time. After we reviewed the records of over night inspection of the airplane before the date the occurrence, 34 gallons of 10% Acetic Acid were used to finish 17 times of cleaning task in 19 days. Although the maintenance manual does not specify periods to do waste line cleaning, it uses a Note to remind maintenance personnel of the work. To avoid the build-up of waste, maintenance personnel must clean waste lines frequently. The original text is extracted as follows.

Note ∶ *You use this procedure to keep the vacuum waste lines clean of the waste build-up. To get the maximum effect, you must frequently do this task.*

There is a CAUTION specified in the working procedures which is listed as follows.

CAUTION ∶ DO NOT GET THE TOILET SYSTEM CLEANER ON THE AIRPLANE STRUCTURE. THE TOILET SYSTEM CLEANER IS AN ACID AND CAN CAUSE DAMAGE TO THE AIRPLANE.

The CAUTION remind of the fact that the cleaner is an acetic solution. To prevent from damaging airplane structure, the cleaner should not be remained inside airplane structure after cleaning task.

1.6.3.6 Disinfection of Potable Water System

According to CAL AMP 38-010-01 (Job Card 9L38-005, issued date Apr. 19, 2007), the contents of this job card is to carry out disinfection of potable water system which is classified as a service work and needs to be carried out every 3 months. After the completion of the service and the replacement of filter, a leakage test of the filter needs to be carried out. The latest work been done of this job card was on Aug. 31, 2007, and the check results was normal.

1.6.4 Specifications on Waste Tank Installation

1.6.4.1 Aircraft Maintenance Manual

According to Boeing 737-600/700/800/900 AIRCRAFT MAINTENANCE MANUAL, Waste Tank Installation (Page 203, Task 38-32-07-400-801, Oct. 10, 2006), the original text of the installation procedures are extracted as follows (refer to Fig.1.6-2~Fig.1.6-3).

(1) Put the waste tank assembly in its position.

(2) Install the bolt [17], nut [18], and washers [15] to the tank assembly.

(3) Install the bolt [16], nut [18], and washers [15] to connect the link[19] to the tank assembly.

(4) Install the bolt [20], washer [21], bushing [22], bushing [25], washer [23], and nut [24] to connect the tie rod assembly [26].

(5) Install the strap for the aft end of the waste tank assembly.

(6) Apply the grease, D00504 or silicone-based grease, D50007 to the packings [10].

(7) Put the seal [10] in their position to connect the tube assembly to the waste outlet of the waste tank assembly.

(8) Install the clamshell [8] and sleeve [9] to connect the waste outlet.

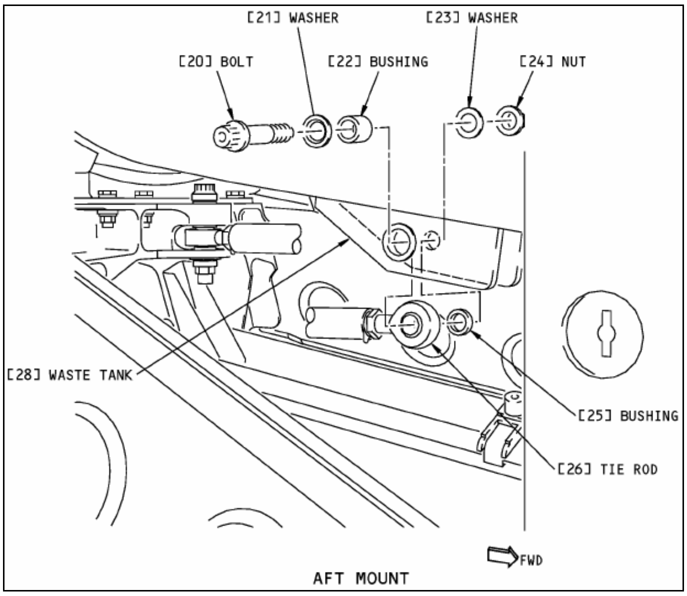


Figure 1.6-2 Waste Tank Foundation Tie Rod Installation

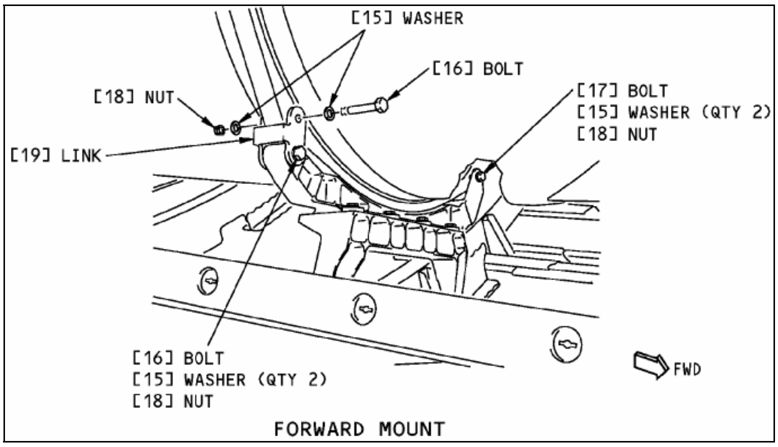


Figure 1.6-3 Waste Tank Foundation Forward Fixture Installation

From the installation procedures stated above, there were no specifications on the coupling distance between waste tank outlet and the connecting tube.

After the occurrence, China Airlines requested Boeing Company to provide the related specification on the gap dimension. Boeing's reply (Oct. 31, 2007) are extracted as follows.

> *This gap is standard for the tube coupling configuration used for this clamp design. A typical tube coupling configuration, with gap dimensions, is shown in the ref /G/ AMM.*

Boeing’s reply stated that the gap dimension of the coupling tube can be referred to AMM 38-32-00 page 403, Figure 401(B) (as shown in Figure 1.6-4). The specification on the flange distance of the connecting tubes of waste line system is from 0.11 in to 0.17 in.

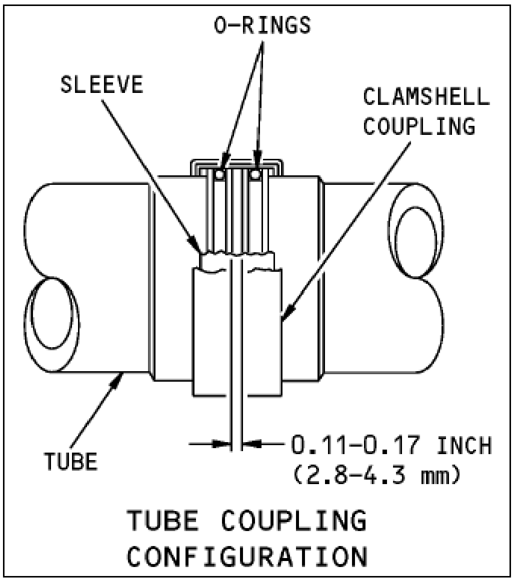


Figure 1.6-4 Tube Coupling Specification on Waste Line

1.6.4.2 Specification on Boeing Drawing

According to Boeing 737-X type drawing number 417A8630 (Status Date 10-08-04), the nominal distance of the tube coupling between waste tank outlet and drain tube is 0.1500 (as shown in Figure 1.6-5). The distance was not specified or explained in 738 AMM.

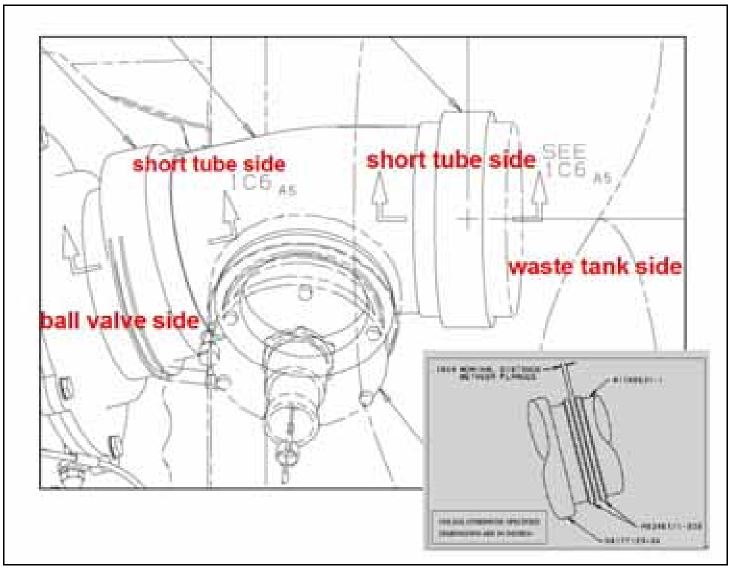


Figure 1.6-5 Nominal Distance Between Flanges

The design on the drainage of waste water is from waste tank outlet to short tube, ball valve and then to the outlet of waste water panel. In accordance with Boeing 737-X type drawing number 417A8630, the couplings from waste tank outlet to the ball valve are all matched design. (refer to Fig. 1.6-5)

1.6.4.3 Boeing's Reply Mail

On June 25, 2008, CAL submitted a batch of mails to ASC. Those mails were discussions between CAL and Boeing in relation to the occurrence. One of the mails, CAL service request ID number 1-661368477-1 dated October 25, 2007, suggested Boeing to incorporate gap dimension between waste tank outlet flanges into AMM of 738 airplanes. On October 31, 2007, Boeing replied with service request ID number 1-661368477-2 as follows.

> *Boeing plans to include a special note with the gap dimension of 0.15 inches at the waste tank drain flange and adjacent tube into the AMM. This gap is standard for the tube coupling configuration used for this clamp design.*

Boeing's response stated that the dimension is a standard coupling distance between connecting tubes, and Boeing plans to incorporate the gap dimension into AMM by using a special note.

On December 5, 2007, CAL sent another mail, service request ID number 1-661368477-7, asked about the situation was acceptable or not if the measured gap dimension (0.26 in) was larger than the nominal distance (0.15 in) specified in the drawing. On December 7, 2007, Boeing replied with service request ID number 1-661368477-8 stated that the gap is acceptable as long as the clamp could be installed at the interface between waste tank outlet flanges.

Boeing's reply is listed as follows.

> *Boeing advises that a gap of 0.26 inches at the interface between the waste tank drain fitting and the ref /E/ tube assembly is acceptable as long as the clamp can be installed at this interface.*

1.7 Weather

Northern Taiwan was affected by a low pressure centered near Luzon Island of Philippines when the aircraft took off. The weather was cloudy. Taoyuan International Airport took the following surface weather observations at 0200 UTC (1000 Taipei time):

Wind - 360 degrees variation 330-040 degrees at 11 knots; Visibility - 3,500 meters; Present Weather - mist; Clouds - scattered 500 feet broken 800 feet broken 1,800 feet; Temperature - 28 degrees Celsius; Dew Point - 24 degrees

Celsius; Altimeter Setting - 1008 hPa; Trend Forecast - Temporary clouds few 500 feet scattered 900 feet broken 1,800 feet.

The cloud top along the route of the aircraft was about 20,000 feet near northern Taiwan.

The area between Northern Ryukyu Islands and Tohoku of Japan was affected by a high pressure on the day of the occurrence. The weather was good and no ceilings. Saga Airport took the following surface weather observations at 0500 UTC (1400 Tokyo time):

Wind - 210 degrees variation 190-250 degrees at 11 knots; Visibility – more than 10 kilometers; Clouds - few 3,500 feet; Temperature - 32 degrees Celsius; Dew Point - 21 degrees Celsius; Altimeter Setting - 1014 hPa.

The upper air analysis charts showed that a jet stream was above Sakhalin of Russia. The wind was southeast at 25 knots at cruise altitude of the aircraft.

1.8 Aids to Navigation

N/A

1.9 Communications

N/A

1.10 Airport Information

1.10.1 Ramp Operation

The video camera No.2373 of the apron D3 in the terminal 2 of the Taoyuan international airport recorded the following findings:

1. The aircraft was towed to apron D3 by an aircraft towing truck at 0901 Taipei local time; The boarding bridge approached and connected to the aircraft at 0905 Taipei local time.

2. Two catering trucks approached to 1R and 3L doors of the aircraft at 0905 Taipei local time and left at 0918 Taipei local time.

3. One drinking water car approached to 3R door of the aircraft at 0923 Taipei local time and left at 0928 Taipei local time.

4. One fueling truck approached to the right wing side of the aircraft close to the front cargo at 0929 Taipei local time and left at 0938 Taipei local time.

5. One loading conveyor approached to the right wing side of the aircraft close to the front cargo at 0952 Taipei local time and left with the boarding bridge at 0938 Taipei local time.

6. The aircraft was pushed back at 1018 Taipei local time.

There was no evidence from video recording to prove that the aircraft's crack was caused by the ramp operation of the Taoyuan international airport.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The occurrence airplane was equipped with a Fairchild model FA2100 Solid-State Cockpit Voice Recorder (SSCVR), with part number 2100-1020-00 and serial number 00173. The SSCVR was manufactured by L-3 Communication Corporation. The SSCVR recording consisted of four channels. One channel captured the audio from the captain's panel, another captured the audio from the first officer's panel, a third captured the audio from the cockpit area microphone (CAM), and the fourth SSCVR channel captured from passenger public address system.

The SSCVR data was downloaded, however, part of SSCVR data was erased. The total recording of 123 minutes and 24 seconds (the SSCVR recorded from 1335:51 to 1539:15 and was erased at 1512:48) was recovered properly. Quality of the recording was good. The SSCVR recording didn't include cruise, approach, landing and power-off.

Appendix 2 listed the detailed CVR transcripts after 10 minutes the aircraft landed, and the relevant contents are extracted as follows:

Japan Local Time	UTC Time	Source	Context
1352:04.7	0452:04.7	CAM-1	現在 我們現在發現喔 它機腹下面裂了 (now we find it now oh there is a crack in the bottom of the fuselage)
1352:08.8	0452:08.8	CAM-2	喔 (wow)
1352:09.5	0452:09.5	CAM-1	裂痕很大 然後沒有辦法 … 沒有辦法加壓 然後加壓因為因為…因為它現在… (the crack is very big then it could not it could not be pressurized then pressurize because because… because it now…)
1352:21.4	0452:21.4	CAM-1	那 不是外傷 不是外面刮到的 (that is not an injury it is not scraped from

			outside)
1352:25.0	0452:25.0	CAM-1	不知道為什麼 它這樣… 先跟你講一下 好不好… (does not know why such as to… tell you first ok)
1352:35.3	0452:35.3	CAM-?	...
1352:45.6	0452:45.6	CAM-1	對嘛 … (right…)
1352:45.9	0452:45.9	CAM-?	… 剛才 preflight… 台北出來的時候 有沒有發覺到 (… preflight just now… departed from Taipei have felt about it or not)
1352:49.2	0452:49.2	CAM-1	嗯 (eh)
代號說明 Abbreviation		CAM-1: CM-1through cockpit area microphone CAM-2: CM-2 through cockpit area microphone CAM-?: Unable to determinate the voice source	

1.11.2 Flight Data Recorder

The aircraft was equipped with a L-3 Communication Solid-State Flight Data Recorder (SSFDR), part number 2100-4043-00, and serial number 000177291. The total recording of 44.88 hours of data was downloaded properly.

After the occurrence happened, ASC obtained the technical document [1] provided by the China Airlines. totally about 1,000 parameters were recorded in the SSFDR, and it complies with ICAO Annex 6 “Type 1” Flight Data Recorder, it satisfy to recorded the 32 mandatory parameters.

The occurrence flight was touched ground at 04:26:09, and the SSFDR stopped recording at 04:30:58. The plots of flight parameters are attached in Appendix 3.

[1] SSFDR technical document 【DFDAU 737-600/-700/-700C/-800/-900 DATA FRAME INTERFACE CONTROL AND REUIREMENTS DOCUMENT, DOCUMENT NUMBER: D226A101-2, REV G】

1.12 Wreckage and Impact Information

On 20th September 2007, during transit check in Saga airport after landing, a 30 in（77 cm） long broken through crack was found by the operator’s maintenance personnel, the location of crack reported was on the belly skin of the fuselage section 46. Upon finding, the AOG team from CAL, with the assistance of the technical support e-mail from Boeing Customer Support（NTSB informed ASC Boeing on-site Customer Support did not arrive until after the corrosion had been buffed out）, conducted the damage inspection and temporary repair started on 22nd September 2007 till 25th September 2007 per CAL Engineering Order EO # 738-53-00-0068 Fuselage Skin Damage from Approx. Sta 839.2 to 869.7 Outboard of S-27L prior to the ferry flight back to Taiwan.

ASC had reviewed the damage through three document prior to the first damage site inspection on 11th October 2007, they were (1) immediate photographic documentation of the damage prior to the temporary repair in Saga, received (by ASC) on 5th October 2007, (2) the CAL to Boeing correspondence e-mail, namely 1-624827258-17 and 1-624827258-26 regarding damage inspection, corrosion removal, damage report, repair scheme, and the two e-mail 1-624827258-28 and 1-624827258-29 of “structurally acceptable and the technical approval” for time-limit repair for ferry flight, and (3) the Damage report provided by CAL dated 28th September 2007 and a revised version dated 17th October 2007. See Appendix 13 for all CAL reports and CAL - Boeing correspondences.

The photograph of damage on the exterior of airplane are shown in Figure 1.12-1 (A) ~ (D), whilst the interior view for damaged structure at the crack site and typical structure corrosion are shown in Figure 1.12-2 (A) ~ (S). From these photographs, in addition to the location of the crack, the extension of structure corrosion inside the cargo bilge area was observed. The corrosion was mostly located on the fuselage belly skin left side of the stringer S-27L, on the channel of the S-27L stringer, and at the lower side of the intercostals which was beneath the waste tank outlet coupler later found leaked.

From above document, it is concluded that the broken through crack is located at outboard side along the S-27L stringer, and between fuselage body station BS 839.2 and BS 869.7. The location of damage is shown in Figure 1.12-3.

Upon the arrival of the airplane in Taiwan on 11th October 2007, the formal investigation over the corrosion and crack damaged in the aft cargo compartment conducted by ASC then started, whilst the detail findings of structure damages were documented in section 1.12-1 through 1.12-8 respectively.

Figure 1.12-1 (A) Cracked Skin External View

Figure 1.12-1 (B) Location of Crack

Figure 1.12-1 (C) Detail Cracked Skin External View

Figure 1.12-1 (D) Detail Cracked Skin External View

Figure 1.12-2 (A) Floor panel Open Up Inspection for Skin Damage

Figure 1.12-2 (B) Corrosion forward of Sta. 78

Figure 1.12-2 (C) Corrosion aft of Sta. 787

Figure 1.12-2 (D) Corrosion forward of Sta. 807

Figure 1.12-2 (E) Corrosion forward of Sta. 807 Close up View

Figure 1.12-2 (F) Corrosion aft of Sta. 807

Figure 1.12-2 (G) Skin Corrosion aft of Sta. 807

Figure 1.12-2 (H) Skin Corrosion aft of Sta. 807 Close up View

Figure 1.12-2 (I) Corrosion forward of Sta. 827

Figure 1.12-2(J) Corrosion aft of Sta. 827

Figure 1.12-2 (K) Corrosion at Sta. 847

Figure 1.12-2 (L) Corrosion forward of Sta. 847

Figure 1.12-2 (M)   Corrosion aft of Sta. 847

Figure 1.12-2 (N) Crack Rear End at Sta. 869.7 Cargo Compartment Interior View

Figure 1.12-2 (O) Corrosion forward of Sta. 867

Figure 1.12-2 (P) Corrosion aft of Sta. 867

Figure 1.12-2 (Q) Relative Position of the Leaking Waste Tank Outlet and the Corroded Intercostal

Figure 1.12-2 (R) The Corroded Intercostal

Figure 1.12-2 (S)   The Corroded Intercostal Close up View

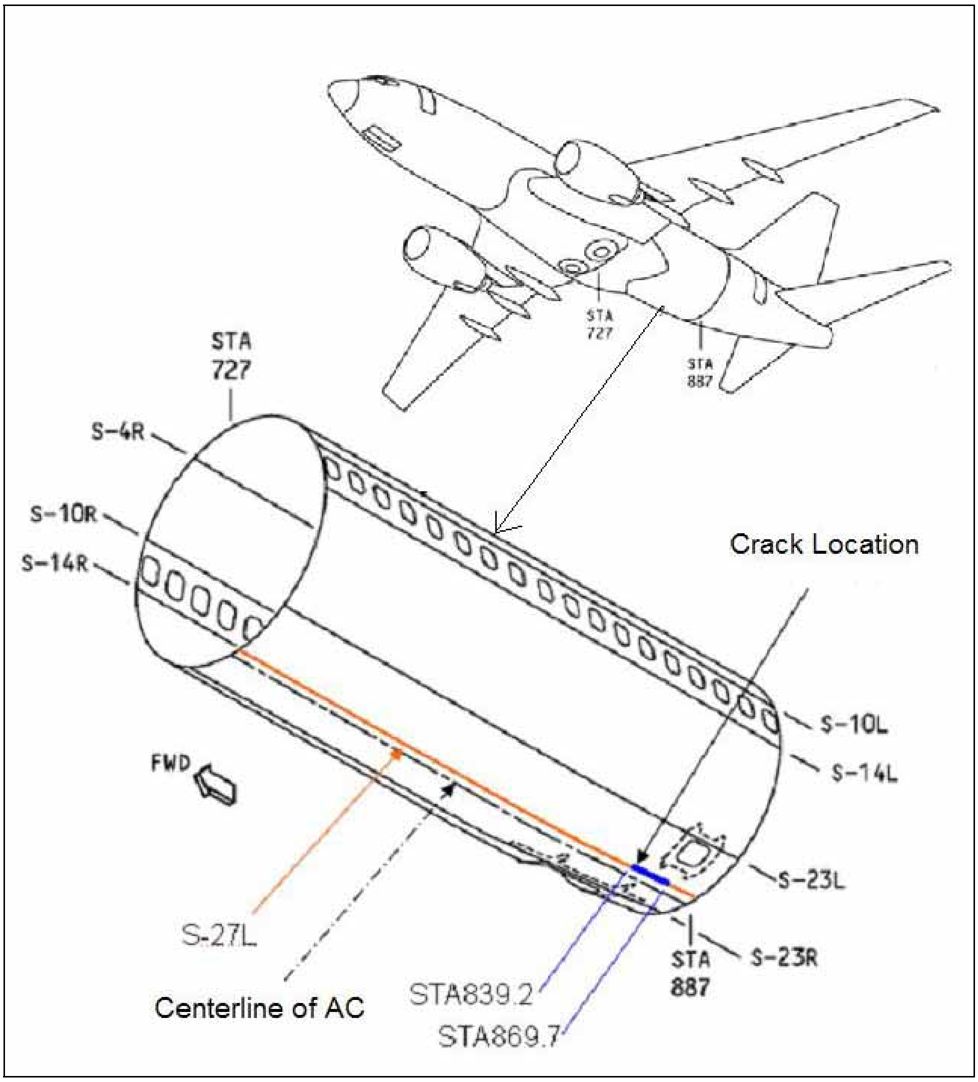


Figure 1.12-3Location of Crack

1.12.1 Structural Damage to the Airplane

The structure damage from corrosion was temporarily repaired per CAL EO 738-53-00-0068 at Saga airport, the temporary repair included corrosion removal of the lightly corroded skin, whilst external repair patch size 40.25 in by 20.45 in for the heavily corroded belly skin, covering the 30 in (77 cm) long crack where the most serious corrosion located, and an external repair angle over the corroded stringer S-27L before the ferry flight back to CAL's home base in Taiwan. The immediate damage investigation by ASC in Taiwan upon the ferry flight arrival, by accessing to the aft cargo compartment where the crack located, the damage to the waste water system, fuselage belly skin, stringers, intercostals, and shear ties were again verified against the damage reports delivered by the operator earlier. The 40.25 in. × 20.45 in. external repair patch was then removed to expose the heavy corrosion area where the skin crack located for investigation. ASC, in addition, took samples of the heavily corroded and cracked belly skin for specimen for further laboratory inspection. See Figure 1.12-4 for location information of these damages.

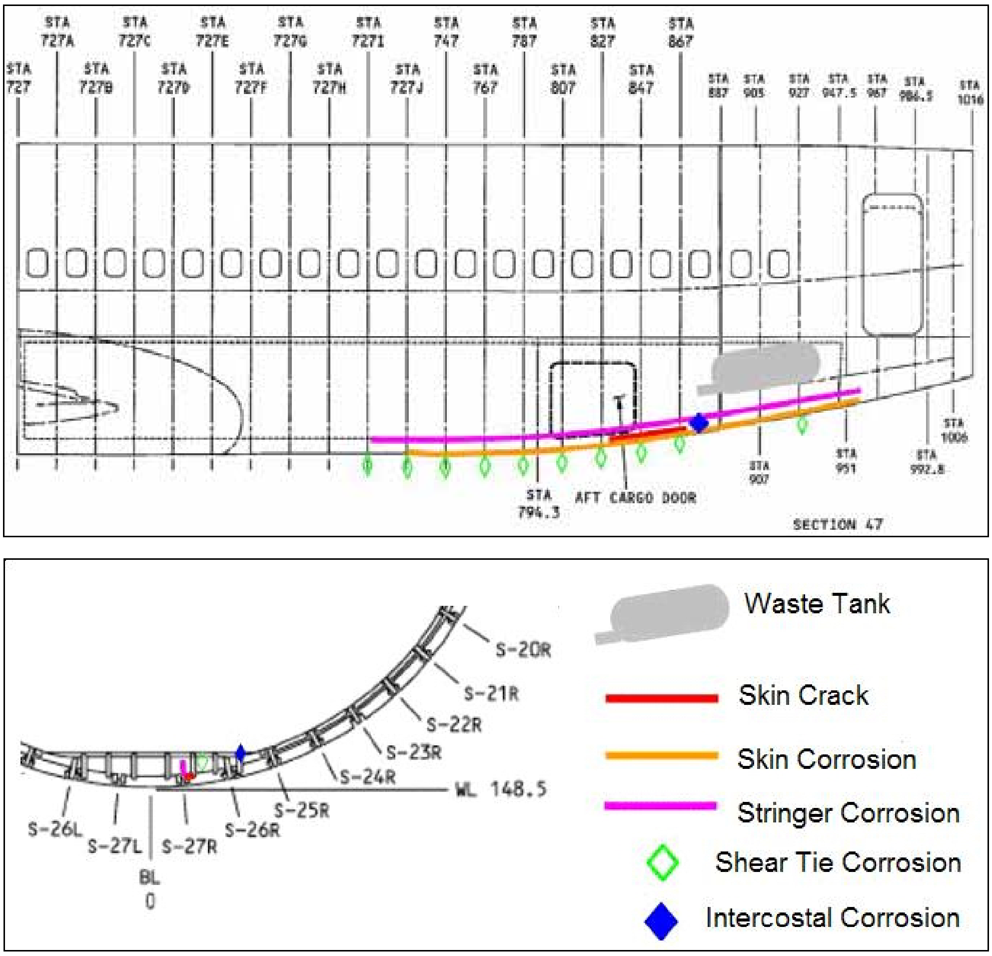


Figure 1.12-4Location of Damages

1.12.2 Damage Condition of the Waste Water System

During ASC's investigation in CAL's maintenance depot, contamination mark from leaked waste tank was found over the insulation blanket located beneath the waste tank outlet, which was up stream to the skin crack in the aft cargo compartment.   The most up stream point of the contamination mark was right below the coupler ring of the waste tank with the metal short tube; the contamination mark appeared as a 20 in long pattern of liquid flow, which traveled down stream to the lower edge of the insulation blanket, leaving several green-yellowish, black, and dry traces on the top surface of the insulation skin. After removal of the contaminated insulation blanket, same trace of leaking was also found on the belly skin. See figure 1.12-5 ~ 1.12-7 for detail.

Figure 1.12-5Trace of Contamination from Leaked Waste Water

From figure 1.12-5 the contamination mark on the insulation blanket indicates that the waste tank fluid leaked from the connector for plastic outlet piece of the waste tank and the metal tube is suspected.

Figure 1.12-6Structure Members underneath the Insulation Blanket

After removal of the contaminated insulation blanket, as shown in figure 1.12-6, it was found that the leaking waste tank fluid had penetrated the layers of the insulation blanket and reached the belly skin leaving a visible trace. (See figure 1.12-7)

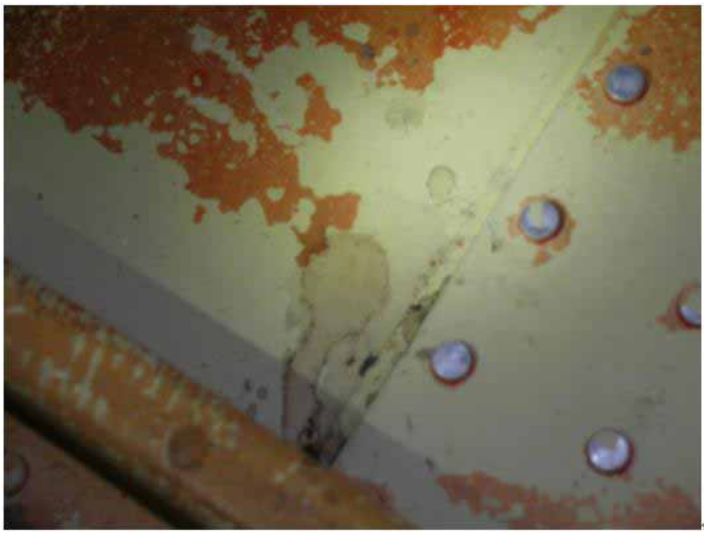


Figure 1.12-7Leakage Trace over The Skin Panel

Further examination of the leakage by removing the waste tank revealed that the outlet port flange from the waste tank had been broken, see red circle indicated in figure 1.12-8, the appromax 5 in long broken flange located at the lower right side of the outlet port. See figure 1.12-9.

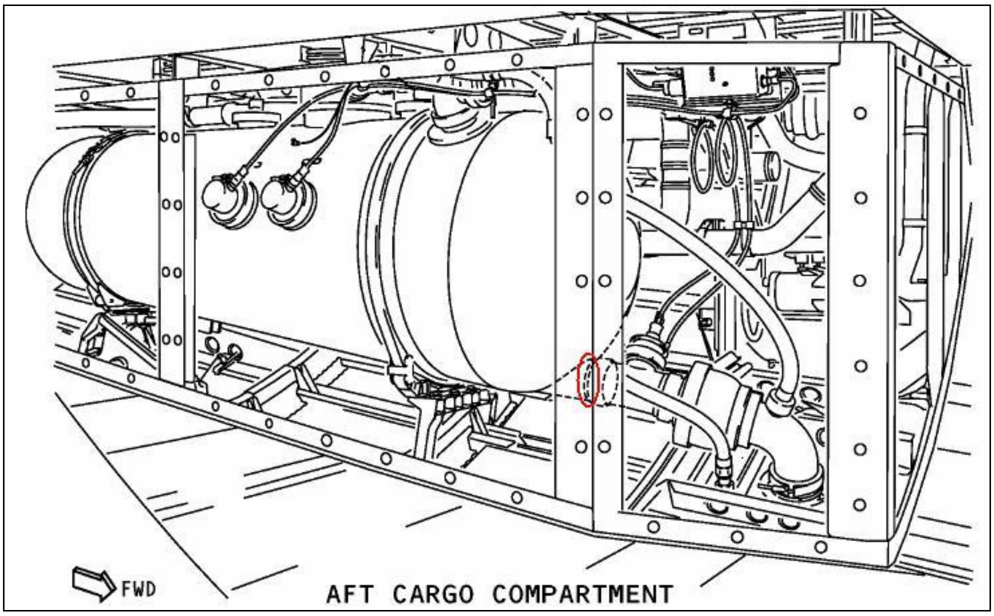


Figure 1.12-8Location of the Damaged Waste Tank Outlet Port

Figure 1.12-9Damage of the Waste Tank Outlet Port

1.12.3 Skin Damage of the Aft Cargo Compartment

1.12.3.1 Skin of the Aft Cargo Compartment

The part number of the involved skin panel from the aft cargo compartment is 146A3231-8, referred to Boeing Drawing number 146A3231 Sheet 15 and Sheet 16, see figure 1.12-54. There is no tear strap designed. From the drawing:

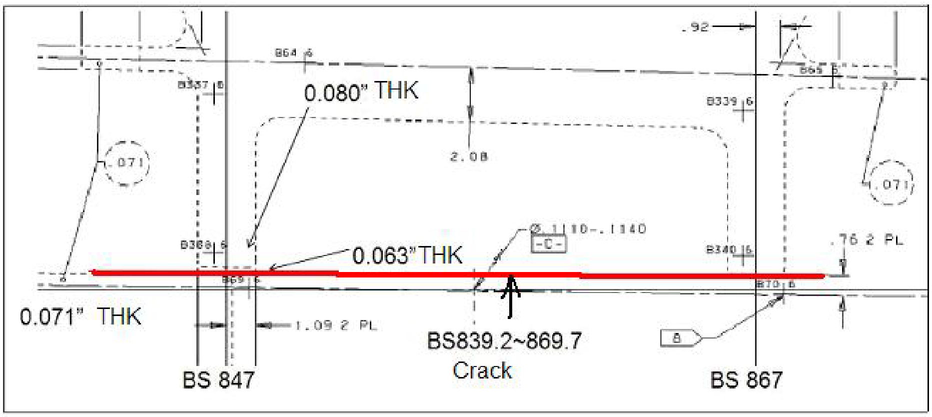


Figure 1.12-10 Skin Panel at BS847 and BS867

(1) Skin thickness outboard of BS847 S-27L changed with two steps, first from 0.071" reduced to 0.063", within very short distance from 0.063" increased to 0.080".

(2) Outboard of BS867 S-27L, the skin thickness changed only one step from 0.063" toward 0.080".

(3) In between BS847 and BS867, outboard of S-27L, the skin thickness is 0.063”, the skin crack is located. Also in the 0.063” thin area of the (1) and (2) area, there is no so called tear strap[2] exists.

(4) From the Boeing drawing, the subject skin was chemically milled in accordance with BAC5772, Type II. From this document BAC5772, Section 9.1, 9.4, and 9.5 it has been identified that Sodium Hydroxide (i.e. NaOH) is utilized in the process. For the NaOH, Section 5.3 of BAC5772 described ” 100 ppm chloride maximum is required when aluminum recovery systems are employed.”Section 6 indicated “Equipment for smut removal and aluminum recovery may be used.”Section 9.1 requested that“Water used for makeup shall not contain more than 150 ppm total chloride”

1.12.3.2 Skin Damage of the Aft Cargo Compartment

From the damage report dated 28th September 2007 and the 17th October 2007 revised version, together with the on-site damage assessment by ASC in the operator’s home depot, the reported corrosion damages, each with different severity, were verified again for their location, depth, and area size in the investigation conducted by ASC. On the upper surface of the belly skin in fuselage section 46 and section 47, along stringer S-27L, from BS727J toward BS967, all corrosion sites were found located at flow channel outboard side of S-27L. The corrosion damage had been blend out as a temporary repair for the ferry flight in Saga, since the CAL decided to replace the whole belly skin panel as a permanent repair in Taiwan, the corroded skin panel was then removed from the airplane by CAL and was inspected by ASC for detail. In Chart 1.12-1, the detail investigation results for the skin corrosion are listed, these corrosion sites were denoted as K1 ~ K13 common to the body station.

Table 1.12-1 Corrosion Damage Blend Out Summary

No.	Body Station	Relative Location to S-27L	Area (L by W)	Min Residual Thickness / Original Skin Thickness
			Unit : Inch	
K1	727J	Adjacent to S-27L	3 X 1.5	0.086 /0.100

[2] The design of Tear Straps, either with Bonded Type or Integrated Type (fabricated by Chemical Milling), are generally utilized in airplane fuselage skin design for civil air transportation. The basic idea of beefing up the fuselage skin at certain locations (typical with 20 in in separation) could retain the crack locally, restrict the growing of the crack going further, and allow the crack to be spotted by routine checks before too late.

	~727J+3	OB side		
K2	727J+3 ~ 727J+12.5	Adjacent to S-27L OB side	9.5 X 1	0.060 /0.063
K3	747 ~ 767	Adjacent to S-27L OB side	20 X 5.7	0.053 /0.063
K4	767 ~ 787	Adjacent to S-27L OB side	20 X 6.5	0.054 /0.063
K5	787 ~ 807	Adjacent to S-27L OB side	20 X 7.0	0.040 /0.063
K6	807 ~ 827	Adjacent to S-27L OB side	20 X 7.0	0.042 /0.063
K7	827 ~ 847	Adjacent to S-27L OB side	20 X 7.0	0.057 /0.063
K8	847 ~ 872	Adjacent to S-27L OB side	25 X 7.0	Broken Skin
K9	879 ~ 887	Adjacent to S-27L OB side	8 X 1.75	0.059 /0.063
K10	887 ~ 907	Adjacent to S-27L OB side	Light Surface Corrosion	Blend Out Depth 0.003
K11	907 ~ 927	Adjacent to S-27L OB side	Light Surface Corrosion	Blend Out Depth 0.003
K12	927 ~ 947	Adjacent to S-27L OB side	Light Surface Corrosion	Blend Out Depth 0.003
K13	947 ~ 967	Adjacent to S-27L OB side	Light Surface Corrosion	Blend Out Depth 0.003

The relative location of these corrosion sites is indicated in figure 1.12-11.

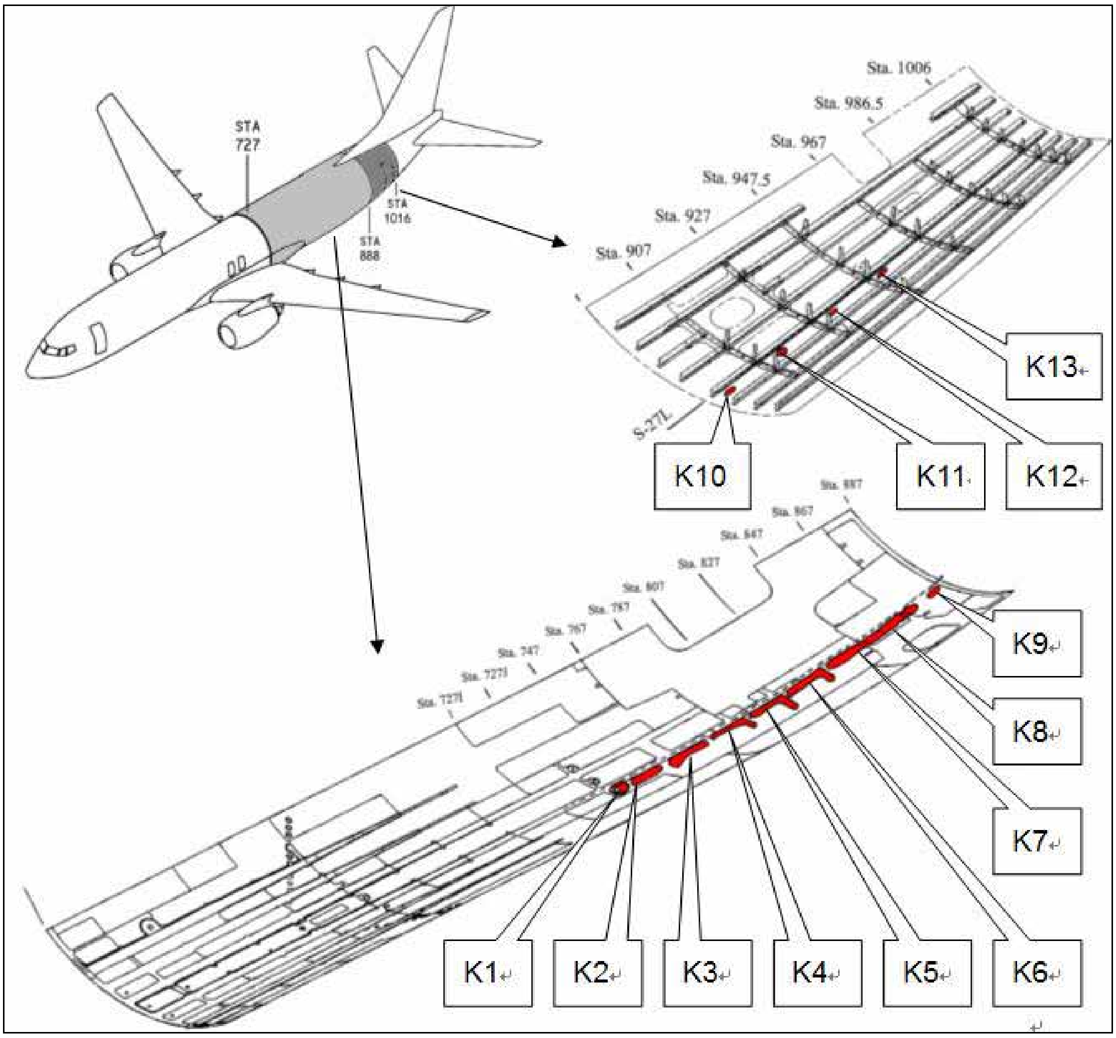


Figure 1.12-11 Relative Location of Corrosion Sites in Aft Cargo Compartment

K1 area and K2 area: Corrosion site K1 area located surrounding the BS727J left side drain valve, adjacent to the BS727J fuselage frame. Corrosion site K2 area located next to the above mentioned corrosion as indicated in figure 1.12-12. In this figure the stringer S-27L, frame, and attached structure parts were removed, the corrosion was blent out.

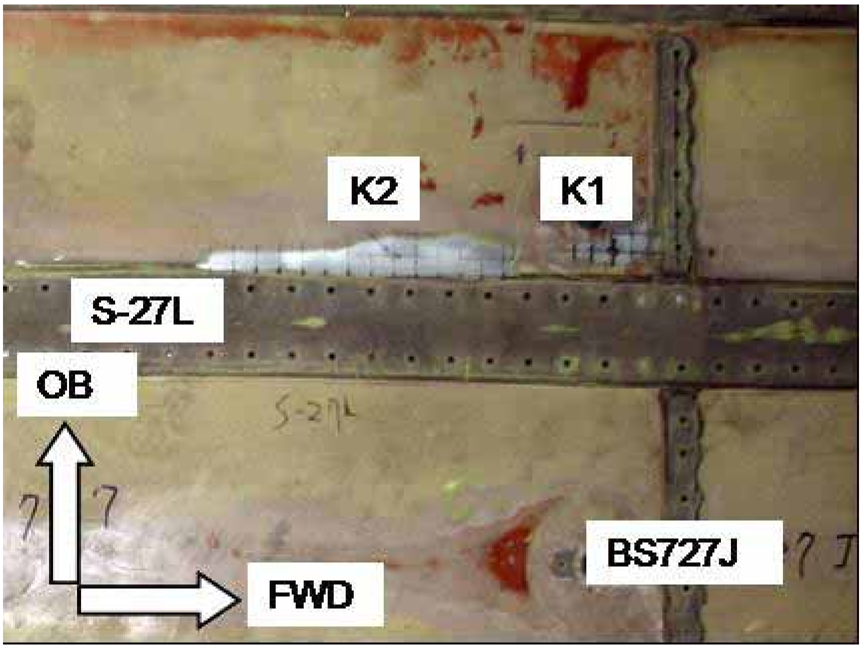


Figure1.12-12 Corrosion of K1, K2 Sites

K3 area: Corrosion site K3, started at the BS747 frame shear tie, extended along S-27L to the rear, the most severe corrosion existed at where the lowest portion of all. See figure 1.12-13. In this figure the stringer S-27L, frame, and attached structure parts were removed, the corrosion was blent out.

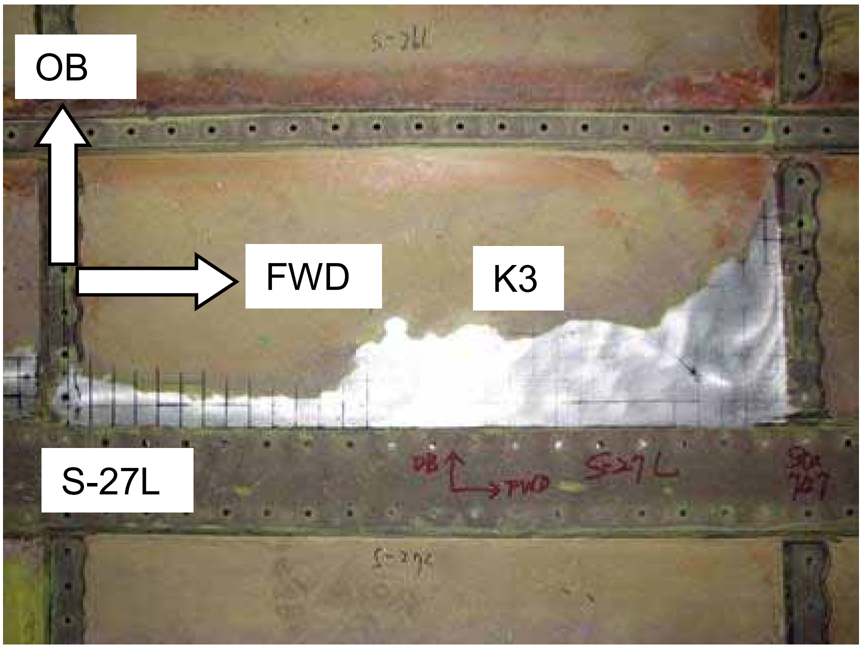


Figure 1.12-13 Corrosion Site K3

K4 area: Corrosion site K4, started at the BS767 frame shear tie, extended along S-27L to the next frame shear tie of BS787, the most severe corrosion existed at where the lowest portion of all. See figure 1.12-14. In this figure the stringer S-27L, frame, and attached structure parts were removed, the corrosion was blent out.

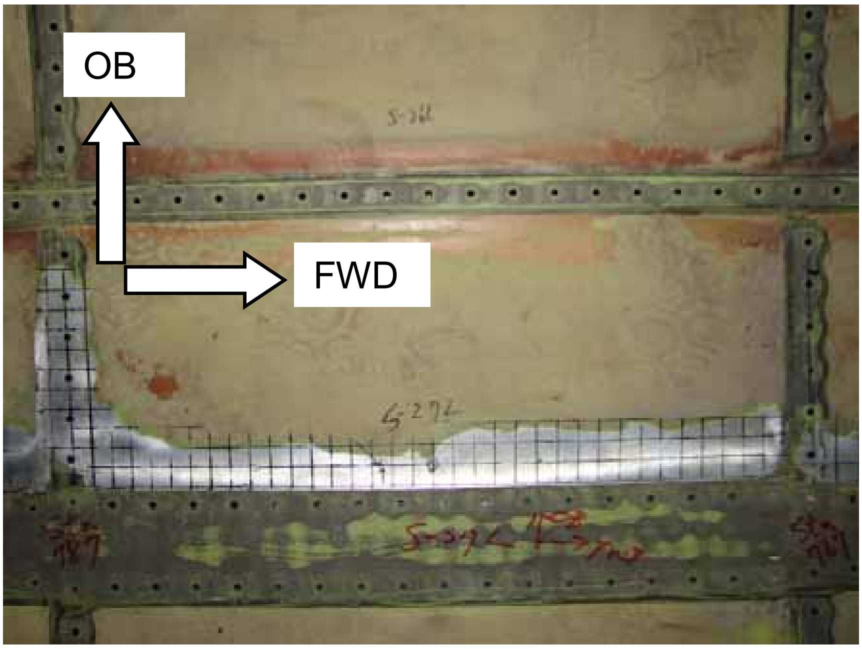


Figure 1.12-14 Corrosion Site K4

K5 area: Corrosion site K5, started at the BS787 frame shear tie, extended to the rear along S-27L and went beneath the BS807 frame shear tie, the most severe corrosion existed at where the lowest portion of this area. See figure 1.12-15. In this figure the stringer S-27L, frame, and attached structure parts were removed, the corrosion was blent out.

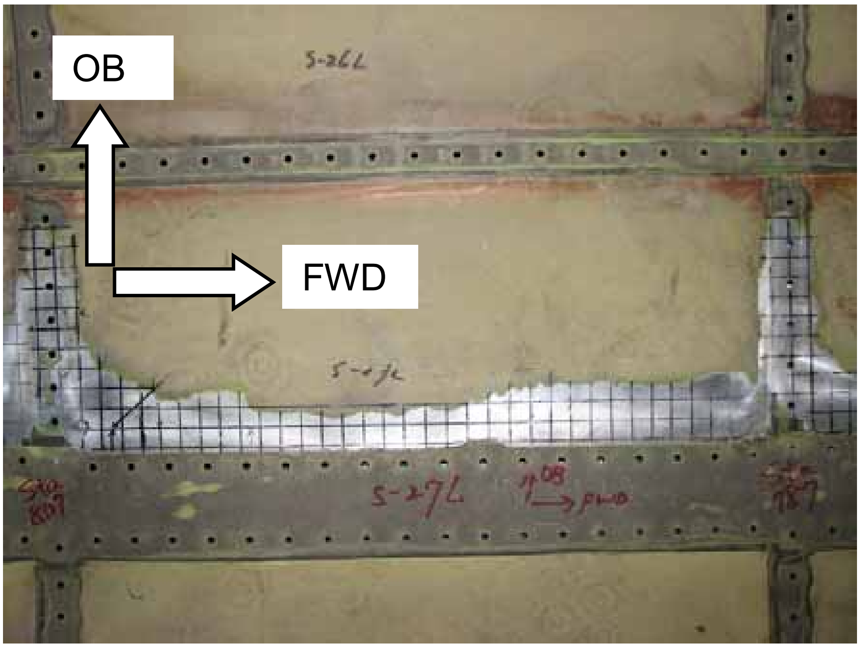


Figure 1.12-15 Corrosion Site K5

K6 area: Corrosion site K6, started at the BS807 frame shear tie, extended to the rear along S-27L and went beneath the BS827 frame shear tie, the most severe corrosion existed at where the lowest portion of this area. See figure 1.12-16. In this figure the stringer S-27L, frame, and attached structure parts were removed, the corrosion was blent out.

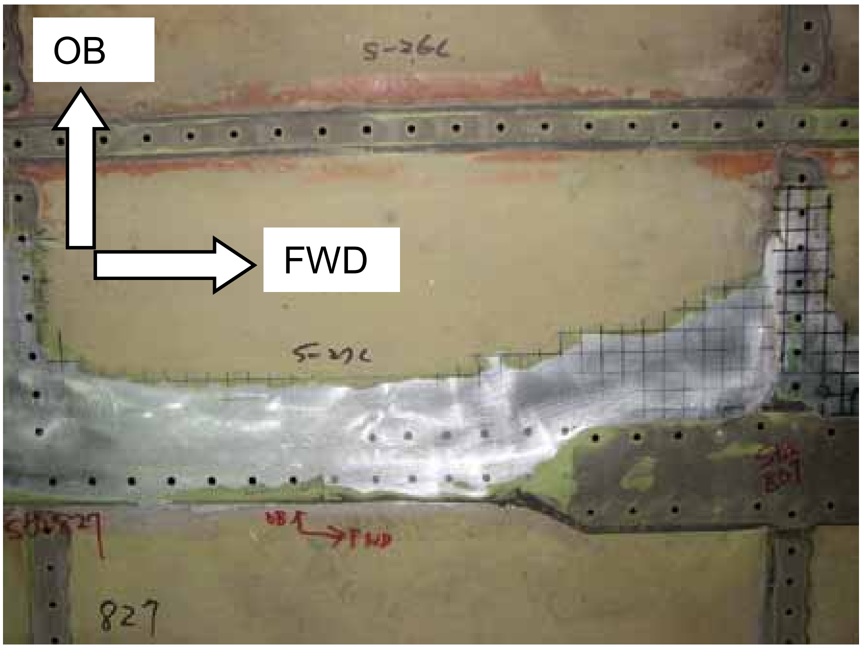


Figure 1.12-16 Corrosion Site K6

K7 area: Corrosion site K7, started at the BS827 frame shear tie, extended to the rear along S-27L and went beneath the BS847 frame shear tie, the most severe corrosion existed at where the lowest portion of this area. See figure 1.12-17. In this figure the corrosion was blent out. In addition, the through crack forward end located at BS839.2 in this corrosion area, see figure 1.12-18.

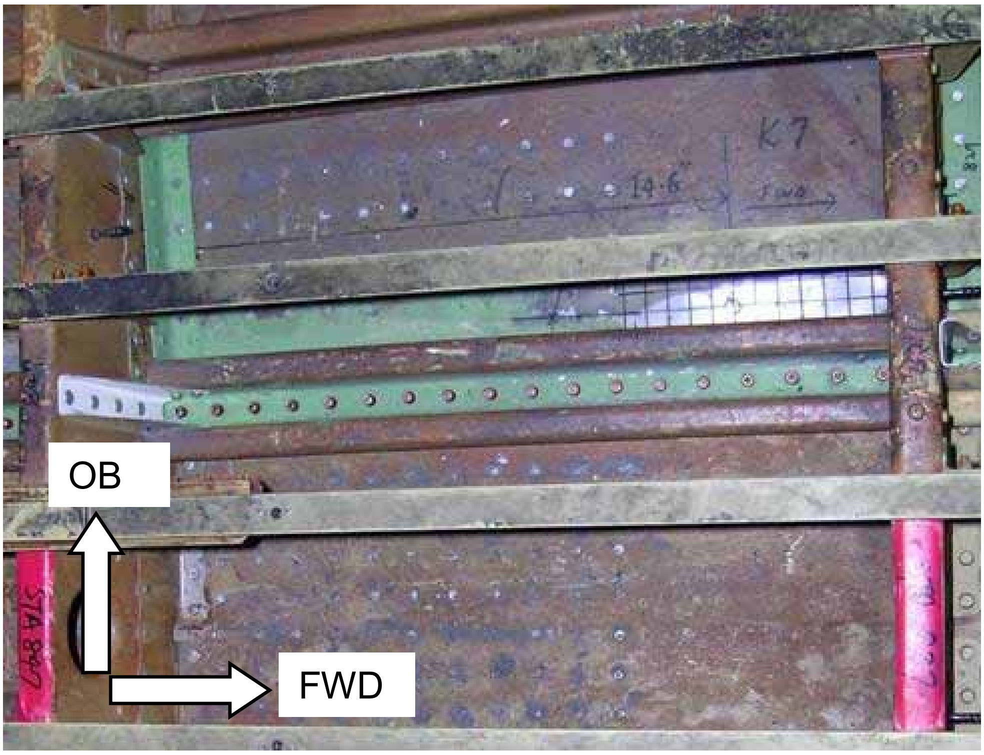


Figure 1.12-17 Corrosion Site K7

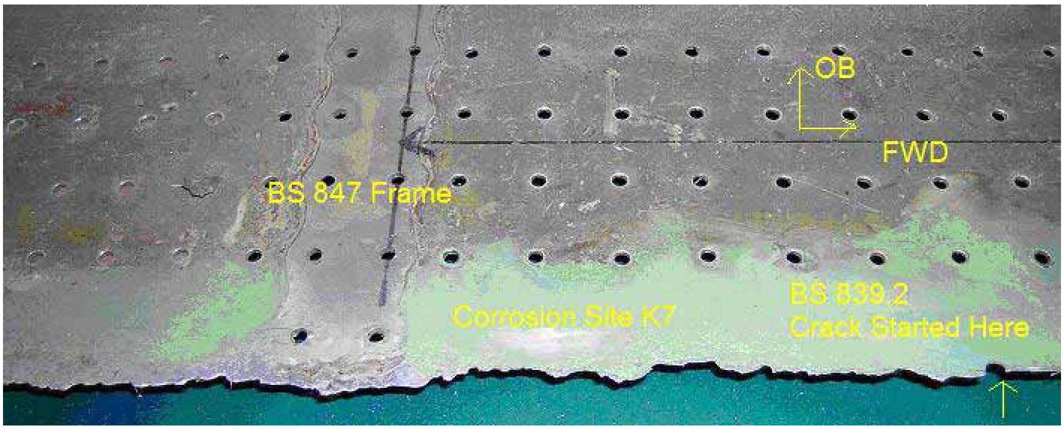


Figure 1.12-18 Forward End of Crackin the K7 Corrosion Site

K8 area: Corrosion site K8, started at the BS847 frame shear tie, extended to the rear along S-27L and went beneath the BS867 frame shear tie, then continued to BS872 passing the BS867 frame; the most severe corrosion existed at where the lowest portion of this area. The through crack rear end located at BS869.7 in this corrosion area, see figure 1.12-19 and 1.12-20.

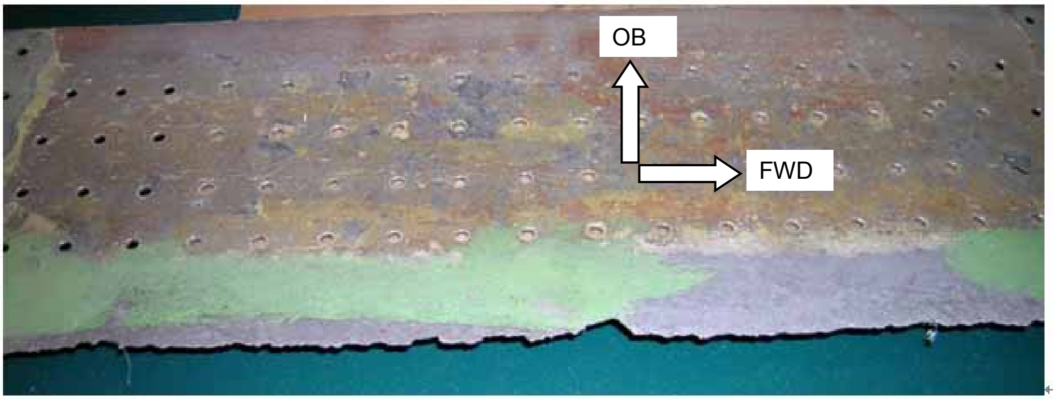


Figure 1.12-19 Corrosion Site K8

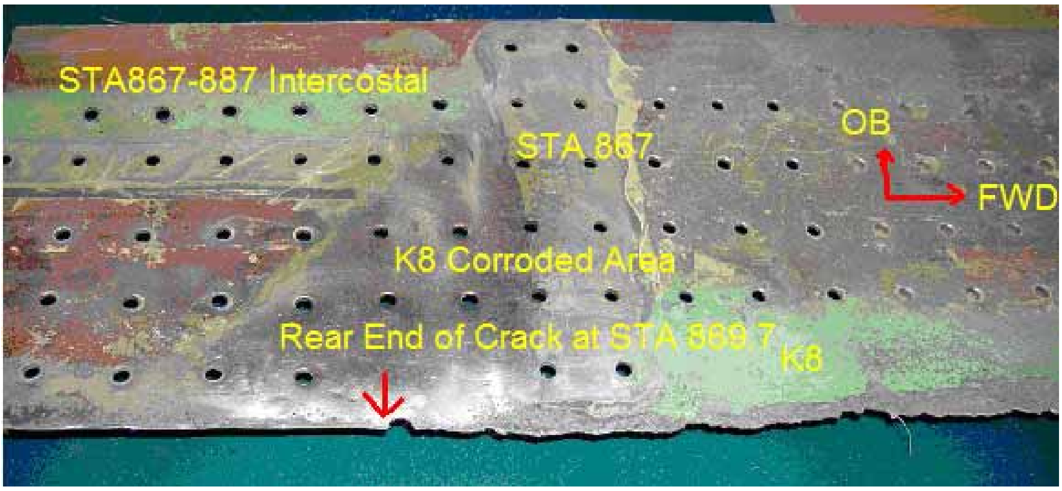


Figure 1.12-20 Rear End of Crack in The K8 Corrosion Site

K9 area: Corrosion site K9, started at the BS877, extended to the rear along S-27L and went beneath the BS887 frame shear tie, the most severe corrosion existed at where the lowest portion of this area. See figure 1.12-21. Corrosion had been blent out in this area, in the figure also showed part of the K8 corrosion blent out whilst K9 area is located at left half of the figure, the S-27L crosses vertically inside the picture.

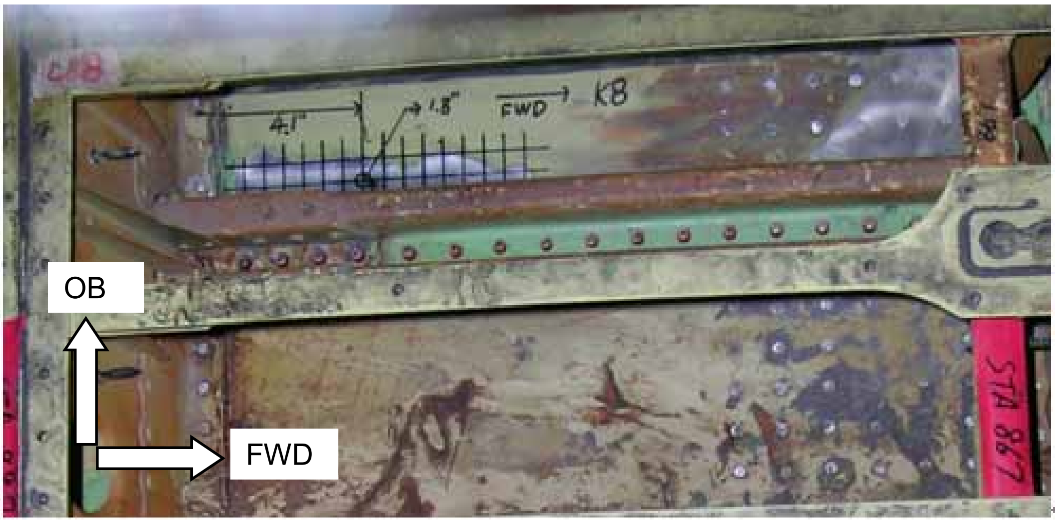


Figure 1.12-21 Corrosion Site K9

K10 area: Corrosion site located at the butt joint of the fuselage skin panels at BS887, i.e. the splicing of fuselage section 46 and section 47. Corrosion was found on the frame chord in section 47, and light surface corrosion on the fuselage skin outboard of S-27L was also found, see figure 1.12-22.

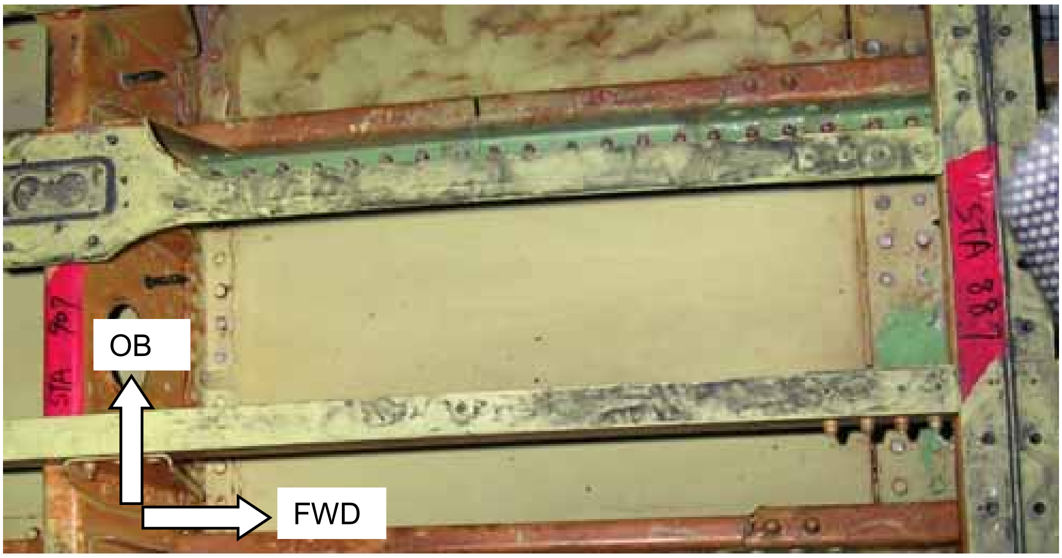


Figure 1.12-22 Corrosion Site K10

K11 area: Corrosion site located in front of BS927 outboard of S-27L, observed as light surface corrosion over skin panel, see figure 1.12-23.

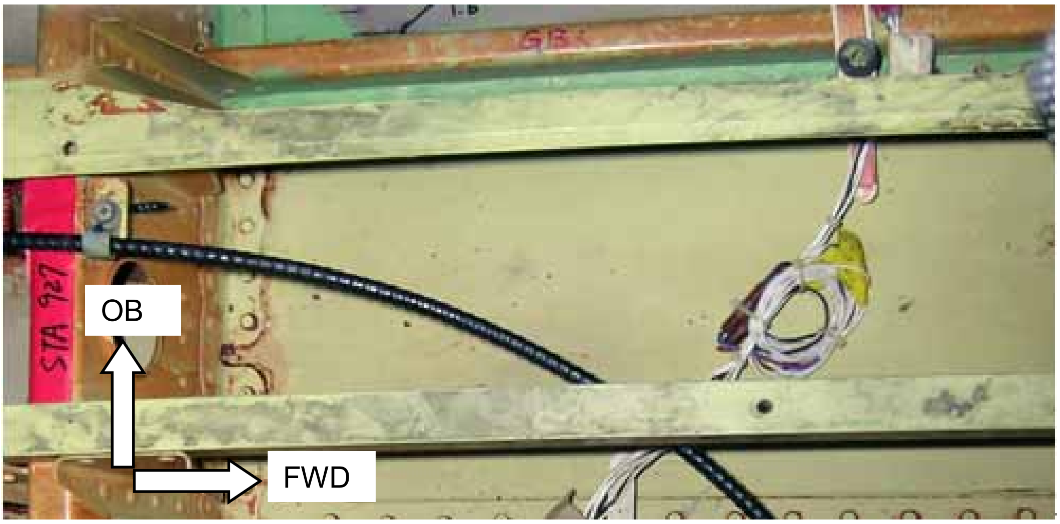


Figure 1.12-23 Corrosion Site K11

K12 area: Corrosion site located in front of BS947 outboard of S-27L, observed as light surface corrosion over skin panel, see figure 1.12-24

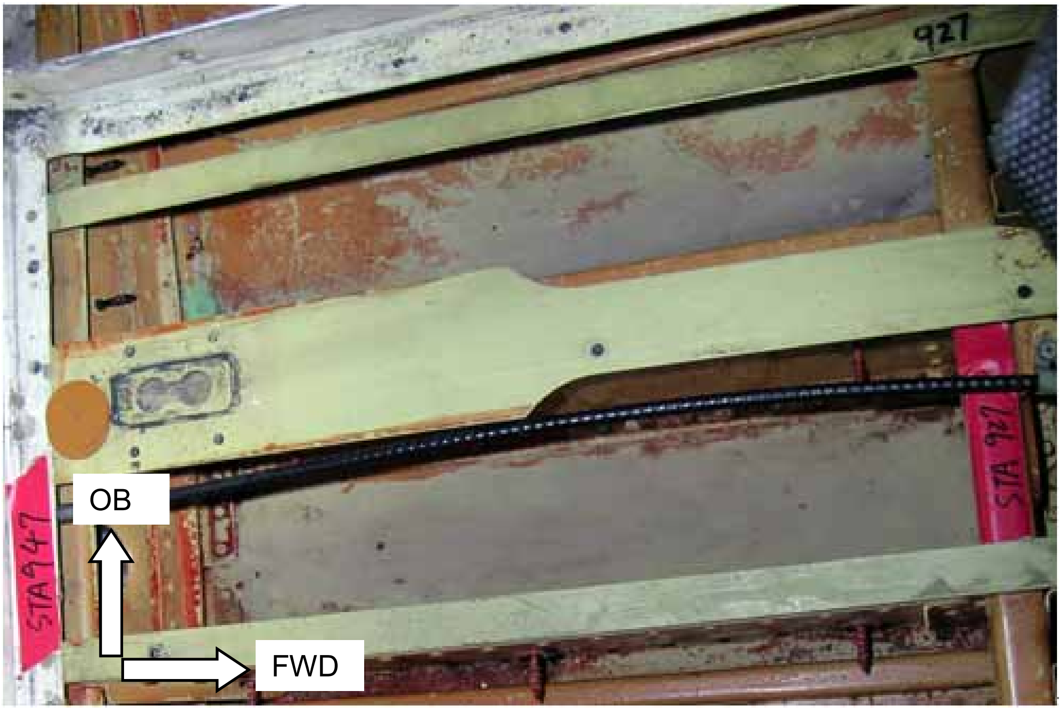


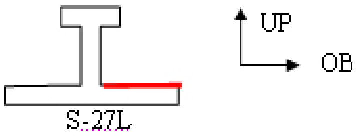
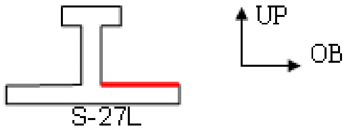
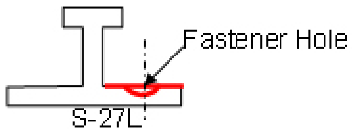
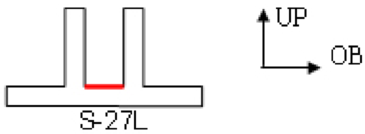
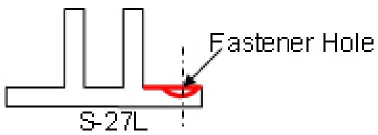
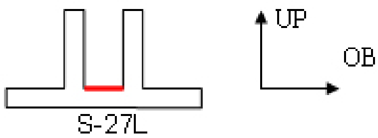
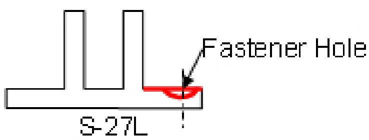
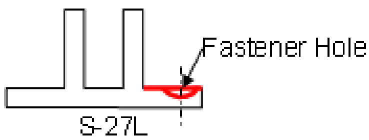
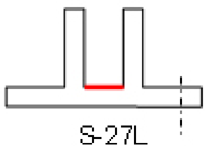
Figure 1.12-24 Corrosion Site K12

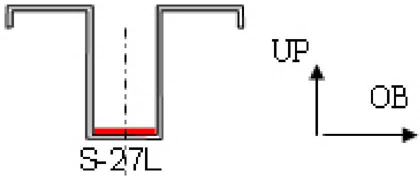
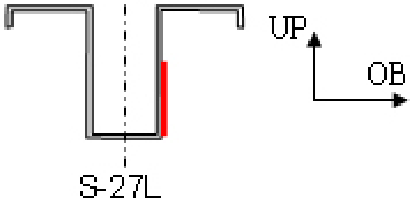
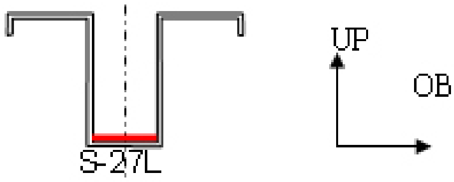
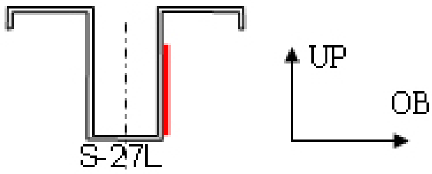
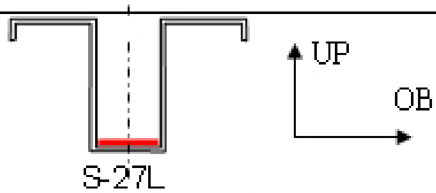
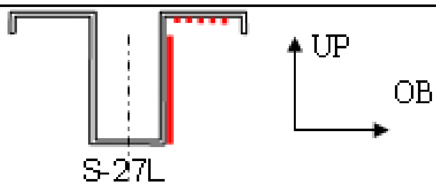
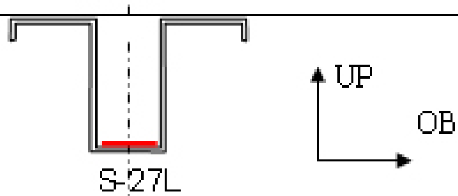
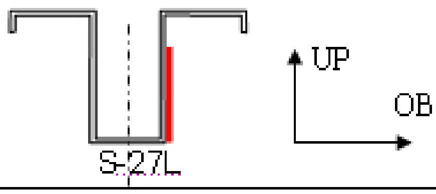
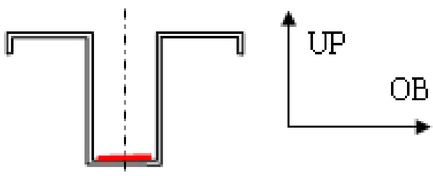
K13 area: Corrosion site located in front of BS967 outboard of S-27L, observed as light surface corrosion over skin panel.

1.12.4 Damage to the Stringer

Multiple corrosion sites were observed on stringer S-27L from BS 727I to BS 967 during investigation, these corrosion sites are distinguished by fuselage frames into groups as G1 ~ G17, see Chart 1.12-2 for summary.

Table 1.12-2 Stringer Damage Summary

No.	Location Description		Area
	Body Station	Corrosion Site Information	(Inch)
G1	Sta. 727I~727J		19" * 1.2"
G2	Sta. 727J~747		20" * 1.2"
G3	Sta. 747~767		20" * 1.2"
G4	Sta. 767~787		Length: 20" All Surface
G5	Sta. 767~787		Length: 20" All Surface
G6	Sta. 787~807		Length: 20" All Surface
G7	Sta. 787~807		Length: 20" All Surface
G8-A	Sta. 807~817		Length: 10" All Surface
G8-B	Sta. 807~817		Length: 10" All Surface

G9-A	Sta.813~827		Length: 14" All Surface
G9-B	Sta.813~827		14" * 0.5"
G10-A	Sta. 827~847		Length: 20" All Surface
G10-B	Sta. 827~847		20" * 0.75"
G11-A	Sta. 847~867		Length: 20" All Surface
G11-B	Sta. 847~867		Side: 20"*0.75" Bottom: Approx. 10" * 0.5"
G12-A	Sta. 867~887		Length: 20" All Surface
G12-B	Sta. 867~887		20" * 0.75"
G13， G14， G15， G16， G17	Sta. 907~927 Sta. 927~947 Sta. 947~967 Sta. 967~986.5 Sta. 986.5~1006	 S-27L (in Section 47)	Light Corrosion on Surface

G1 area (BS727I ~ BS727J): Stringer in this area is fabricated with extruded I type beam, evenly distributed light surface corrosion was observed on the left side flange upper surface, see figure 1.12-25. For the purpose of non-revenue ferry flight, the corrosion was removed and protective top coat was applied for temporary repair.

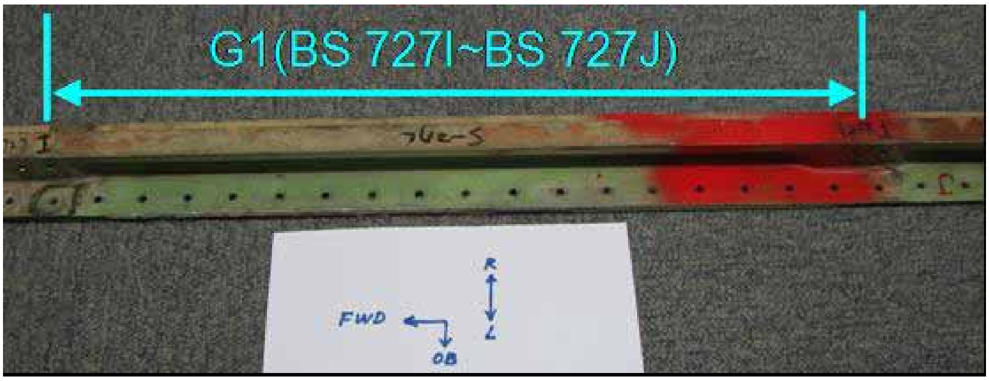


Figure 1.12-25 Stringer Corrosion Area G1

G2 area (BS727J ~ BS747): Stringer in this area is extruded I beam, evenly distributed light surface corrosion was observed on the left side flange upper surface, see figure 1.12-26. For the purpose of non-revenue ferry flight, the corrosion was removed and protective top coat was applied for temporary repair.

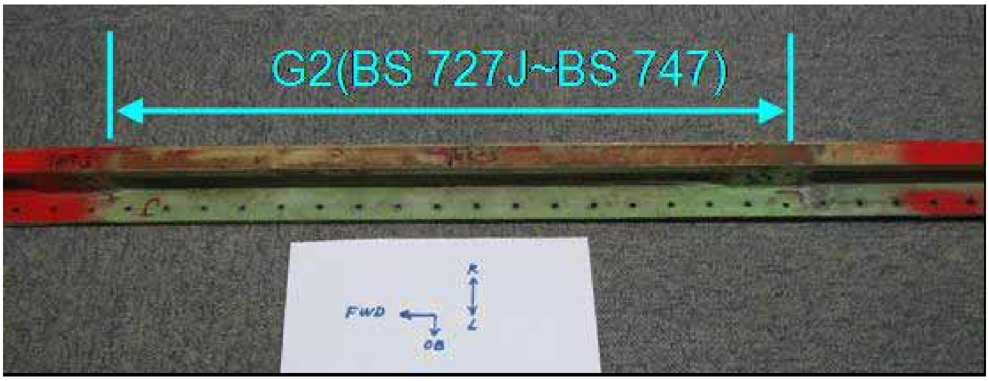


Figure 1.12-26 Stringer Corrosion Area G2

G3 area (BS747~ BS767): Stringer in this area is extruded I beam, medium surface corrosion with various depths was observed all over the left side flange upper surface, revealing dimples of material loss. See figure 1.12-27.

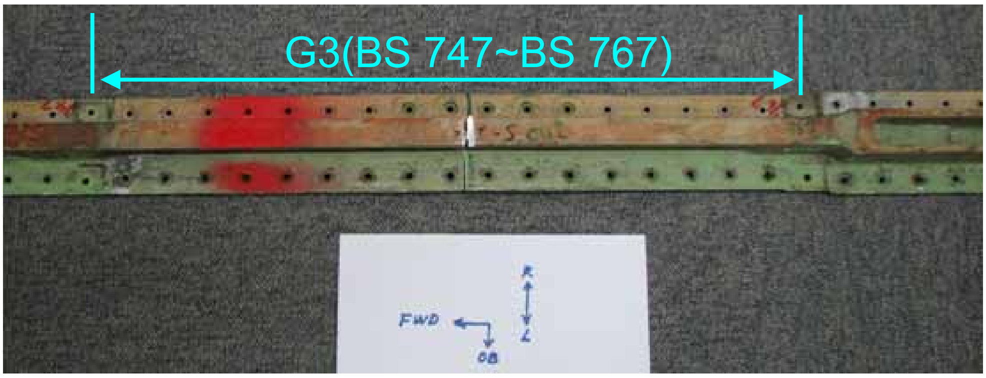


Figure 1.12-27 Stringer Corrosion Area G3

After removal of the collars of the fasteners (Lock Bolt), deep corrosion craters were found underneath the collar, see figure 1.12-28.

Figure 1.12-28 Deep Corrosion Found in G3 Area

G4 area (BS 767~BS 787)Stringer in this area is extruded I beam, however after BS767 the I beam was altered into extruded double T beam shape. The valley area in the center was corroded lightly on the upper surface, see figure 1.12-29.

G5 area (BS767~BS787): Corrosion pits with various depthes were found on the left side flange upper surface, see figure 1.12-29.

Figure 1.12-29 Stringer Corrosion in G4, G5 Area

After removal of the collars of the fasteners in G5 area, deep corrosion craters were found on the strnger underneath the collar, see figure 1.12-30.

Figure 1.12-30 Deep Corrosion in G5 Area

G6 area (BS787 ~ BS807): Double T shape beam, light surface corrosion was found on the bottom between the two vertical legs. See figure 1.12-31.

G7 area (BS787 ~ BS807): Corrosion pits with various depthes were found on the left side flange upper surface of the stringer, see figure 1.12-31.

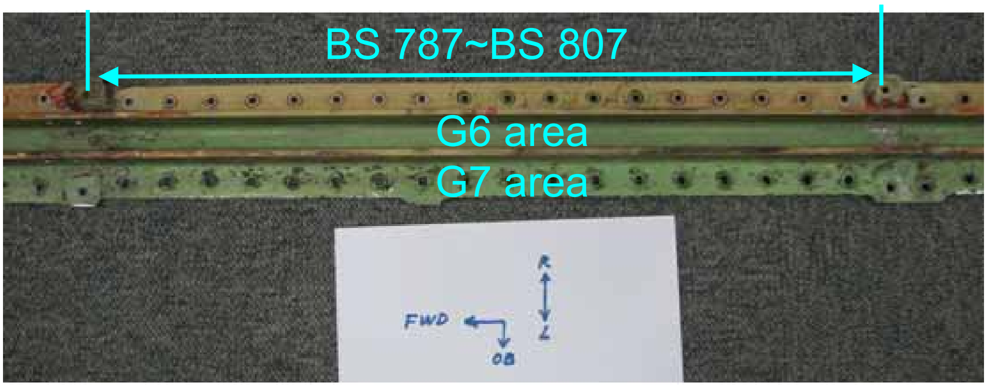


Figure 1.12-31 Corrosion Site G6, G7

After removal of the collar and the close fit bolt, more severe corrosion damage craters than those found in G5 area were observed on the stringer surface. See figure 1.12-32.

Figure 1.12-32 Deep Corrosion in G7 Area

G8 area (BS807 ~ BS817): At BS807 stringer is double T beam whilst starting at BS 813 and aft is changed to formed hat section stringer.

- G8-A area (BS807 ~ BS817): Corrosion pits with various depthes were found on the left side flange upper surface of the stringer. After removal of the collar and the close fit bolt, deep corrosion craters similar to those in G7 were observed on the stringer surface. See figure 1.12-33.
- G8-B area (BS807 ~ BS817): Light surface corrosion was found on the bottom between the two vertical legs. See figure 1.12-33.

G9 area (BS813 ~ BS827): Stringer becomes hat section starting from BS813 all over toward BS871.5. Including G9, G10, G11, and G12 areas, corrosion can be found on outboard side flange and surface beneath the outboard flange. However no corrosion was found at the hat channel, these observations are described as below:

- G9-A area (BS813 ~ BS827): Bottom channel at centerline of stringer showed signs of surface corrosion. Corrosion was also found on the mating surface with the double T beam. The corrosion found on the bottom of channel, especially around the fastener holes, are severe, see figure 1.12-33.
- G9-B area (BS813 ~ BS827): Graydish corrosion deposits was found on the outboard side vertical web, showing signs of exfloration corrosion. See figure 1.12-34.

Figure 1.12-33 Corrosion Sites G8-A, G8-B, G9-A, G9-B

Figure 1.12-34 Corrosion Area G9-B

G10 area (BS827 ~ BS847): Hat section stringer, see figure 1.12-35.

- G10-A area: Bottom channel at centerline of stringer showed signs of surface corrosion similar to G9-A area.
- G10-B area: Graydish corrosion deposits was found on the outboard side vertical web, drain holes at BS 829.5 outboard side and BS844.8 inboard side were found heavily corroded showing signs of exfloration corrosion, stringer wall around the drain holes were consumed by the corrosion. See figure 1.12-36.

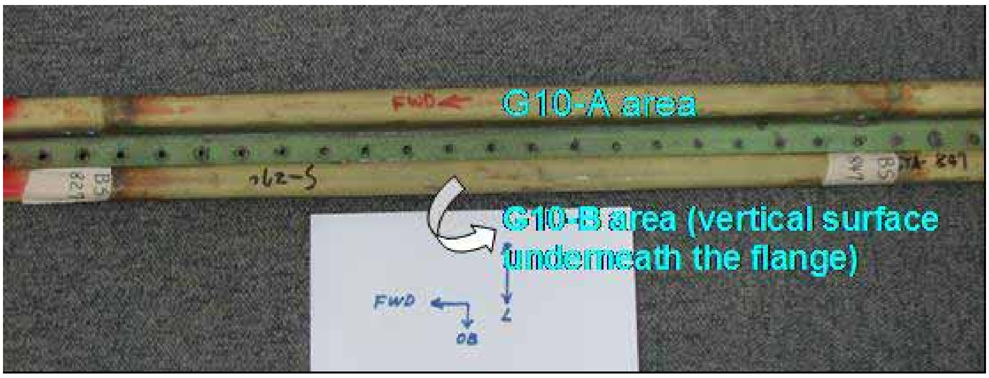


Figure 1.12-35 Corrosion Area G10-A、G10-B

Figure 1.12-36 Corrosion in G10-B Area

G11 area (BS847 ~ BS867): Hat section stringer, see figure 1.12-37.

- G11-A area: Bottom channel at centerline of stringer showed signs of surface corrosion similar to G10-A area. One rivet hole at BS849 was corroded that the hole was enlarged with irregular sharp edges.

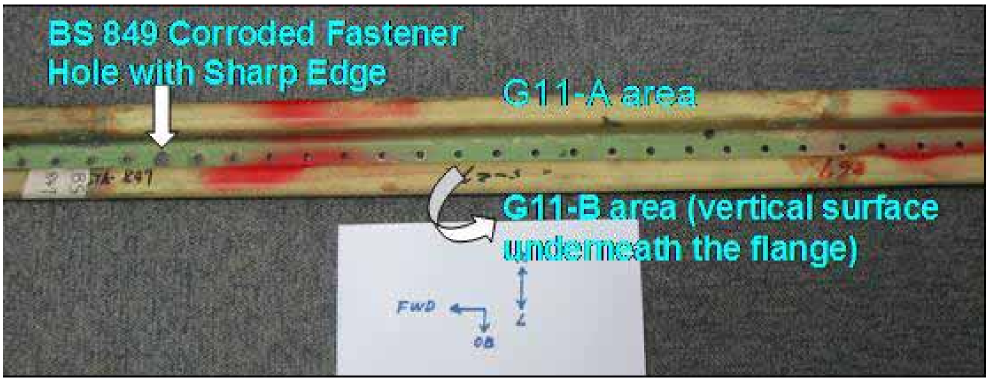


Figure 1.12-37 Corrosion Area G11-A、G11-B

- G11-B area: Graydish corrosion deposits was found on the outboard side vertical web, a drain hole at BS 851.2 outboard side was found heavily corroded showing signs of exfloration corrosion, stringer wall around the drain holes were consumed by the corrosion to enlarge the hole to 20mm in diameter. In addition, areas of pitting corrosion were found on the outboard side surface from BS847 ~ BS867 of the stringer. See figure 1.12-38.

Figure 1.12-38 Corrosion Area G11-B

G12 area (BS867 ~ BS887): Hat section stringer, spliced jointed with another formed hat section in between BS880 ~ BS883, see figure 1.12-39.

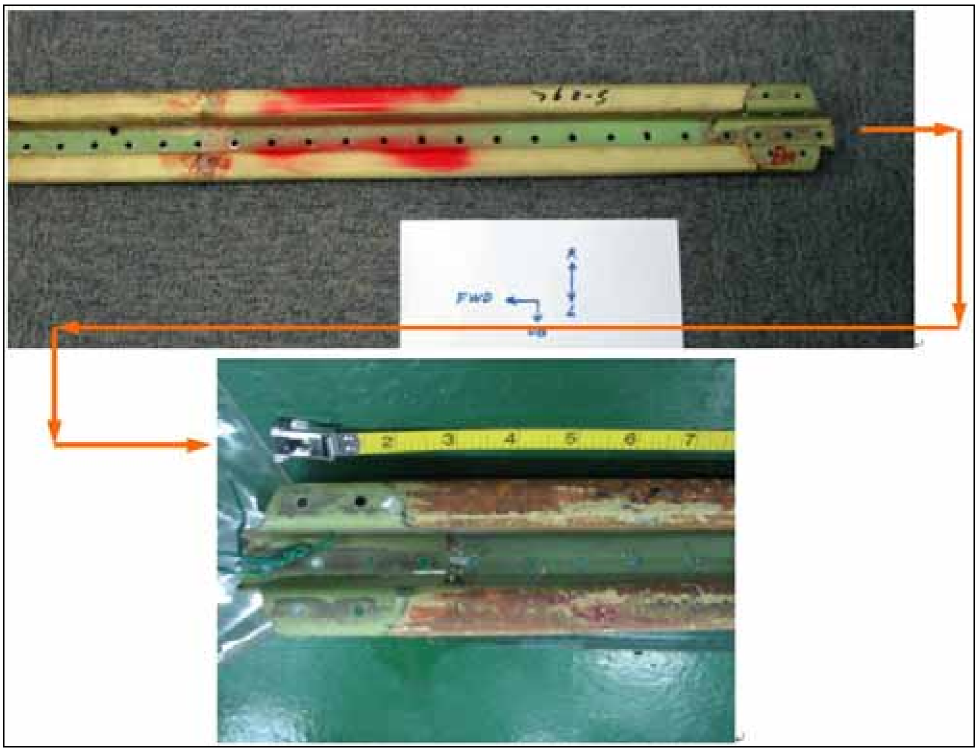


Figure 1.12-39 Corrosion Area G12

- G12-A area: Bottom channel at centerline of stringer showed signs of surface corrosion similar to G11-A area.
- G12-B area: Graydish corrosion deposits was found on the outboard side vertical web, showing signs of exfloration corrosion till BS871. See figure 1.12-40. The drain hole located at outboard side BS870.5 suffer heavy corrosion that the hole was enlarged with material loss, see figure 1.12-41.

Figure 1.12-40 Corrosion Area G12-B

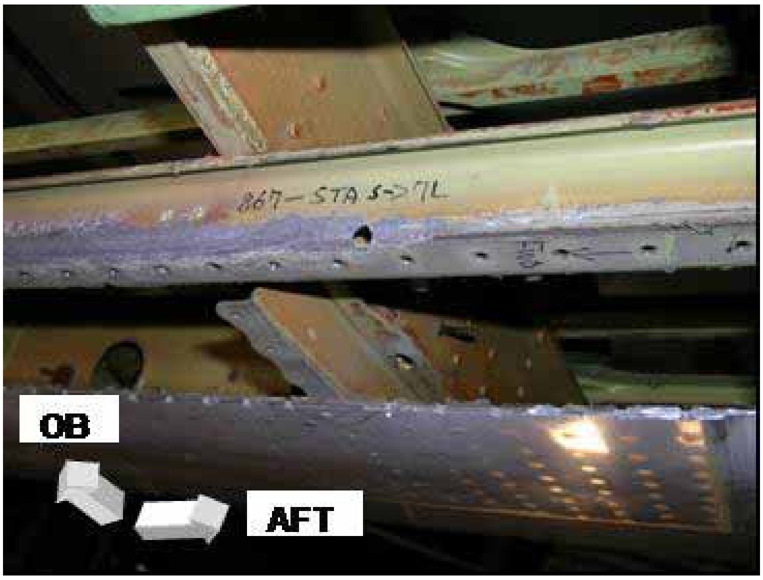


Figure 1.12-41 Material Loss on Stringer Drain Hole

G13 area (BS907 ~ BS927): Bottom channel at centerline of stringer showed signs of light surface corrosion. See figure 1.12-42 and 1.12-43.

Figure 1.12-42 BS 907~BS 917 Corrosion with G13 Area

Figure 1.12-43 BS 917~BS 927 Corrosion with G13 Area

G14 area (BS927 ~ BS947): Bottom channel at centerline of stringer showed signs of light surface corrosion. See figure 1.12-44.

Figure 1.12-44 Corrosion Area G14

G15 area (BS947 ~ BS967): Bottom channel at centerline of stringer showed signs of light surface corrosion. See figure 1.12-45 and 1.12-46.

Figure 1.12-45 BS 947~BS 956 Corrosion with G15 Area

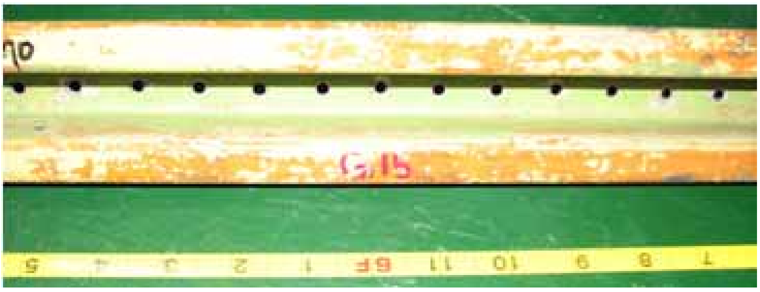


Figure 1.12-46 BS 958~BS 967 Corrosion with G15 Area

G16 area (BS967 ~ BS986.5): Bottom channel at centerline of stringer showed signs of light surface corrosion. See figure 1.12-47.

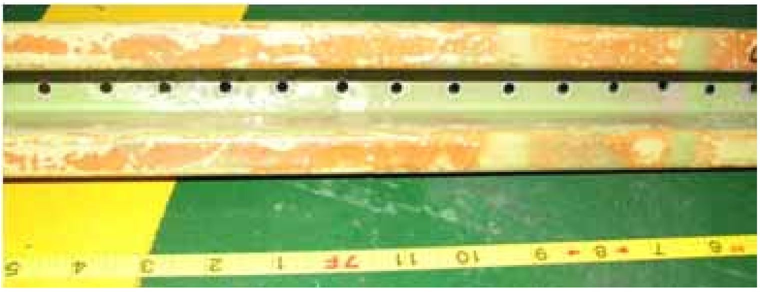


Figure 1.12-47 Corrosion Area G16

G17 area (BS986.5 ~ BS1006): Bottom channel at centerline of stringer showed signs of light surface corrosion. See figure 1.12-48.

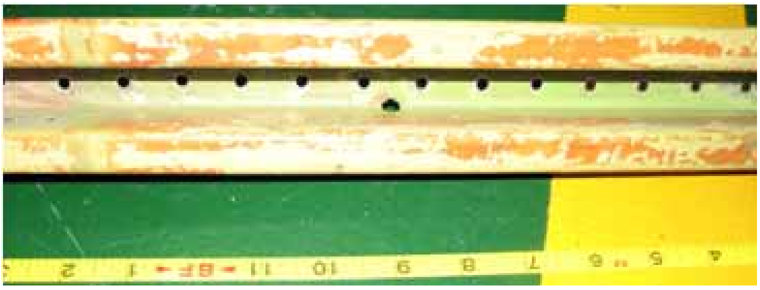


Figure 1.12-48 Corrosion Area G17

1.12.5 Damage to Intercostal

During investigation, the intercostals between BS867 ~ BS887, S-26L and S-27L, was found damaged with corrosion, and such heavy corrosion has resulted in a through hole, see figure 1.12-49. The outlet port of the waste water tank located upstream of outboard side of BS867 ~BS887 S-26L and S-24L, whilst the damaged intercostals was exactly at down stream of the leaking point of the waste tank outlet, see figure 1.12-50 and 1.12-51.

Figure 1.12-49 Corroded Intercostal with Material Lost Through Hole

Figure 1.12-50 Relative Positions of Leakage and Corroded Structure Parts

Figure 1.12-51 Leakage Downstream to Corroded Intercostal

1.12.6 Damage to Shear Ties

A shear tie is a bracket manufactured with a “T” cross-section aluminum alloy extrusion, with which to connect the fuselage frame and skin. Corrosion damage to the shear ties, which were found during investigation, are denoted H1 ~ H12 as in the Chart 1.12-3.

Table 1.12-3 Summary of Corroded Shear Ties

Denotation	BetweenS-27L / S-26L
H1	BS 727I
H2	BS 727J
H3	BS 747
H4	BS 767
H5	BS 787
H6	BS 807
H7	BS 827
H8	BS 847
H9	BS 867
H10	BS 927
H11	BS 947
H12	BS 987

In the Chart 1.12-3, the observed corrosion of the shear ties were all located on the lower surface of their lower flange. The shear ties at BS847 and BS867 were the most heavily corroded ones. For ferry flight purpose, all 12 corroded shear ties were replaced per operator’s EO 738-53-00-0068, see figure 1.12-52 and 1.12-53.

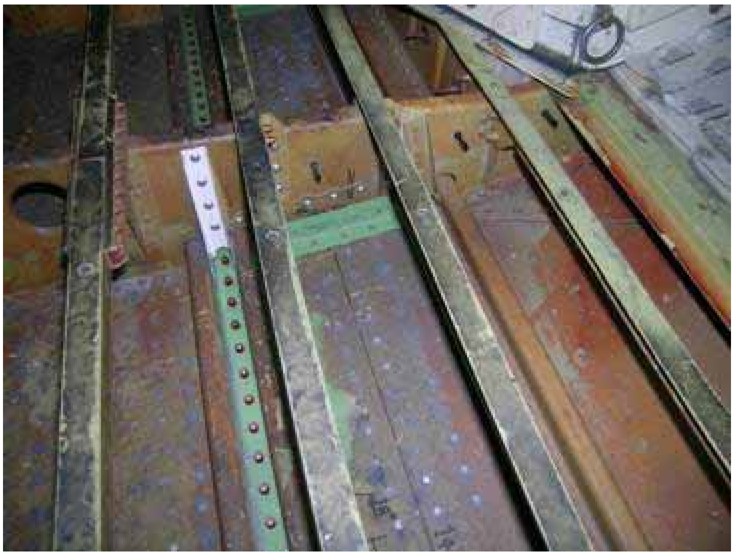


Figure 1.12-52 Shear Tie at BS847 between S-26L and S-27L

Figure 1.12-53 Shear Tie at BS867 between S-26L and S-27L

1.12.7 Relative Position to All Corrosion Parts

It is concluded that from the relative position of all corrosion damage to structure parts, these corrosion sites were concentrated along the flow path of leakage fluid from the leaking waste tank outlet coupler. In addition, the shapes of corrosion areas which can be visualized by observing the corrosion blending out areas were consisted with how the fluid was trapped in the lower portions of the airplane belly structure composed of stringer S-27L, shear ties, and the milled skin panels. All structure damage sites due to corrosion are summarized as in figure 1.12-54 for visualizing this finding.

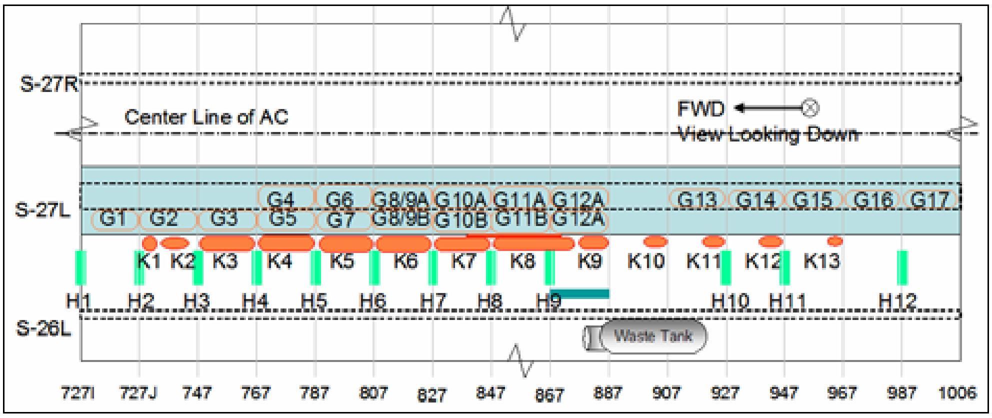


Figure 1.12-54 All Structure Corrosion Damage Sites Summary

1.12.8 Other Findings Regarding Structure Corrosion Issue

During the site investigation of cargo compartment in operator's home maintenance depot, mixture of the condensate water and the corrosion inhibiting compound (CPC) was found on the bottom of the aft cargo compartment. In addition, the CPC film was observed had being washed away at the bottom skin drain path of condensate water, however no corrosion was found at this area. See figure 1.12-55.

Figure 1.12-55 CPC on The Belly Skin

Although the CPC film was washed off by condensate water on the side fuselage skin panel in the aft cargo compartment during the site investigation of cargo compartment in operator's home maintenance depot, no corrosion was found neither, see figure 1.12-56.

Figure 1.12-56 Side Skin Panel with CPC Washed Off

1.13 Medical and Phathological Information

N/A

1.14 Fire

N/A

1.15 Survival Aspects

N/A

1.16 Tests and Research

The damaged skin was segmented properly and then sent to Chung-Shan Institute of Science and Technology (CSIST) for further examinations and tests on October 16 2007. The investigators from the Aviation Safety Council, personnel from NTSB, CAA, and CAL all participated throughout the entire process. The examination report was documented as in Appendix 4. To further verify the influence of corrosion, more metallographic examinations were conducted by CSIST and Graduate Institute of Materials Science and Technology, National Taiwan University of Science and Technology (NTUST). See Appendix 5 for the metallographic photographs.

The purger for waste tank was sent to Material and Chemical Research Laboratories, Industrial Technology Research Institute (ITRI) for further examination. The investigators from the Aviation Safety Council, personnel from

CAA, and CAL all participated throughout the process. The examination report was documented as in Appendix 6.

CAL performed a one time leakage inspection on the 737-800 fleet from Sep. 22 to Sep. 24, 2007. Twelve airplanes were inspected. Three airplanes were found to have cracks on waste tank outlet flanges Two out of those three aircrafts had waste water leakage and corrosion was found on the belly skin as shown in Fig.1.16-1 and Fig. 1.16-2. The corrosion was fixed in accordance with the manual. From the maintenance records, one of those two aircrafts had dirty in the region which was found during the latest inspection of waste tank compartment (AV4, Jul. 1, 2006) before the occurrence. The dirty was cleaned in accordance with the manual. CAL sold the other aircraft to a foreign airlines and no maintenance information available. These 3 waste tanks were removed and were sent back to the manufacturer (EDO Fiber Science) for inspection and overhaul. Manufacturer's test report is shown in Appendix 7.

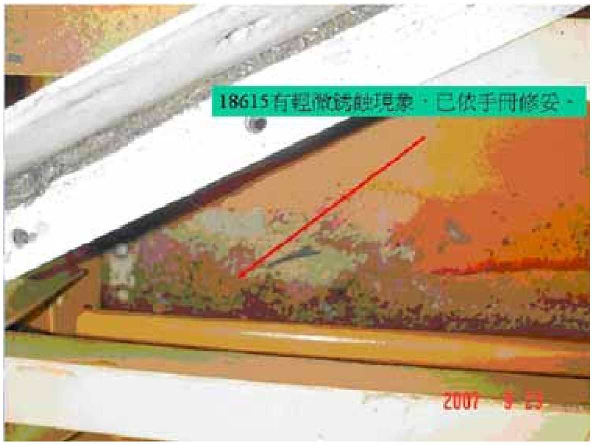


Figure1.16-1 Corrosion on aircraft B-18615

Figure 1.16-2 Corrosion on aircraft B-16802

1.16.1 Examination of the fuselage skin

Refer to figure 1.16-3, it shows the location of damaged skin, the crack had grown from BS839.2 and reached to BS869.7. Following the direction of crack, it passed adjacent to S-27L. For the purpose of material test, the damaged skin was segmented properly as shown in figure 1.16-4. Following examinations and tests were macro observation and photographic documentation, Scanning Electron Microscope (SEM) examination on fracture surface, chemical analysis by Chemical Analysis Energy Dispersive X-Ray Spectroscopy (EDS) and SPARK analysis, hardness and conductivity testing, metallographic examination, corrosive tests by Ion Chromatography (IC) method, to determine the root cause of failure.

The following sections summarized the results of the examinations and tests.

Figure 1.16-3Location of crack adjacent to the S-27L stringer

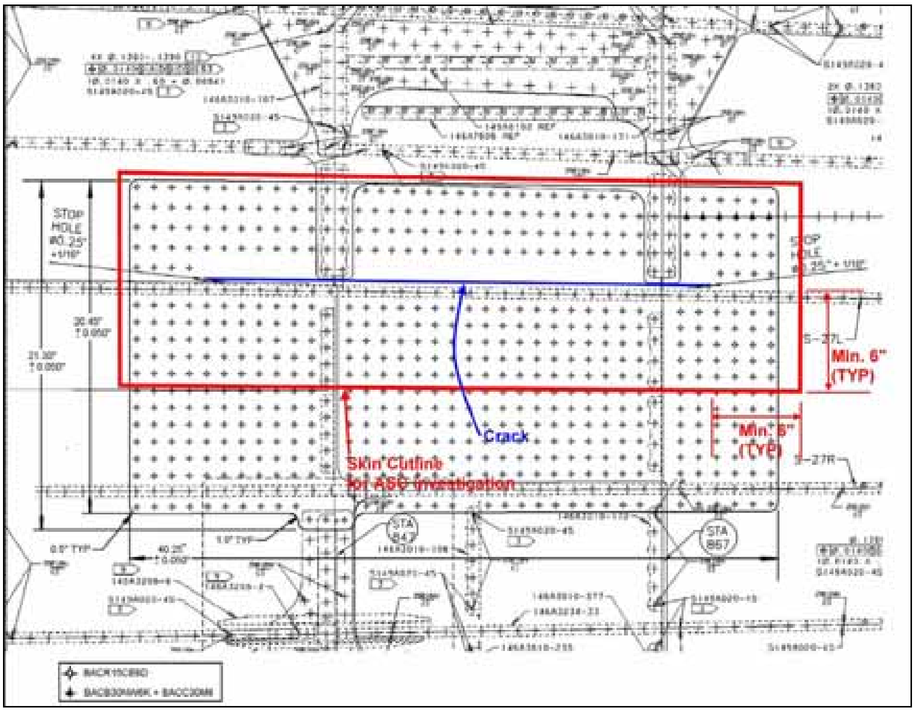


Figure 1.16-4Sampling of the damaged skin

1.16.1.1 Macro Observation

The damaged overall view of the interior and exterior surface of the damaged skin (sampling) was shown in figure 1.16-5 and 1.16-6. The interior surface of the sampling (indicated by circle in Figure 1.16-5) was covered with corrosion products, and the fracture surface was rugged and rough with corrosion products. The sampling was segmented to ten sections for macro observation and photographic documentation. Figure 1.16-7 shows the macro observation of fracture surface of item 1, and figure 1.16-8 for item 9. The fracture surface obviously revealed rougher and showed the corrosion features. This is a key feature of exfoliation corrosion. See Appendix 4 for the photographs of other items.

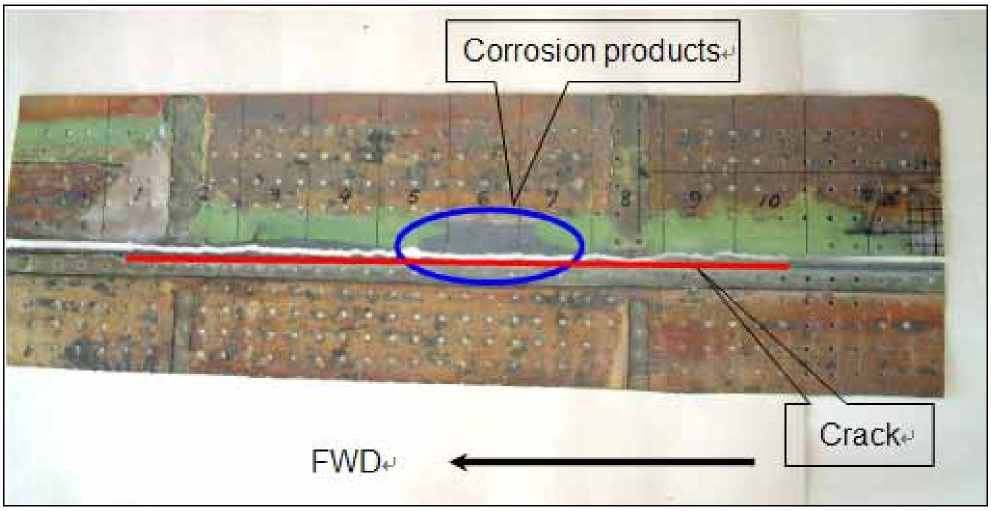


Figure 1.16-5Interior surface of the damaged skin

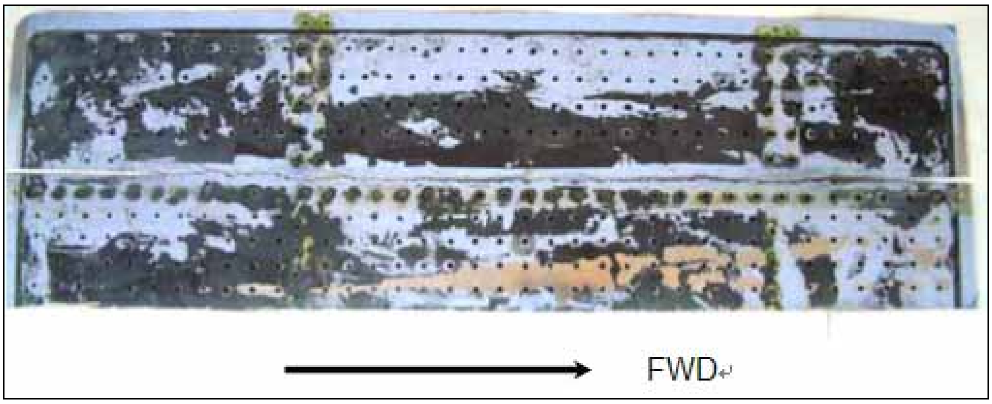


Figure 1.16-6Exterior surface of the damaged skin

Figure 1.16-7 Macro observation of item 1

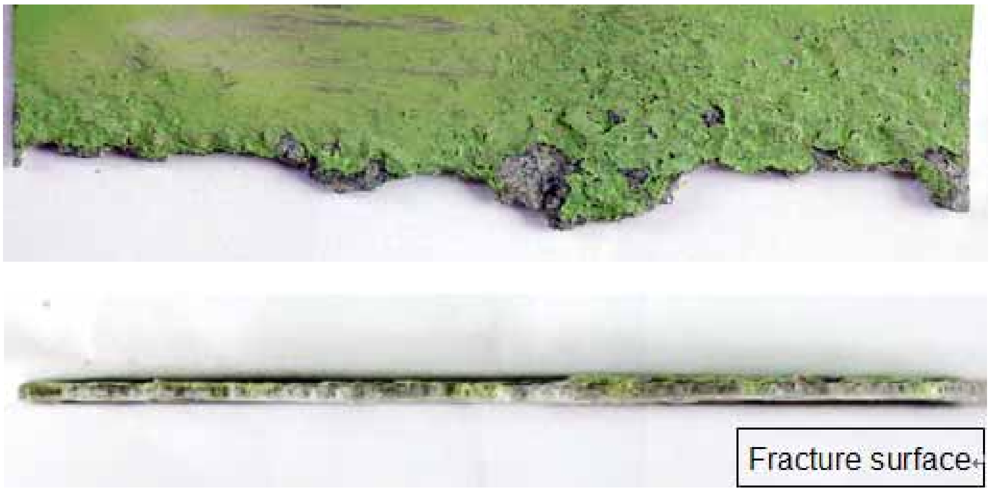


Figure 1.16-8 Macro observation of item 9

1.16.1.2 Examination of the Fracture Surfaces

The fracture surface of item 1 examined by Scanning Electron Microscope (SEM) was shown in figure 1.16-9. The topcoat was present up to the exterior surface of the skin, but the interior surface of the skin revealed in severe exfoliation condition. The fracture surface of item 9 was examined by Scanning Electron Microscope (SEM) shown in figure 1.16-10, the fracture surface near the interior surface of the skin revealed intergranular failure mode. Moreover, the fracture surface near the exterior surface of the skin revealed overload failure mode (dimple).

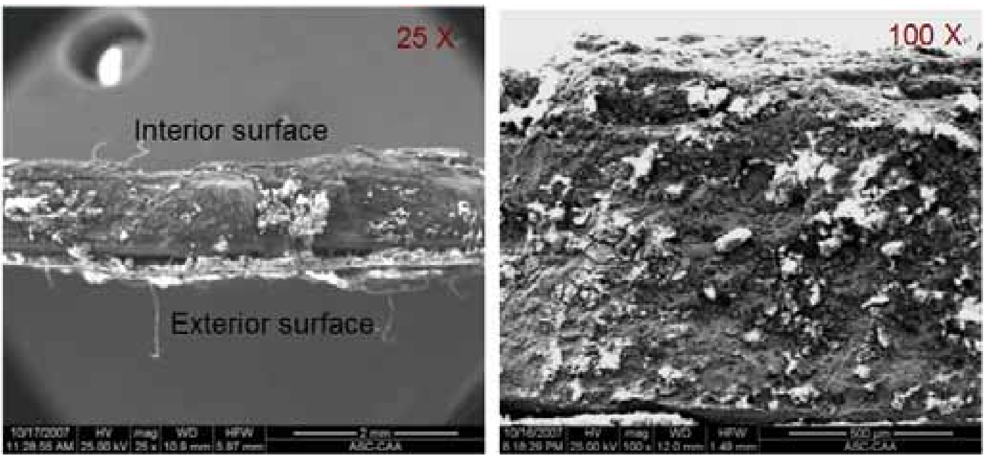


Figure 1.16-9Fracture surface of item 1

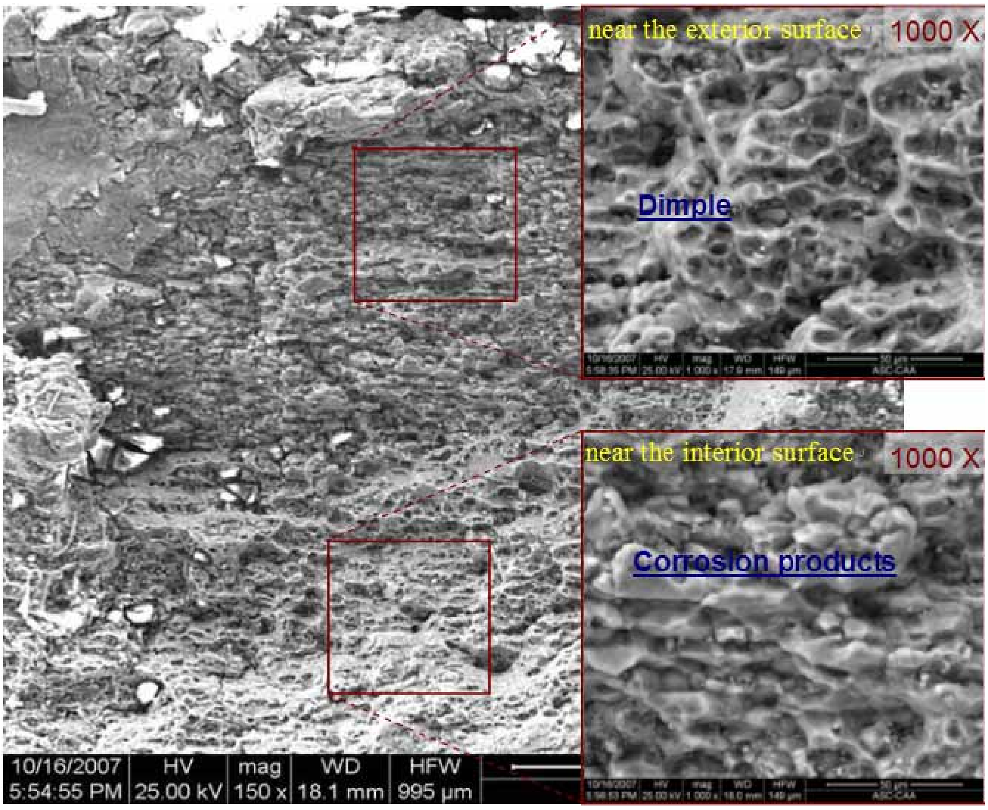


Figure 1.16-10 Fracture surface of item 9

Figure 1.16-11 showed the SEM photographs of item 5. The main failure cause of the fuselage skin is due to intergranular fracture and it possesses more area than overload.

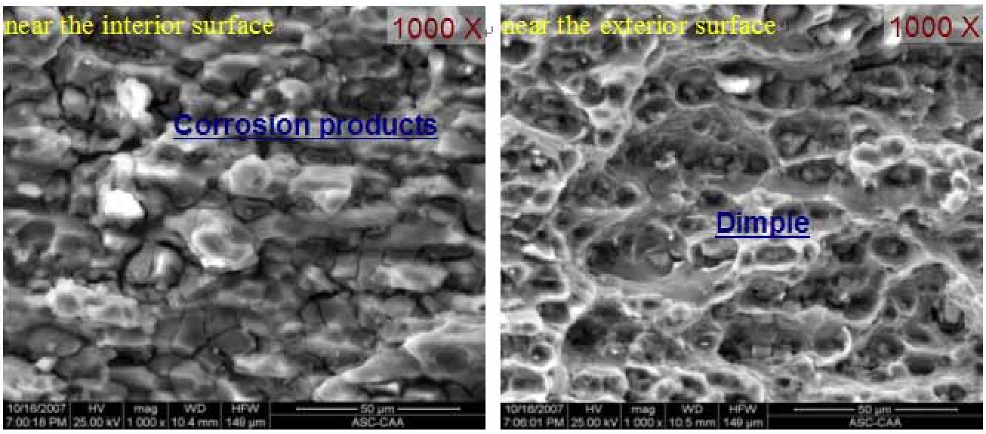


Figure 1.16-11 Fracture surface of item 5

The SEM photographs of fracture surface of item 5 near the interior surface revealed the same typical intergranular failure mode. Apparently this failure mode occurred from the interior surface of the fuselage skin and continued to grow to the direction of the skin depth, until its loading surface couldn't stand the load, which resulted in overload fracture (Figure 1.16-12).

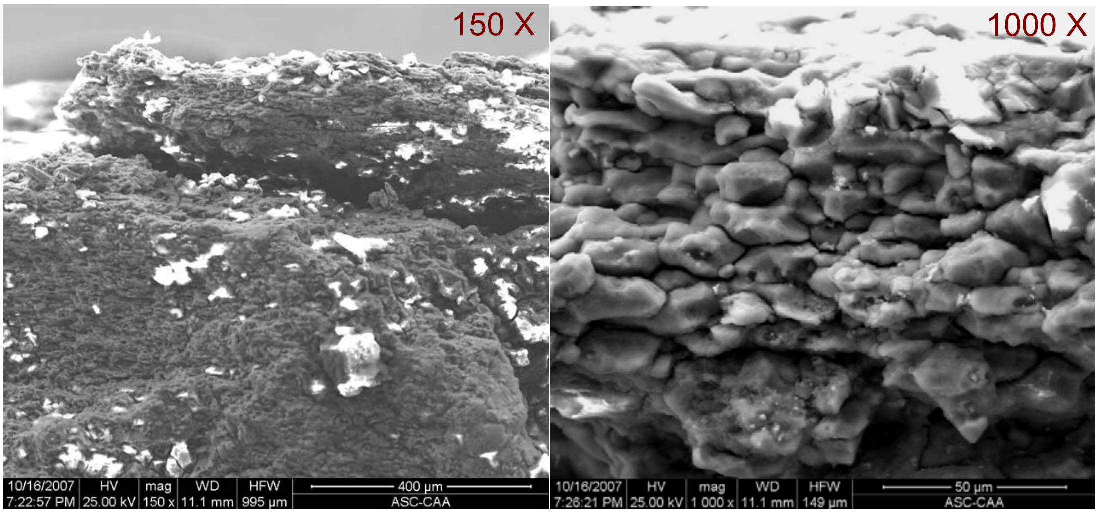


Figure 1.16-12 Fracture surface of item 5 near the interior surface

From the transverse metallographic section[3] of item 4, more intergranular fractures were found near the interior surface of the fuselage skin. It was clearly visible in which through the interior portion of the transverse direction, shown in

[3] the direction perpendicular to the crack

figure 1.16-13. The metallographic section was examined up to 100X, it was found that the thickness of the cladding of the fuselage skin near the fracture surface became a little thin, and the nipple feature was revealed obviously.

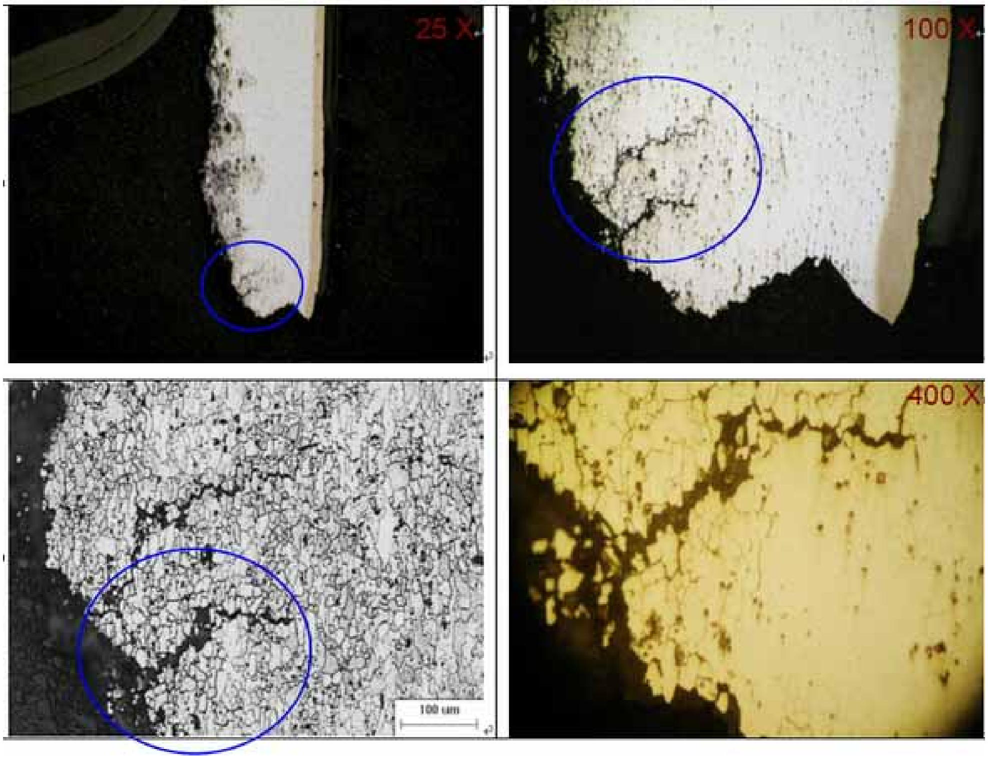


Figure 1.16-13 Metallographic photographs of item 4

1.16.1.3 Examination for Corrosion Products

In order to make sure the corrosive relationship between corrosion products and intergranular fracture, Chemical Analysis Energy Dispersive X-Ray Spectroscopy (EDS) was implemented to analyze the chemical composition. A little bit chlorine (Cl), which was the key element of aluminum alloy corrosion caused by chloride, was found (figure 1.16-14). To get more precise analytical results of the corrosive and to remove the factor of the chloride-rich marine environment, The Ion Chromatography (IC) method was necessary for further examination.

The corrosion products were scratched by knife and were crushed to powder, which was immersed into deionize water as a testing sample. To identify the contributing factor towards corrosion, the cleaner for waste tank (10% acetic acid) and a chemical reagent acetic acid were examined by Ion Chromatography (IC) method in advance. The results showed that the chemical composition of corrosion products were acetic acid and chloride.

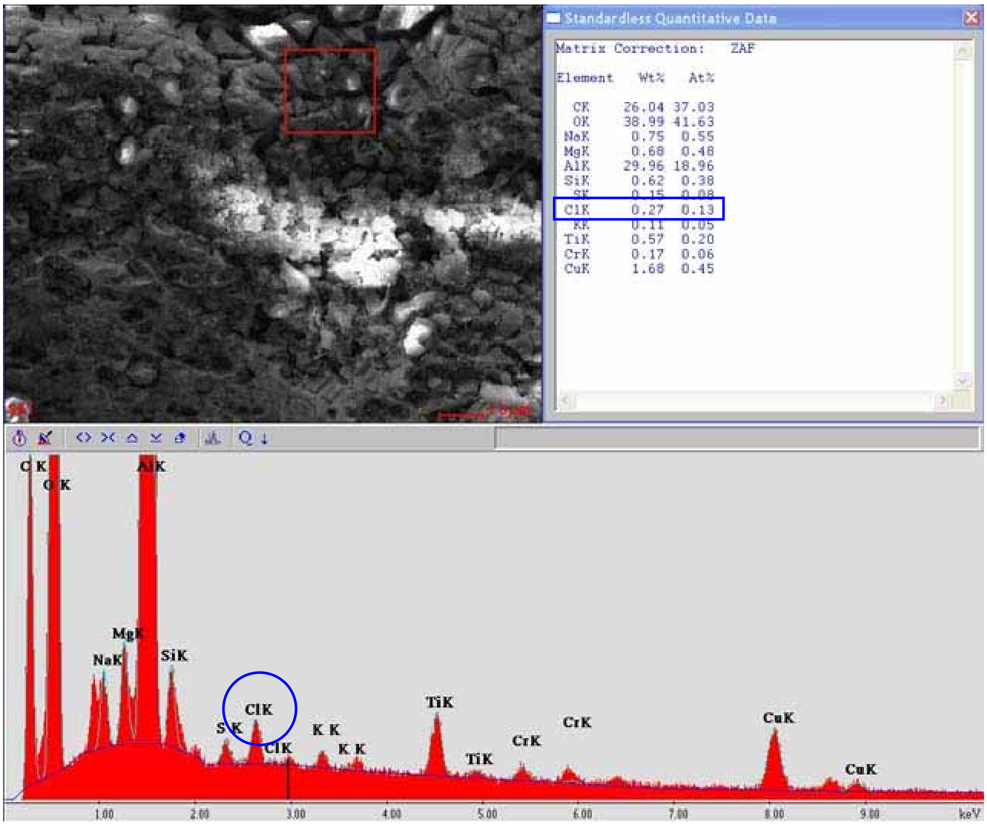


Figure 1.16-14 SEM/EDS photographs of item 9

1.16.1.4 Test results by CSIST

Base on the above analysis, conclusions of CSIST are made as follows:

1. *The fuselage skin of Boeing 737-800 commercial aircraft, No. B-16805, was reputed to be manufactured from alloy 2024(AMS-QQ-A-250/5A) in the T3 condition. The results indicated that the material met specification.*

2. *The fuselage skin failed as a result of exfoliation corrosion, which propagation from the interior surface (clad layer was removed by chemical milling process) toward the exterior surface. The failure analysis indicated that the corrosive that caused this type of exfoliation corrosion was probably chlorine ion in the presence of 10% acetic acid solution.*

3. *Both acetic ion and chlorine ion will be found from the extraction solution of corrosion deposit on the fraction surface of the fuselage skin. The chlorine ion which has main effective factor will be induced corrosion fracture to the detriment of the fuselage skin.*

4. *Both the cleaning liquid which was submitted by ASC and the extraction solution of corrosion deposit of the fuselage skin have the same composition of anions by Ion Chromatography method.*

1.16.1.5 Conclusion of Examinations and Tests

After the examinations and tests conducted at the Chung-Shan Institute of Science and Technology (CSIST), personnel from NTSB, CAA, and CAL all participated a technical meeting held by ASC on Oct. 18, 2007. The testing procedures, findings and summaries of the examinations and tests were described in the technical meeting, and the record of the meeting is listed in Appendix 1. The conclusions are made as follows: "The failure mechanism of the fuselage skin was caused by intergranular corrosion (exfoliation). The failure initiated from the regions of the inner surface of the fuselage skin, and subsequently propagated toward the exterior surface of the fuselage skin, the effective thickness of the fuselage skin became a little thin. The residual strength of the skin was not of sufficient magnitude and distribution to endure the hoop-wise stress resulted from cabin pressurization loads, finally the fuselage skin fractured due to the overstress."

1.16.2 Estimating Corrosion on Fracture Surface

Based on the results of the examinations and tests from CSIST, the corrosion is the contributing factor of the crack. In order to estimate the damage data caused by corrosion, more metallographic examination was conducted at by Graduate Institute of Materials Science and Technology, National Taiwan University of Science and Technology (NTUST). Thirty inspection items of metallographic sections were sampled from the damaged skin along the transverse direction, shown in figure 1.16-15. The metallographic processes included coarse grinding, mounting, polishing, lapping and etching.

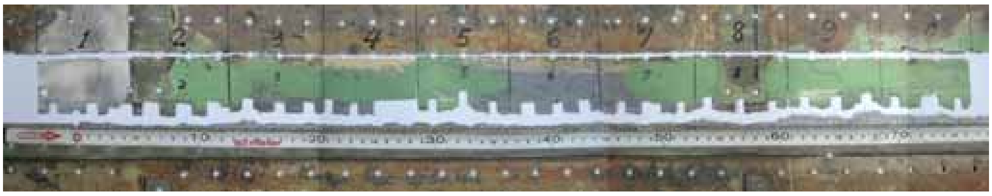
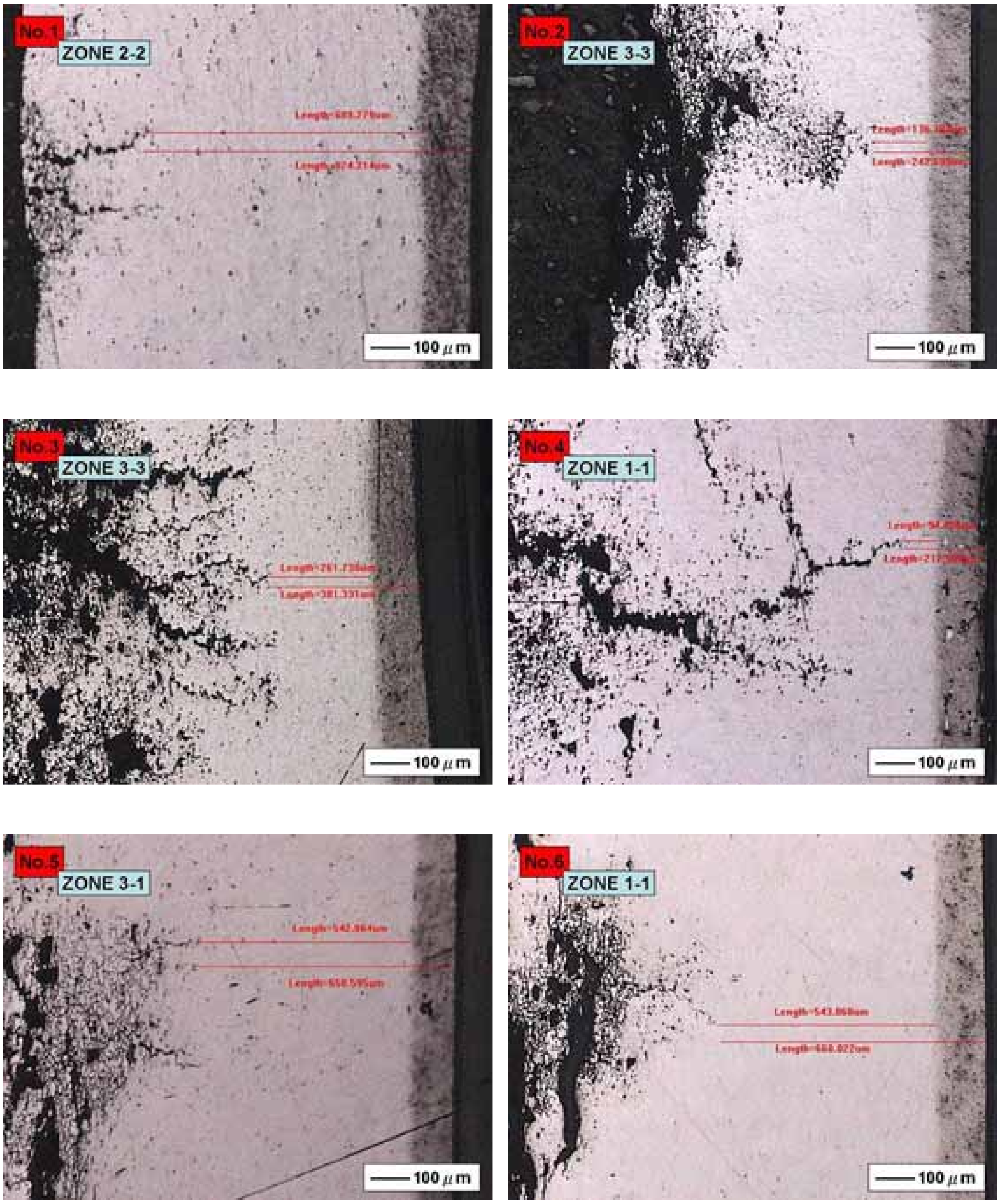


Figure 1.16-15 Sampling Metallographic Inspection Items

The pittings and intergranular fractures are found clearly in all inspection items. Figure 1.16-16 shows the metallographic photographs, severe corrosions are found in some inspection items, even some pitting almost passes through the skin, like item 2-3-3[4] , item 4-1-1and item 9-1-1, and the effective thicknesses of these items are 0.0054 in, 0.0037 in and 0.0044 in (the standard is 0.063 in

[4] Legend of inspection items: X is the number of part; Y is the relative position; Z is a random point that the pitting is clearly visible.

referred to Boeing Drawing). The metallographic photographs of other inspection items are documented as in Appendix 5. Table 1.16-1 is the sampling positions and the effective thicknesses of each inspection items. Figure 1.16-17 illustrates the corrosive condition of the damaged skin, blank area represents some damage caused by corrosion, and the remainder represents the effective thickness of the skin.



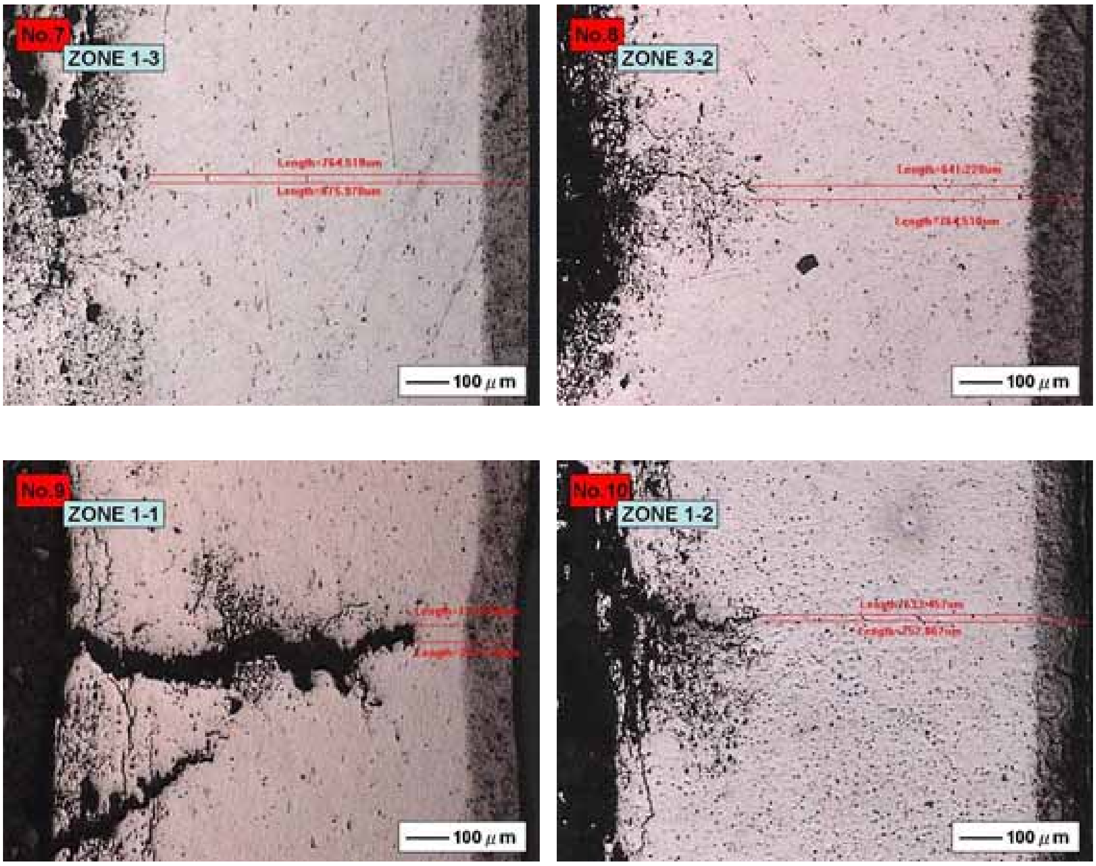


Figure 1.16-16 Metallographic photographs

Table 1.16-1 Effective Thickness of Inspection Items

No. Items	Sampling Position[5] (cm)	Sample 1 Effective Thickness (in)	Sample 2 Effective Thickness (in)	Sample 3 Effective Thickness (in)	Average Effective Thickness (in)
1-1	-2.3	0.0377	0.0429	0.0431	0.0412
1-2	0.9	0.0292	0.0271	0.0302	0.0289
1-3	3.5	0.0407	0.0295	0.0308	0.0337
2-1	5.5	0.0216	0.0187	0.0204	0.0202
2-2	8.3	0.0082	0.0139	0.0250	0.0157

[5] Sampling position along the direction of the crack

2-3	10.8	0.0238	0.0215	0.0054	0.0169
3-1	13.8	0.0114	0.0203	0.0250	0.0189
3-2	16.6	0.0152	0.0132	0.0185	0.0156
3-3	19.0	0.0249	0.0183	0.0103	0.0178
4-1	20.7	0.0037	0.0251	0.0257	0.0182
4-2	23.0	0.0130	0.0274	0.0147	0.0184
4-3	25.0	0.0238	0.0213	0.0201	0.0217
5-1	29.6	0.0279	0.0356	0.0305	0.0313
5-2	32.1	0.0296	0.0296	0.0337	0.0310
5-3	35.0	0.0214	0.0224	0.0366	0.0268
6-1	37.8	0.0214	0.0279	0.0327	0.0273
6-2	40.6	0.0234	0.0224	0.0252	0.0237
6-3	42.8	0.0215	0.0177	0.0298	0.0230
7-1	45.7	0.0134	0.0283	0.0301	0.0239
7-2	48.8	0.0291	0.0241	0.0300	0.0277
7-3	51.2	0.0288	0.0273	0.0275	0.0279
8-1	53.4	0.0359	0.0387	0.0326	0.0357
8-2	56.3	0.0335	0.0371	N/A	0.0353
8-3	59.1	0.0320	0.0252	0.0364	0.0312
9-1	61.7	0.0044	0.0210	0.0224	0.0159
9-2	64.4	0.0315	0.0233	0.0314	0.0287
9-3	67.1	0.0246	0.0272	0.0371	0.0297
10-1	69.5	0.0293	0.0249	0.0206	0.0250
10-2	72.1	0.0194	0.0275	0.0360	0.0276
10-3	75.1	0.0359	0.0346	0.0324	0.0343

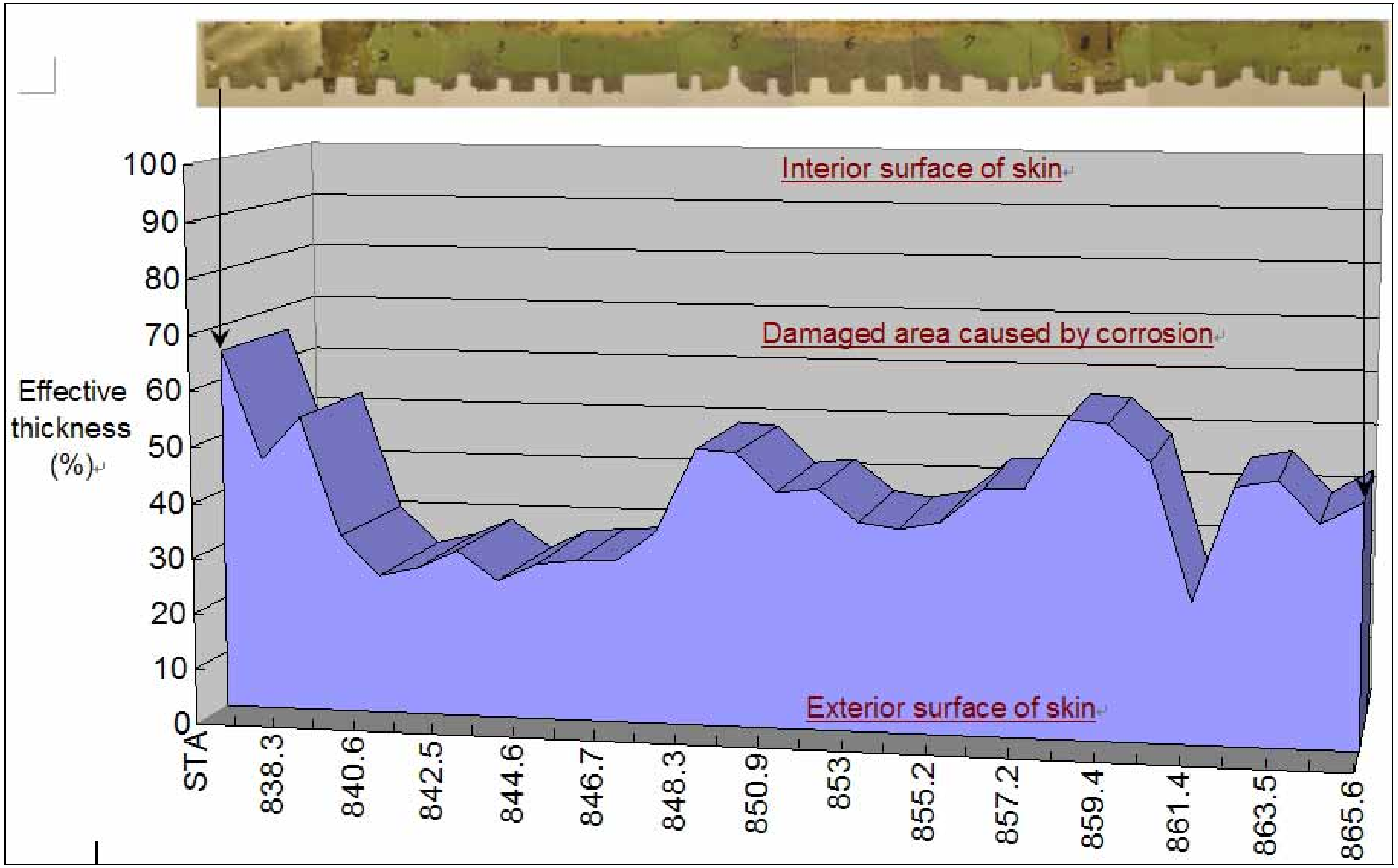


Figure 1.16-17 Effective thickness of the skin

1.16.3 Examination of Cleaner

To identify the contributing factor towards corrosion, the cleaner was examined at ITRI. Testing sample A is the cleaner for waste tank (10% acetic acid), and testing sample B is the groundwater[6] (the glacial acetic acid was diluted with the groundwater). The bleacher for sterilization of potable water was examined at ITRI for further examinations and tests on January 17 2008. The examination report was documented as in Appendix 6. Table 1.16-2 shows the examination results of purger, and table 1.16-2 shows the examination results of the bleacher.

Table 1.16-2 Examination result of cleaner

Item(s)	Method(s)	Sample A	Sample B	Glacial Acetic Acid
pH	pH meter	2.18	7.05	N/A
Cl^- ppm	Automatic Potentiometric Titrator	12.7	14.9	<1
$SO_4^=$ ppm	Ion Chromatography (IC) [7]	7.5	50.6	11.3

Table 1.16-3 Examination result of bleacher

Item(s)	Method(s)	Result
Total chorine w%	ASTM D2022[8]	3.5 ± 0.1
Active chlorine (ClO_2^-) w%	ASTM D2022	2.4 ± 0.1

[6] The groundwater is sampled on Nov, 01 2007

[7] Dionex-DX-500; Column:AS4A-SC, AG4A-SC; Flow Rate:2mL/min

[8] Standard Test Methods of Sampling and Chemical Analysis of Chlorine-Containing Bleaches

1.16.4 Waste Tank Examination

Followings are excerpts from “5. DISCUSSION OF RESULTS” of the examination report. The examination report was documented as in Appendix 8.

1. The forward surface of the fitting shows no signs of contact with the adjacent tube in the assembly.
2. The rounding of the aft flange is predominately in the 270 to 20 degree area, which is approximately opposite the forward flange mode 1 cracking in all three drains examined. However, components of the attachment clamp, including the sleeve or o-ring, are likely candidates.
3. The complexity of the mode 1 crack line indicates a complex loading situation. The mode 2 cracks in the forward flange are a distinctly different failure method. This failure method occurs in close proximity to the ends of mode 1 cracks, suggesting a pinch or pivot point. (Figure 1.16-18)
4. The two crack modes seen in the physical examination and shown in figure 8 of Appendix 8 are very similar to the crack behavior suggested by the finite element analysis. (Figure 1.16-18)
5. The close proximity of mode 1 and mode 2 cracks suggest the drain flange is under a bending loading with pivot points. (Figure 1.16-19 and 1.16-20)

Followings are excerpts from “6. CONCLUSIONS” of the examination report.

1. From the examination of the drain flanges, no definitive conclusions can be made.
2. There is evidence that the drain flange was in a continual state of complex loading as applied by a component of the drain flange clamp.
3. The failure appears to have been progressive and occurred over an extended period of time.

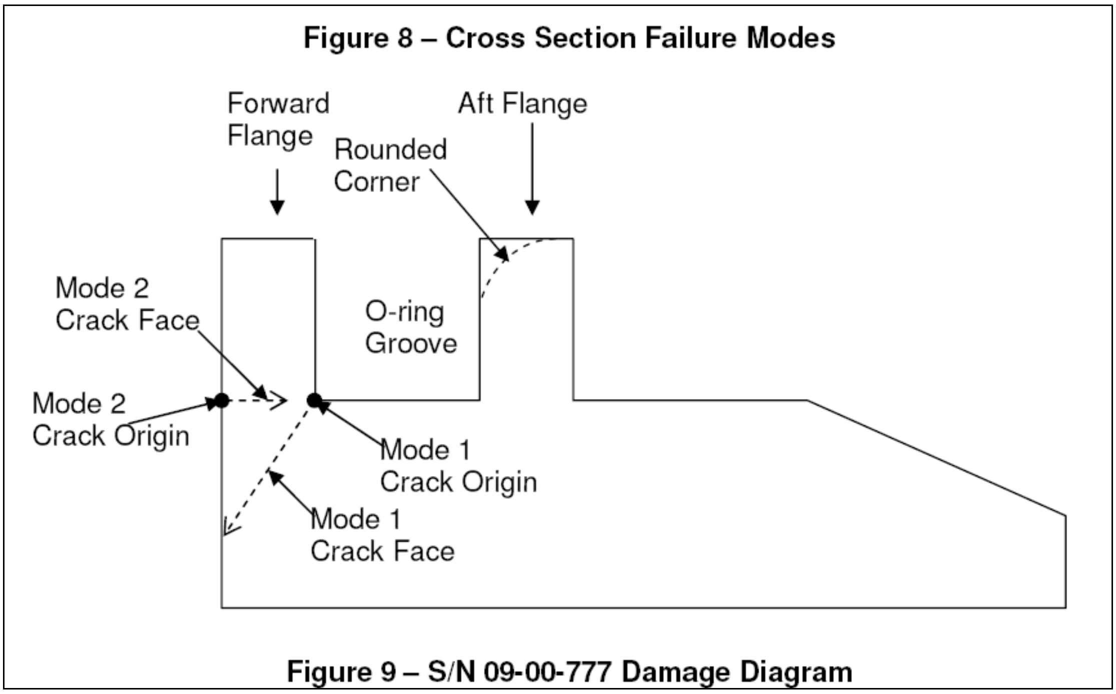


Figure 1.16-18 Cross sections of failure modes

Figure 19 – Finite Element Results, Forward + Down Combined Loading, Max Principal Stress

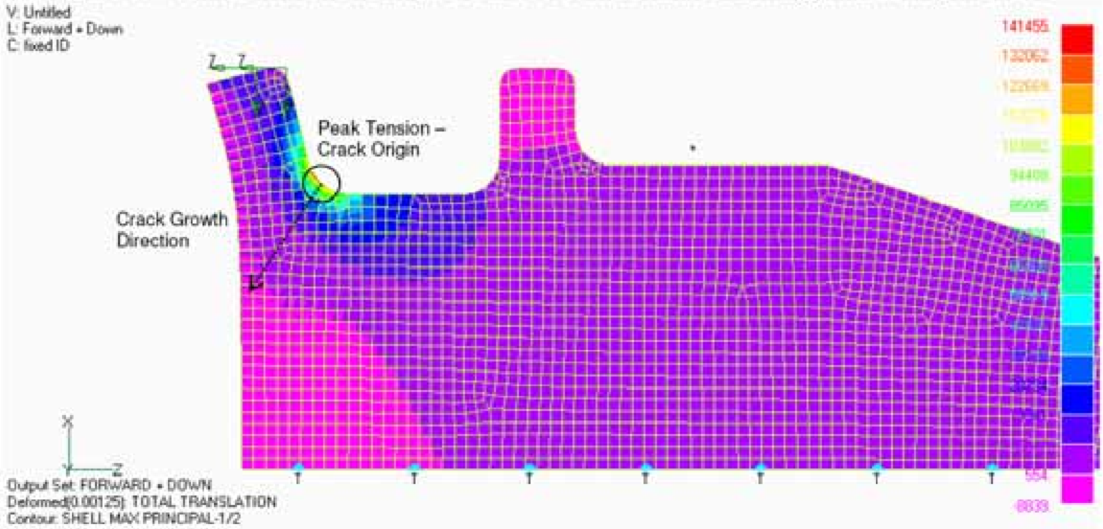


Figure 20 – Finite Element Results, Forward + Down Combined Loading, Min Principal Stress

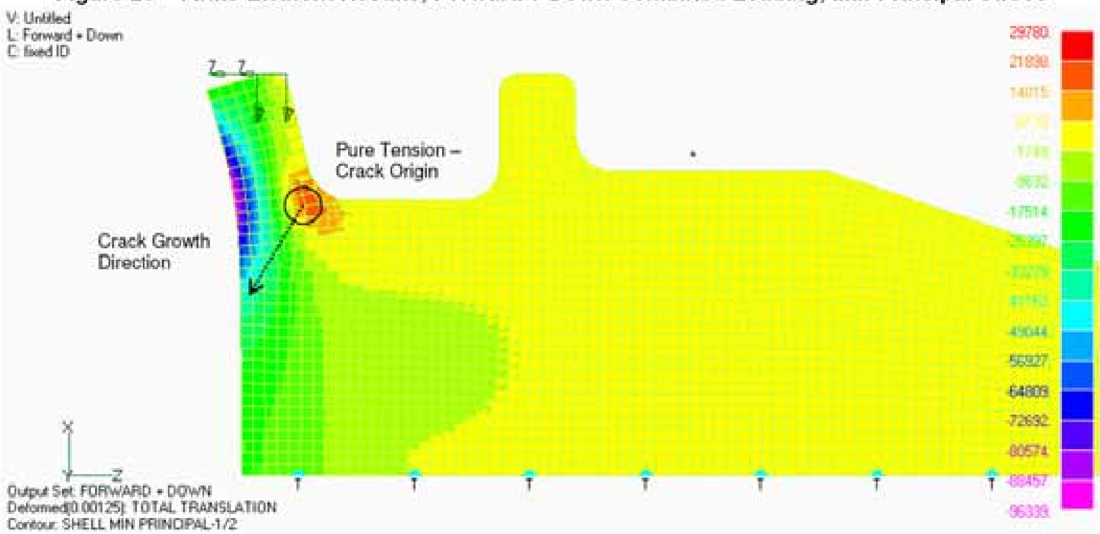


Figure 1.16-19 Mode 1 crack analyzed by FEA

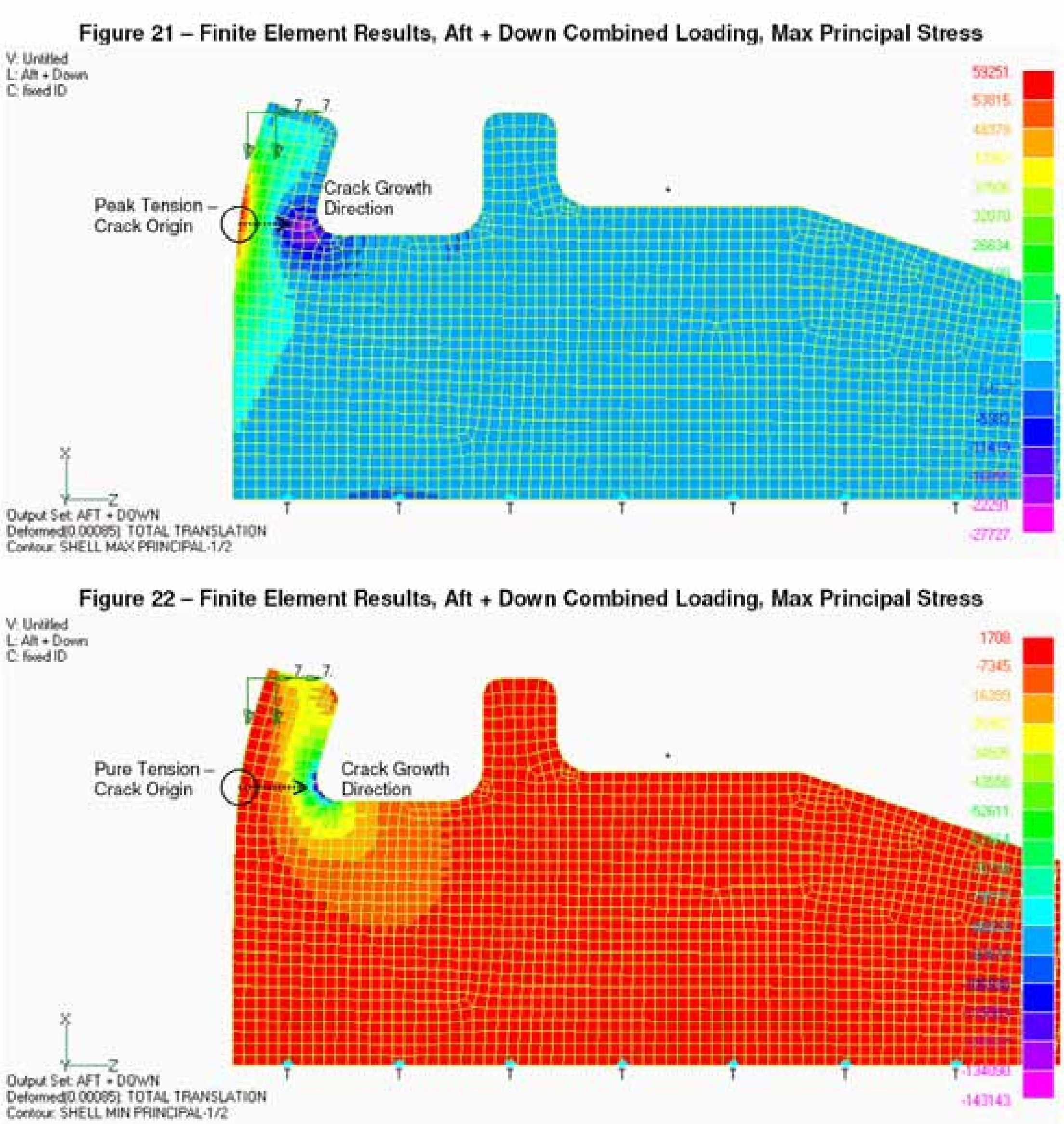


Figure 1.16-20 Mode 2 crack analyzed by FEA

1.17 Organizational and Management Information

N/A

1.18 Additional Information

1.18.1 CAL B737 Fleet Waste Tank Outlet Flange Information

1.18.1.1 Distance Measurement and Adjustment Between Waste Tank Outlet Flange and Tube

CAL maintenance personnel performed distance measurements on another two airplanes which was suspicious of waste water leakage that supervised by ASC investigators. The positions of measurement located on 3, 6, 9, and 12 o'clock looking aft from nose as shown in Figure 1.18-1. There were two airplanes with the measured distances larger than the gap dimension of 0.1500 in specified in Figure 1.18-1. Therefore, ASC coordinated CAL to perform distance measurement on the whole 738 fleet and extended the measurement to include the gap dimension between the short tube and the connecting ball valve. The results are shown in Table 1.18-1 (in inches).

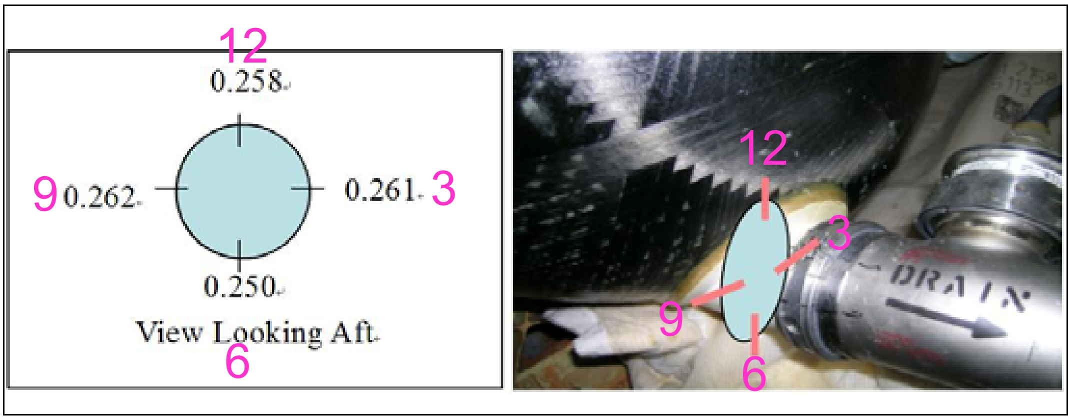


Figure 1.18-1Locations of Flange Distance Measurements

Table 1.18-1 Dimensions of Distance Measurements

Airplane Number	Location	3 o'clock	6 o'clock	9 o'clock	12 o'clock
#1	Waste tank outlet	0.261	0.250	0.262	0.258
#2	Waste tank outlet	0.126	0.130	0.111	0.115
#3	Waste tank outlet	0.348	0.310	0.275	0.331
#4	Waste tank outlet	0.043	0.087	0.084	0.051
	Short tube to ball valve	0.069	0.041	0.021	0.066
#5	Waste tank outlet	0.045	0.032	0.093	0.092
	Short tube to ball valve	0.051	0.090	0.061	0.042
#6	Waste tank outlet	0.206	0.187	0.191	0.235
	Short tube to ball valve	0.184	0.203	0.122	0.118
#7	Waste tank outlet	0.015	0.003	0.003	0.002
	Short tube to ball valve	0.030	0.103	0.080	0.018
#8	Waste tank outlet	0.246	0.205	0.058	0.132
	Short tube to ball valve	0.001	0.249	0.437	0.042
#9	Waste tank outlet	0.165	0.174	0.035	0.044
	Short tube to ball valve	0.006	0.508	0.391	0.227
#10	Waste tank outlet	0.182	0.210	0.194	0.179
	Short tube to ball valve	0.169	0.135	0.147	0.129

The measurements of airplane number #1 shown in Table 1.18-1 were the gap dimension after the replacement of a serviceable waste tank. The waste tanks of airplane number #1, #2 and #3 were removed and were all sent back to the manufacturer for repair. According to manufacturer's report, cracks were found on outlet flanges and were all located on 3-6 o'clock position. During the process of gap measurement, cracks were also found on outlet flanges of airplane number #4, #5, #7 and #10. The cracked waste tanks were all removed and replaced with a serviceable one. Photo of waste tank outlet and coupling short tube is shown in Fig. 1.18-2.

Figure 1.18-2Photo of Waste Tank Outlet and Coupling Short Tube

1.18.1.2 Trace of Contaction on the Inner Race of the Sleeve

In conducting the B737-800 fleet wide inspection for the gap between flanges mentioned in Section 1.6.5, the sampled sleeve from the #7 airplane, shown in Figure 1.18-3, the sleeve for coupling the short tube and ball valve, was visually examined for evidence of misalignment. On the inner race of the sleeve, two pairs of contacting marks from the short tube and from the ball valve can be observed; the pair from the short tube is clear whilst the other one from the ball valve seemed blurred. Within each pair, two traces are parallel with a 5 mm separation.

Figure 1.18-3Trace of Contact Marks on the Inner Race of the Sleeve

Certain tilt angle can be observed for these two pairs of contacting marks over the sleeve. Within the pair from the short tube, the contact mark from the forward flange measured 100 degrees in circle whilst 170 degrees for the mark from aft flange, these two mentioned contact marks are distributed at opposite half of the sleeve. No information of contacting mark orientation was obtained from removal of the sleeve.

1.18.2 Interview Information

1.18.2.1 Flight Crew Interview Notes

The summary of the “FLIGHT SAFETY OCCURRENCE CREW INTERVIEW REPORT”, “CHINA AIRLINES CREW REPORT” and “PURSER’S TRIP REPORT” which provided by China Airlines as follows:

The first officer carried out the “360 degree” check before take-off and no anomalies had found on the aircraft.

The captain operated the aircraft in the initial climb to flight level 370, the final cruise altitude was flight level 390, and the aircraft condition was normal. The out flow valve was not at full-close, the measuring appliance had not demonstrated that still had a distance from the closed-position which was no different with the regulars flight. The whole flight was stable, no turbulence, and the “fasten seatbelt” lights had switch on at takeoff and landing only. The aircraft landing was normal and stable. In the “360 degrees” check, the onboard mechanician had discovered that the fuselage had a crack. The following flight was canceled after contact with Taipei.

The cabin crew at door-3 did not find out abnormal or noise during landing. No cabin crew or passenger had reported that the cabin has anomaly.

1.18.2.2 Maintenance Operations Interview Data

ASC investigator sent email to CAL to inquire about the execution of the zonal inspection of waste tank compartment and its related problems. CAL replied no abnormality was found. Investigators also went to CAL to interview the inspector who executed the latest zonal inspection of waste tank compartment before the occurrence. The inspector answered that no waste water leakage or stain on the insulation blanket was found. The work was accomplished with no abnormality. Investigators also asked, what corrective actions would be if leakage were found during the inspection of waste tank compartment, and stain or wet were found during the inspection of insulation blanket. The inspector answered that a work order will be issued to request the removal of covering and then to carry out a thorough check.

1.18.3 Investigation Process and Parties cooperation

September 20th, 2007, a Boeing 737-800 aircraft, registration number B-16805, operated by China Airlines, flight number CI7552, from Taoyuan International Airport, Taiwan to Saga Airport, Japan. At 1326 local time, the aircraft landed in Saga. During transit check, a 30 in (77 cm) through crack located at lower belly below the after cargo door of fuselage skin was found.

Since the state of occurrence was Japan, the investigative authority was under Japan's jurisdiction. After Aviation Safety Council (ASC), Taiwan negotiated with ARAIC, Japan, in accordance with ICAO annex 13, the investigative authority was delegated to ASC, Taiwan.

- On Sep. 27, 2007, ASC appointed an IIC to initiate the investigation.
- On Sep. 28, 2007, the IIC summoned organization meeting, reported to National Transportation Safety Board, USA (NTSB) and Boeing Company (Boeing). Communicated with CAL knew that the aircraft was repaired in accordance with Boeing's instructions and ready to return.
- On Oct. 2, 2007, NTSB notified ASC its accredit representative and contact information.
- On Oct. 4, 2007, ASC asked CAL and knew that CAL repair team went to Civil Aviation Board, Japan (JCAB) to report the history of repair. NTSB inquired ASC about follow-up plan on the investigation and notified that some on site photos would be available soon. ASC informed NTSB about follow-up investigative plan and requested to send the on site photos to ASC after available.
- On Oct. 5, 2007, ASC received the photos about corrosion on the occurrence aircraft from NTSB through electrical mail
- On Oct. 11, 2007, ASC on board the aircraft to inspect the condition of damage after the aircraft return to Taiwan.

CAL notified ASC that on September 26, CAL sent a paper report to Saga airport authority about the plan how to carry out its temporary damage repair. The personnel from Japan Civil Aviation Bureau (JCAB) stationed in Saga airport also involved in the operation. During the temporary repair, CAL did not contact ARAIC personnel and ARAIC personnel did not go to Saga airport to investigate the occurrence. CAL only coordinated Saga airport authority and JCAB about the repair. On October 5, CAL sent a paper report to Saga airport authority about the finish of its temporary repair. CAL provided ASC the communications between them and Boeing Customer Support about temporary repair on the aircraft. After the aircraft ferried to Taiwan, ASC investigators had chance to inspect damage of the aircraft, but the corrosion was removed and the temporary repair was done. ASC requested CAL to provide all related photos before the temporary repair. The requested photos were received before the investigation report was finished.

2. Analysis

2.1 Analysis of Crack Generating

Base on above descriptions in section 1.16.1.5, the conclusions of the examinations and tests of CSIST are as follows: “The failure mechanism of the fuselage skin was caused by intergranular corrosion (exfoliation). The failure initiated from the regions of the inner surface of the fuselage skin, and subsequently propagated toward the exterior surface of the fuselage skin, the effective thickness of the fuselage skin became a little thin. The residual strength of the skin was not of sufficient to endure external load, finally the fuselage skin fractured due to the overstress.”

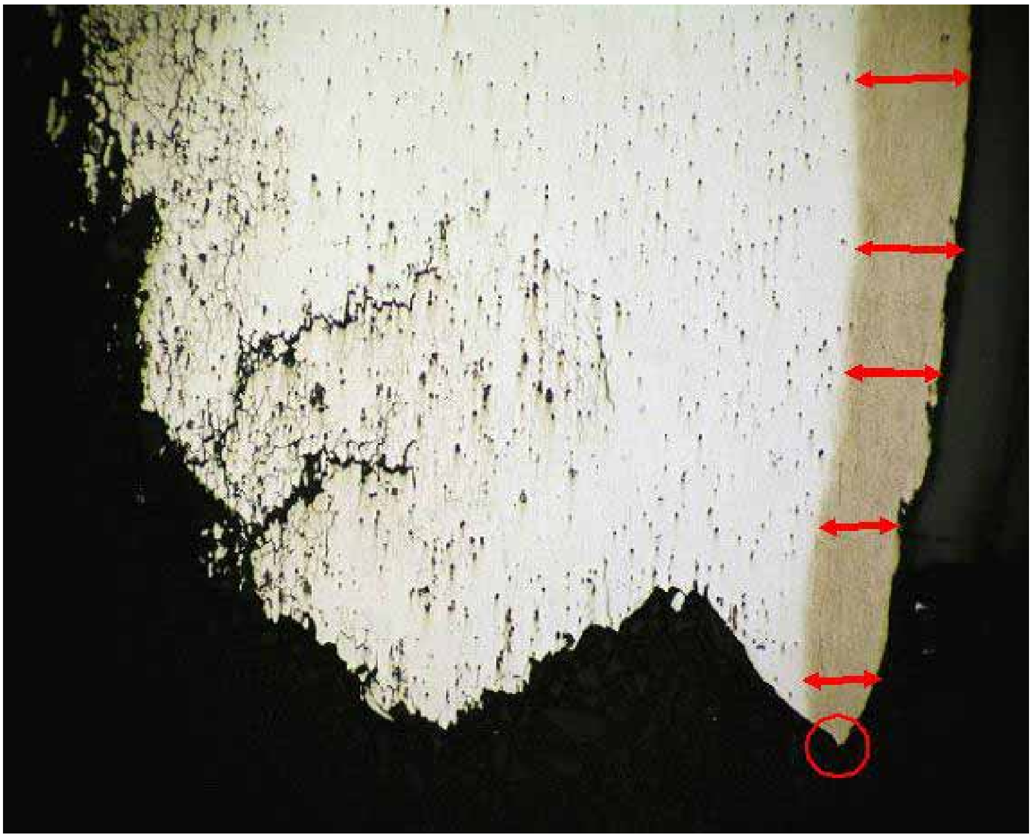


Figure 2.1-1 Metallographic photograph of item 4 (100X)

Figure 2.1-1 shows the metallographic photograph of item 4 (100X), the right side represents the pure aluminum cladding, the thickness of the cladding near the fracture surface becomes thinner, and the nipple feature is revealed obviously. The deformation of the aluminum cladding near the fracture surface provides evidence that the skin endures the hoop-wise loads and results in compressive deformation of the ductile aluminum cladding near the fracture surface. The remaining fracture of cladding displays “nipple”, which is typical of continuous tensile loading to ultimate tensile separation. The “external loads”, discussed in the conclusions of the examinations and tests of CSIST, is considered as the hoop-wise stress associated to the operating of aircraft.

2.2 Cause of Structure Corrosion

From the inspection results including paragraph 1.12.1 to 1.12.6, also referring to figure 1.12-4 locations of damage, it is obvious that all damages are at internal of airplane and limitted within the area where leaked waste water accumulated and trapped. In 1.12.7 described that all other structural members of the aft cargo compartment, below the cargo floor or at side wall area, were not affected by the corrosion. Though CPC for the skin structure showed signs of washed out and resulted in a mixture of water and CPC gathered on the bottom, it is identified the condensation water, resulted from normal operation in an environment of wide temperature variation, has no negative effect to the structure with its forming, flowing, and accumulating over the fuselage skin. The only contributing corrosion source is concluded to be the leakage of waste water from the leaking waste water system. The possible corrosion history is predicted as in Appendix 9.

2.3 Airplane Manufacture and Design

2.3.1 Waste Tank Outlet Couplings

After the occurrence, CAL carried out an one time inspection on the 737-800 fleet. The same waste water leakage problem was found on two other airplanes while one of them had slight corrosion on airplane structure. ASC investigators coordinated CAL to perform an installation quality check of 737-800 fleet on the coupling between waste tank outlet and its adjacent short tube. The examination showed that there were unmatched centerlines, skewed centerlines and their combination on the couplings.

2.3.1.1 Unmatched Centerlines

During installation, the coupling of waste tank outlet and its adjacent short tube are confined within a sleeve. An ideal installation is that the centerline of waste tank outlet overlaps that of the adjacent short tube and becoming a single centerline (refer to Figure 2.3-1). Poor workmanship or installation quality causes two parallel centerlines instead of a single one (refer to Figure 2.3-2). It will result in stress along radial direction on the contact points of sleeve and two adjacent tubing flanges. The same situations were showed in Figures 17 and 18 (refer to Figure 2.3-3) of the manufacturer's test report. Because of the restrictions on tools and space, ASC did not measure the matchness of centerlines.

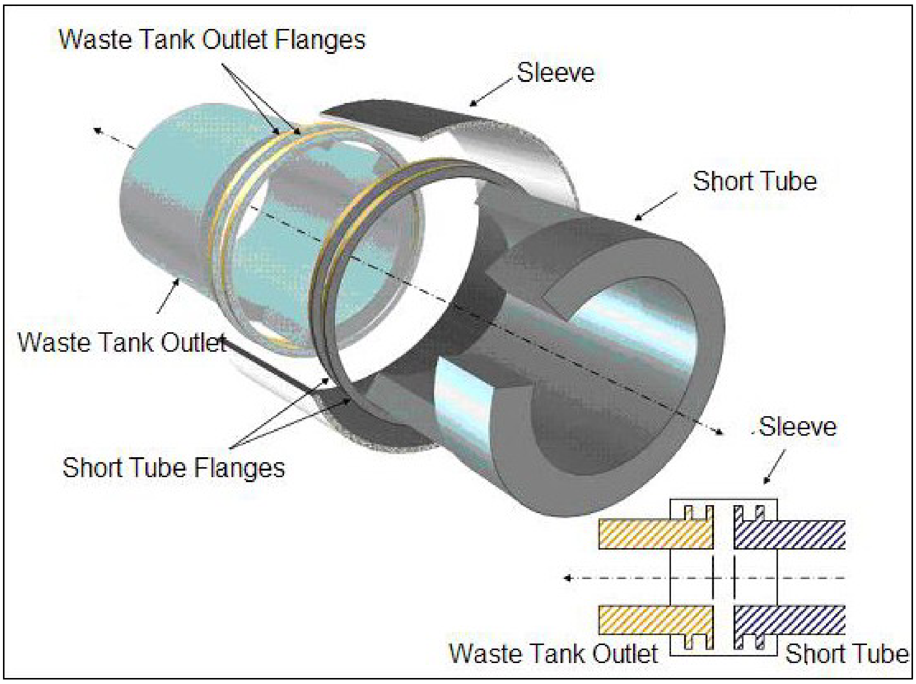


Figure 2.3-1 Overlapped Centerlines

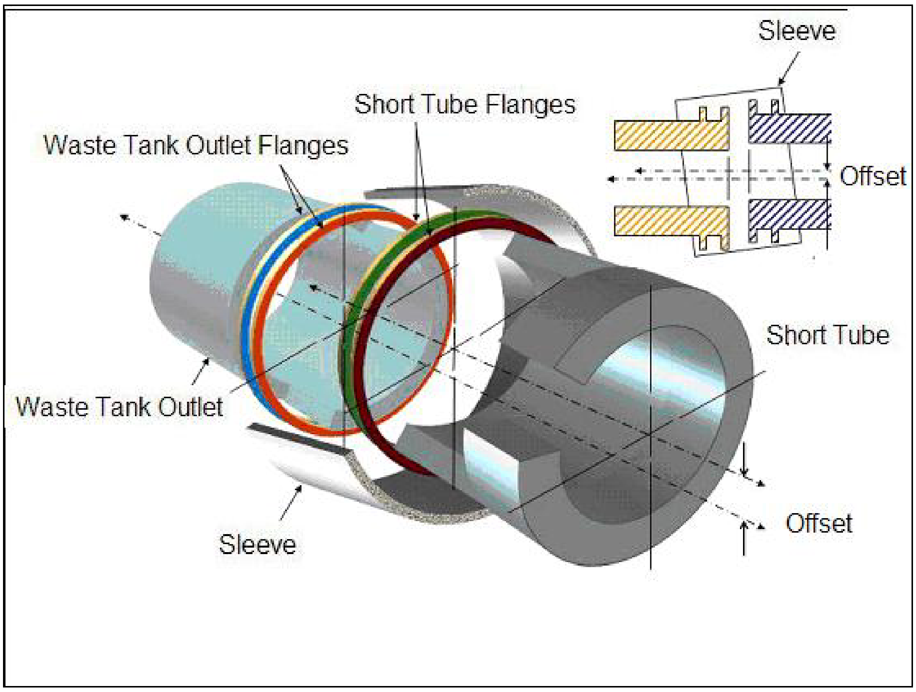


Figure 2.3-2 Parallel Non-overlapped Centerlines

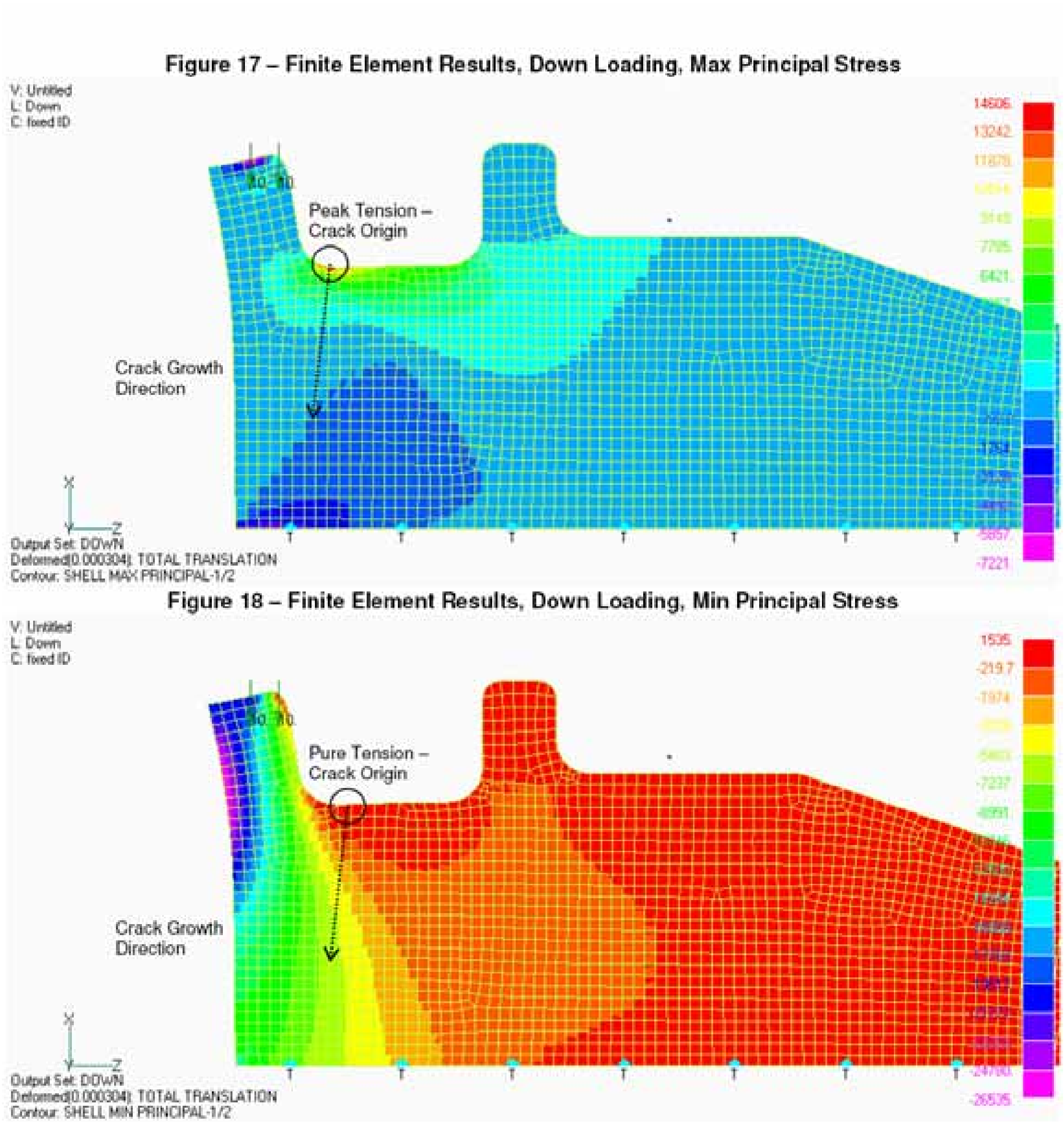


Figure 2.3-3 Mode of Down Loading on Front Flange

2.3.1.2 Skewed Centerlines

Instead of overlapped centerlines, if the extended centerlines of both sides intersect at one point (refer to Figure 2.3-4) during installation, the end faces of flanges will be changed from parallel to skewed plane. This results in different gap distance between two adjacent tubing flanges and the skewed plane causes the compression of sleeve on the flange. Combined stress will be produced from axial and radial directions at the location with small gap distance. The same situations were showed in Figures 19 and 20 (refer to Figure 2.3-5) of the manufacturer's test report. The combined stress causes mode 1 crack (refer to Figure 2.3-7) as shown in Figure 8 of the manufacturer's test report. While for the location with large gap distance, combined stress will be produced from radial and axial directions. The same situations were showed in Figures 21 and 22 (refer to Figure 2.3-6) of the manufacturer's test report. The combined stress causes mode 2 crack (refer to Figure 2.3-7) as shown in Figure 8 of the manufacturer's test report.

According to a test report (QUALIFICATION TESTING OF HYDRAFLOW 15J02/14F02 SERIES COUPLINGS AND FLANGES TO THE REQUIREMENTS OF BELL-BOEING DRAWING NO. 901-366-582 REV. N/C, JANUARY 29, 1987) provided by Boeing, the sleeve and tube flange interface is designed and tested to accommodate up to 3 degrees of difference in the angle of the centerlines, or three degrees of skew at the centerline of the two adjacent fittings at this interface. It is possible that a skewed centerline condition could exist, providing it is less than a three degree angle, which would not result in stresses at the flange of either interfacing component.

From Appendix-2, Gap Measurement and Angle Calculation, there were two aircrafts had the misalignment angle greater than three degrees at each ends of the short tube.

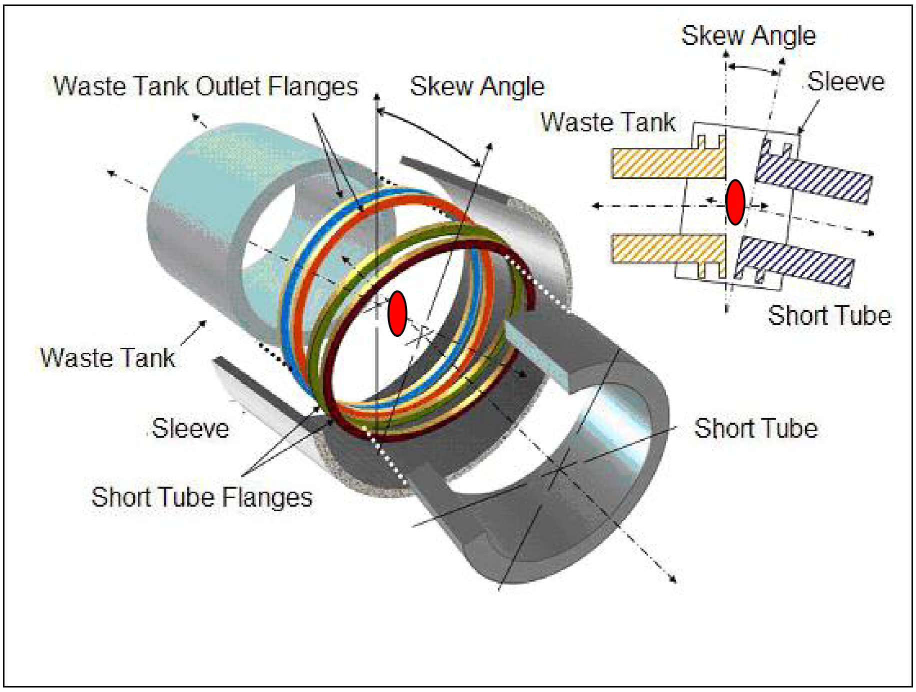


Figure 2.3-4 Non-overlapped Centerlines Intersect at One Point

Figure 19 – Finite Element Results, Forward + Down Combined Loading, Max Principal Stress

Figure 20 – Finite Element Results, Forward + Down Combined Loading, Min Principal Stress

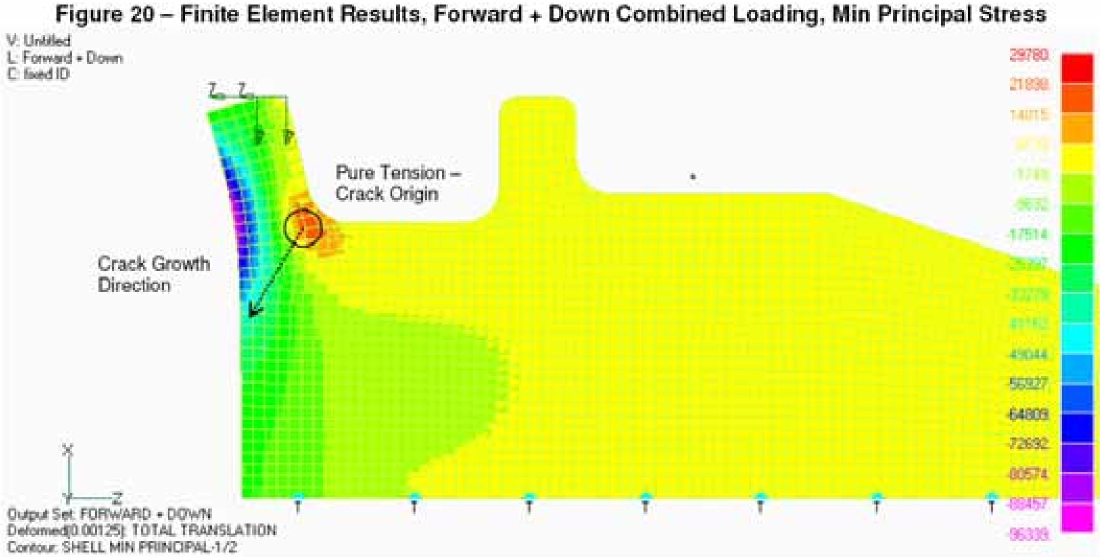


Figure 2.3-5 Mode 1 Crack Due to Combined Forward and Down Loading

Figure 21 – Finite Element Results, Aft + Down Combined Loading, Max Principal Stress

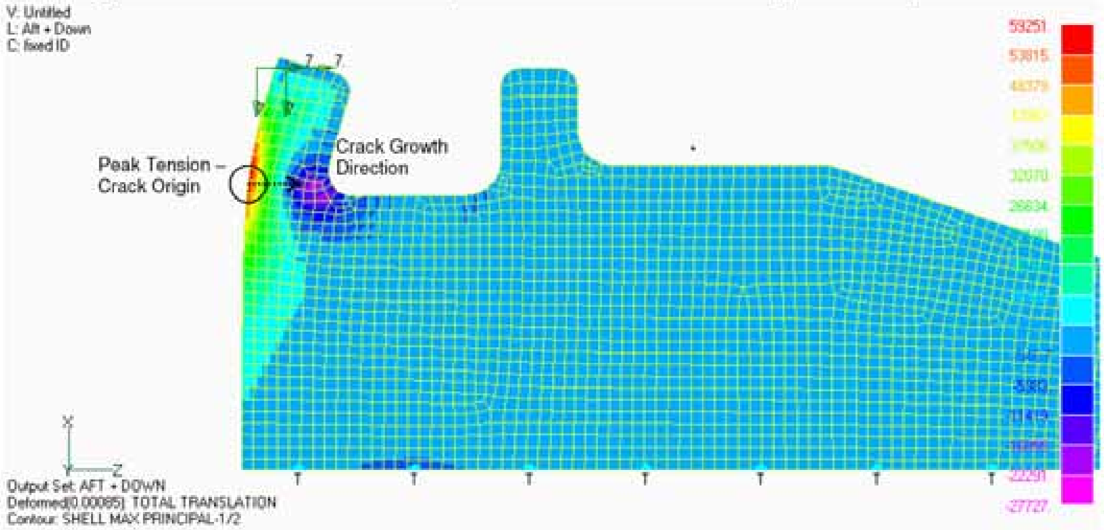


Figure 22 – Finite Element Results, Aft + Down Combined Loading, Max Principal Stress

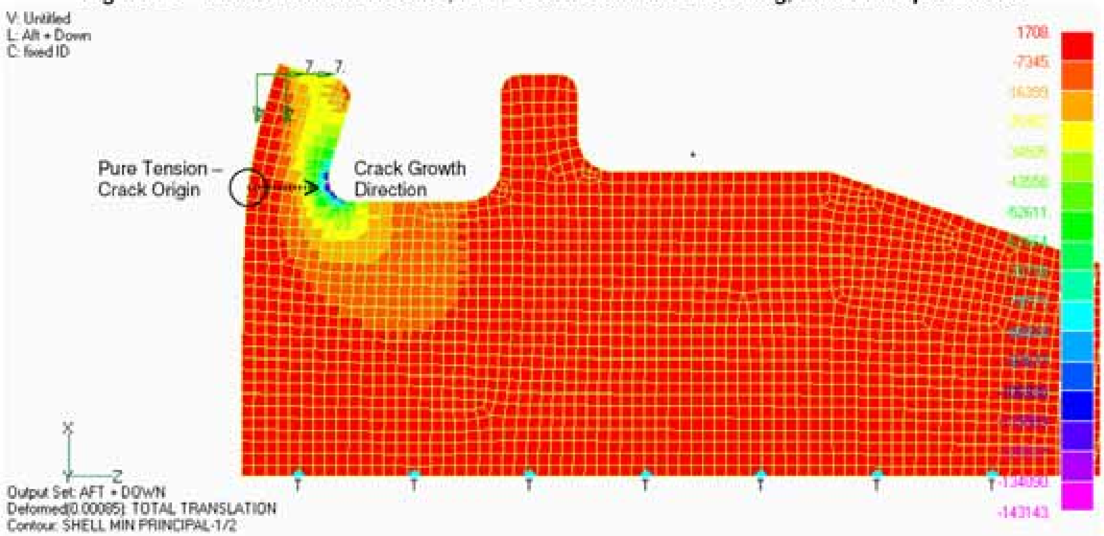


Figure 2.3-6 Mode 2 Crack Due to Combined Aft and Down Loading

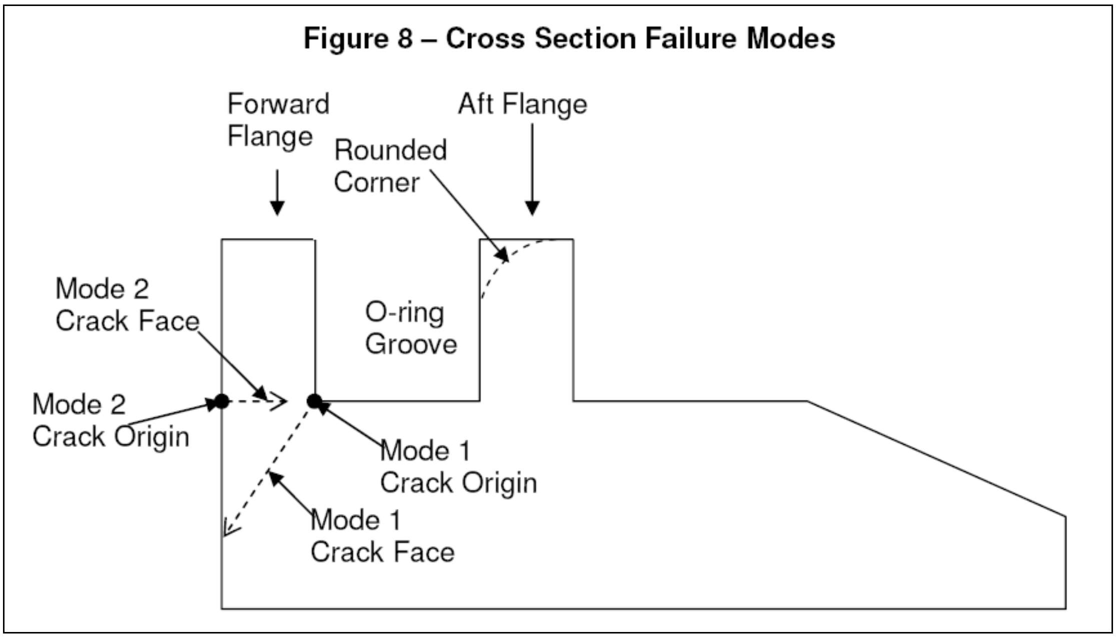


Figure 2.3-7 Flange Failure Modes

2.3.1.3 Unmatched and Skewed Centerlines

If the centerlines of both sides were both unmatched and skewed (refer to Figure 2.3-8) during installation, the flanges of two adjacent tubes will be loaded with the combination of multiple stresses. From chapter 1.6.5, table 1.6-4 and manufacturer's test report on the waste tanks, there were no definite modes or relations between the damaged locations and conditions on the flanges of three damaged waste tanks. Chapter 1.16.4 stated that from the conclusion of the manufacturer's report: " 6. There is evidence that the drain flange was in a continual state of complex loading as applied by a component of the drain flange clamp," this indicates the failures of waste tank outlet flanges were affected by the combination of multiple stresses.

According to the same test report provided by Boeing, it did not test the conditions with unmatched and skewed centerlines.

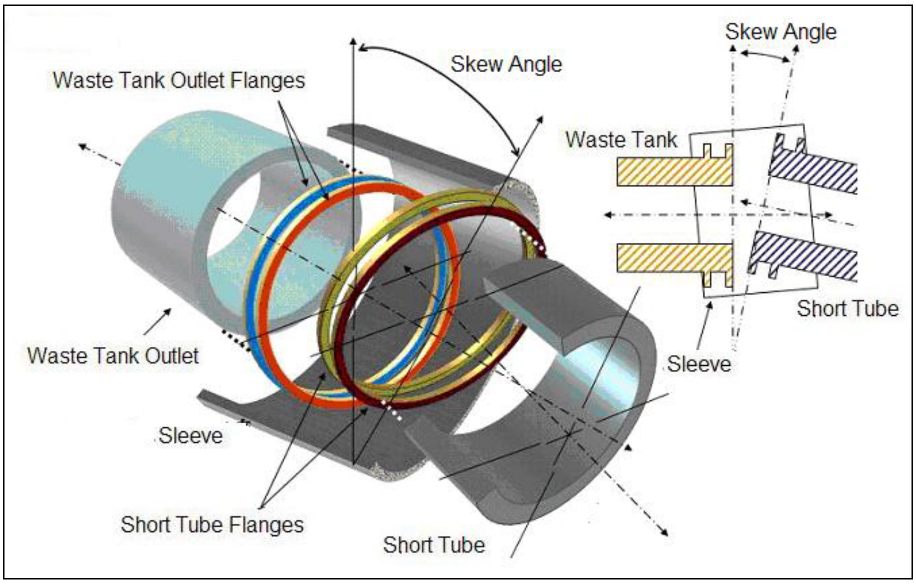


Figure 2.3-8 Unmatched and Skewed Centerlines

2.3.1.4 Gap Dimension

From Boeing documents, the specifications of gap dimension between the ends of two adjacent tubing flanges are as follows.

1. From Boeing company 737-X type airplane, drawing number 417A8630, the nominal distance between the waste tank outlet and the connecting tube is 0.1500 in (refer to Figure 1.6-5). The dimension was not specified or stated in 738 AMM. The design on the matching of waste tank outlet and the connected short tube also refer to Fig. 1.6-5.

2. Boeing's letter stated that the gap distance is 0.1500 in and Boeing planed to incorporate this dimension into AMM by using a special note.

3. China Airlines asked Boeing whether it is acceptable or not if the measured gap distance was 0.26 in which exceeded the nominal distance 0.1500 in specified in the drawing. Boeing replied the gap dimension is acceptable as long as the clamp can be installed in fixed position.

After the communication between CAL and Boeing, the gap dimension was specified as 0.1500 in. Boeing also plans to incorporate this dimension into AMM. After obtained the records of measured gap dimensions, Boeing provided the specification: "as long as the clamp can be installed in fixed position". If the above specification were more realistic in maintenance operation, ASC suggests using this more practical specification to replace the theoretical 0.1500 in gap dimension and incorporating this dimension into AMM.

On site measurement revealed that some of the gap dimensions between the waste tank outlet and the connecting tube satisfied the specification: "as long as the clamp can be installed in fixed position," but not satisfy Boeing's document. There are no evidences that the crack on the flanges were resulted from the contradiction.

2.3.1.5 Contact Mark on the Inner Race of the Sleeve

Observation over the sleeve coupling the short tube and ball valve of the #7 airplane, on the inner race of the sleeve, the pair from the short tube is clear whilst the other one from the ball valve seemed blurred. (See figure 1.6-8).

Figure 2.3-9 Trace of Contact Marks on the Inner Race of the Sleeve

The material of waste tank outlet port is nylon, relatively softer than the CRS sleeve, leaves no contacting mark on the inner ream of the coupling sleeve to be an evidence of abnormal contacting (Riding Condition) of the outlet flange; however whilst on the opposite side the ball valve flange, which was made from metal which is relatively harder, mostly did leave contacting marks in suggesting the misalignment condition in coupling the waste system components was not unusual. As the installation environment for the ball valve side is extremely similar to the waste tank outlet side, it is worthwhile be considered as a good reference to relaize the misalignment that could happed on the waste tank outlet port side.

Certain tilt angle can be observed for the pair of contacting marks over the inner ream of the sleeve with the ball valve. Within the pair, the contact mark near the middle of the sleeve created an approximate 100 degrees in circle contacting mark, whilst 170 degrees for the mark close to the edge, these two mentioned contact marks are distributed at opposite half of the sleeve without overlapping. The above observation provided the evidence that the centerline of the short tube and the centerline of the sleeve are not aligned and certain degree of angle in between was existed. Another observation that the start point of contacting mark from the short tube forward flange is right next to the start point of the short tube rear flange, this phenomenon supports the conclusion from the manufacturer's inspection reportquoted in 1.16.4 "5. The mode 2 cracks in the forward flange are a distinctly different failure method. This failure method occurs in close proximity to the ends of mode 1 cracks, suggesting a pinch or pivot point."

2.3.2 Material of the Waste Tank Outlet Flange

The way of installation and geometric between opposite sides of the short tube are identical, however the ball valve side is free from leaking. It is believed that at the ball valve side all flanges are made from corrosion resistance steel, though excessive stress could happen due to mis-alignment of centerlines resulted from poor quality of install work, the CRS material of flanges can tolerate such unfavorable condition with their superior strength. The waste tank outlet flanges made of plastic material, could not resist complex stresses resulting from the installation of coupling tubes of waste water system. If the material selection of the waste tank outlet flange had been altered to CRS in lieu of Nylon, in such manner, the reliability could be improved in spite of the unfavorable riding and preloaded condition.

2.3.3 Effect of Chemical-Mill

For the involved S-23L ~ S-23R BS727 ~ BS888 cargo compartment skin panel, in accordance with Boeing drawing 164A3231-8 (figure 1.12-10), BAC5772 TYPE II, chemical mill was utilized to rework the panel thickness from 0.1 in thick to 0.063 in thick. The pure aluminum cladding over the skin interior side was thus removed, however alodine surface treatment, together with anti-corrosion primer and CPC, were applied. Since there is no other abnormality observed over the structure underneath cargo compartment floor except the leakage area, it is concluded that the chemical mill process had no connection with the corrosion, though the pure aluminum cladding for corrosion fighting purpose was no longer existed.

2.3.4 Tear Strap Issue

Refer to figure 1.12-10, the crack had grown from BS839.2 and reached to BS869.7. Following the line of crack, it had passed through BS847 via the tiny channel 0.063 in thick between the two thicker banks (0.080 in thick chemical milled at upper side and 0.071 in thick chemical milled below the crack adjacent to S-27L). Theoretically, connecting the two thicker areas together, which were 0.080" and 0.071", in forming a tear strap that goes underneath the S-27L could avoid or delay the crack passing through BS847 frame alongside of S-27L and maintain the damage tolerance property of the skin panel. However, the crack in this occurrence was solely resulted from the inadequate residual strength of skin panel due to heavy corrosion, rather than pure overloading[9]. There is no connection between such stress design and the degradation of crack resistance.

2.4 Maintenance Operations

CAL 737-800 fleet designed its scheduled maintenance plan(AMP) in accordance with MRBR and MPD. The maintenance plan consisted of zonal inspection program, structure inspection program and system inspection program. The maintenance operations related to the skin crack of structure were covered by the zonal inspection program and structure inspection program.

2.4.1 Zonal Inspection Program

The zonal inspection program divides the whole airplane into several zones to be inspected. A general visual inspection is performed on each zones. The purposes of zonal inspection program are to find degradation of structural components and leakage or loose system components etc. Any defects are found during inspection must be corrected immediately.

2.4.1.1 Mode of Maintenance Operation

The inspection period of MRBR 53-840-00, MPD 53-840-00 and AMP 53-840-00 is 13,000 flight cycles or 5 years whichever come first. The occurrence happened on Sep. 20, 2007. CAL carried out the inspection on Jan. 2005. There were no evidences to prove the existence of structural corrosion during inspection. Boeing's letter stated that no removal of the insulation blankets were required. Even the corrosions on the skin existed, structural corrosions under the insulation blankets could not be detected by following the above mentioned "no removal of insulation" procedures. ASC believes that this mode of maintenance operation can not find the corrosions or crack under the insulation blankets.

2.4.1.2 Cause and Effect of Different Zones

The AMP number of the inspection of waste tank compartment is 53-838-00. This task is performed in zone number 141. The AMP number of the inspection

[9] From Table 1.16-1, the thickness estimation is based on the specimen No. 3-3, which is most close to BS 847, where the average residual thickness is 0.0178 in thick.

of area below aft cargo compartment is 53-840-00. This task is performed in zone number 143. These two works are performed neither at the same zone nor at the same time. If 53-838-00 were performed to visually inspect the waste tank compartment which located on zone 141, leakage was found from the waste tank and the area below the waste tank were inspected with the removal of insulation blankets. Because of curved shape of left bilge, leakage from waste tank will flow through skin structure toward a lower surface which located on zone 143. The structure below the leaked waste tank, which located on zone 141, will not be corroded since there were no waste water accumulation in this area. The results of inspection will be normal too after the removal of insulation blankets. Subsequently, the relative effects and inspections are terminated. Visual inspection of the area below aft cargo compartment which located on zone 143, 53-840-00, will not be performed. The leaked fluid will flow through curved skin and draining holes of structure into lower bottom surface to continully corrode structure. Even zonal visual inspection of the area below aft cargo compartment (zone 143), 53-840-00, is performed simultaneously or to be checked due to the leakage, the abnormality of structure can not be detected without the removal of insulation blankets.

According to the analysis, unusual situations occured due to leveling difference and curved structure surface when these two tasks were performed. The structure at higher place (zone 141) where waste water leakage occurred was not corroded. Corrosion came into existence due to the leaked waste water accumulated at lower place (zone 143) which located at right and front side to the adjcent compartment. Since the insulation blankets needed not to be removed during general zonal visual inspection, structural abnormality could not be detected either. ASC believes that CAL should take this into account when general zonal visual inspection was performed. To perform 53-838-00, zonal visual inspection of waste tank compartment at zone 141, once stain or dirty spot are found on the insulation blanket right below waste tank outlet, structural inspection at zone 143 should be performed immediately whether any corrosion on zone 141 were found or not. On the contrary, to perform 53-840-00, visual inspection of area below aft cargo compartment at zone 143, once skin corrosion was found, the associated task of the waste tank compartment at zone 141 should be thought of and to execute immediately. It will be best to remove the insulation blankets on the lower surface to inspect structure and skin visually when performing task 53-840-00 at zone 143. Symptom of skin corrosion can be detected early to prevent similar corrosion from happening again

2.4.2 Structure Inspection Program

The structure inspection program divides the whole airplane into several zones to be inspected. The purposes of structure inspection program are to find damage, failure or irregularity etc. of structural components. Any defects are found during inspection must be corrected immediately.

In chapter 1.6.3.2, the access note of FAA MRBR 53-250-00, Boeing MPD 53-250-00 and CAL AMP 53-250-00 stated: Remove cargo floor panels and scuff plates, Remove/Displace insulation blankets as required.

According to the above statement of the task, the removal of insulation blankets is not compulsory. CAL will remove the insulation blankets that cover skin structure during operation. Maintenance personnel can visually check structure directly. Any damage on the structure can be found easily and maintenance work can be applied immediately. Since the age of the aircraft after production is 6 years and 7 months, the 8 years threshold to perform the task is not yet reached, structural inspection was not executed before the date of the occurrence. The design of inspection periods can not detect and prevent the similar conditions before structure failure.

2.4.3 Maintenance Planning Data

To sum up the analysis, in accordance with current designs on FAA's MRBR, Boeing's MPD and CAL's AMP, structure inspection will remove the insulation blankets and maintenance personnel can detect structure failure directly. But the threshold to perform the first inspection is not yet reached, corrosion on the structure can not be detected. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not is unknown. Therefore, either structural inspection program or zonal inspection program of FAA's MRBR, Boeing's MPD and CAL's AMP can not detect and make prevention of similar structural corrosion.

Airliners' AMPs are all based on manufacture's MPD, with the incorporation of regulations from local authority, and additional maintenance tasks originating from in-service experience. Boeing developed its MPD completely referring to FAA's MRBR. It reveals that FAA did not put this into consideration and Boeing did not find the deficiency either. However, CAL did not have any similar experience before the occurrence. As a result, CAL's AMP could not detect and prevent similar failure from happening.

2.4.4 Influence of Waste Water

The leaked fluid from the waste water tank is the root cause of the corrosion of the skin, as stated in section 2.2.1. From the Conclusions of the examinations and tests report by CSIST, "3. Both acetic ion and chlorine ion were found from the extraction solution of corrosion deposit on the fracture surface of the fuselage skin. Among them, the chlorine ion had the main effect in introducing corrosion to the fuselage skin." and " 4. By Ion Chromatography method, the cleaning fluid specimen for the waste water system provided by ASC had the same composition of anions with the extraction solution of corrosion deposit on the fracture surface of the fuselage skin."; Based on the testing result mentioned in section 1.16.3, the cleaning fluid for waste tank (10% acetic acid water solution) and the groundwater specimen (the glacial acetic acid was diluted with the groundwater) both were found comprising up to 10 ppm of chloride, and also the bleacher (5%) for disinfection of potable water system comprises chlorine. However the organic chlorine for disinfection purpose would make less damage than the chloride would do, and furthermore, the tasks of potable water system disinfection were less frequently conducted than the cleaning tasks for the waste line system. Therefore the leaked fluid from the waste water tank is concluded the main factor that induced corrosion detriment of the fuselage skin.

The pure aluminum cladding for the skin panel was removed by Chemical Milling such that the aluminum alloy layer that vulnerable to corrosion was exposed, although surface treatment to resist corrosion was applied, consistence leakage of waste tank fluid and trapping of this fluid in the lower level of affected area, concentration of Chlorine Ionic as water vaporized, finally deteriorated the corrosion resistance treatment and caused the exfoliation corrosion of the aluminum alloy skin panel. Moreover, ASC could not measure the amount and the consistency of the leaked fluid from waste tank, and the information for the amount of vaporization of leaked fluid and the variation of Chlorine Ionic during the period of leakage of waste tank are not achieved. As a result, it is difficult to estimate the corrosion rate of the skin, and determine the possible timeline while the waste tank leaked.

2.5 Timing of CVR Power off

According to the Article 12 of Aviation Occurrence Investigation Act and the Article 111 of Aircraft Flight Operation Regulation, the operator of the aircraft shall follow the article content: “When an aviation occurrence has occurred, the operator of the aircraft shall take necessary measures to protect the integrity of the CVR data after the aircraft has landed.” and “Flight recorders shall not be switched off during flight time. To preserve flight recorder records, flight recorders shall be de-activated upon completion of flight time or after an occurrence, serious incident or incident. The flight recorders shall not be re-activated before their disposition by the investigating authority.”

Based on the Flight Recorders information in section 1.11.2, the aircraft landed at 1326:09, the crack was found at 1352:05, and the CVR was erased at 1512:48. After CVR was erased, the CVR continued recording uninterruptedly until 1539:15, while the CVR ended (the duration after the aircraft landed was 133 minutes and 6 seconds, and the duration after the crack found was 107 minutes and 10 seconds). After recovering the original CVR data, the audio relevant to this occurrence was not found between the time of 1512:48 and 1539:15.

According to Aviation Occurrence Investigation Act and Aircraft Flight Operation Regulation, the operator was supposed to take measures to stop the CVR recording when an alleged aviation occurrence has occurred. ASC believes that CAL didn’t comply with the Article 12 of Aviation Occurrence

Investigation Act and the Article 111 of Aircraft Flight Operation Regulation to ensure the CVR power off procedure performed to preserve the integrity of the CVR data when flight occurrence happened.

2.6 Flight Operation

The pilots were properly certificated and qualified in accordance with applicable Civil Aeronautics Administration requirements.

Based on the recordings of flight data recorder, no anomalies had found that could relate this aviation occurrence to the performance of the pilots.

2.7 Weather Aspects

The weather report showed that the good weather and cloudless from the area of North Ryukyu Islands down to Northeast Japan was due to high pressure. The records of flight data recorder and pilot interview notes showed that the operation of the aircraft was not influenced by the weather. The weather factor was excluded form the causes of the occurrence.

3. Conclusions

In this Chapter, the Safety Council presents the findings derived from the factual information gathered during the investigation and the analysis of the CI7552 occurrence.

The findings are presented in three categories: findings related to probable causes, findings related to risk, and other findings.

The findings related to the probable causes identify elements that have been shown to have operated in the occurrence, or almost certainly operated in the occurrence. These findings are associated with unsafe acts, unsafe conditions, or safety deficiencies that are associated with safety significant events that played a major role in the circumstances leading to the occurrence.

The findings related to risk identify elements of risk that have the potential to degrade aviation safety. Some of the findings in this category identify unsafe acts, unsafe conditions, and safety deficiencies that made this occurrence more likely; however, they can not be clearly shown to have operated in the occurrence. They also identify risks that increase the possibility of property damage and personnel injury and death. Further, some of the findings in this category identify risks that are unrelated to the occurrence, but nonetheless were safety deficiencies that may warrant future safety actions.

Other findings identify elements that have the potential to enhance aviation safety, resolve an issue of controversy, or clarify an issue of unresolved ambiguity. Some of these findings are of general interest and are not necessarily 220 analytical, but they are often included in ICAO format occurrence reports for informational, and safety awareness, education, and improvement purposes.

3.1 Findings Related to Probable Causes

1. The plastic waste tank outlet flanges could not resist complex stresses resulting from the installation of coupling tubes of waste water system. (2.3.2)
2. The consistence leakage of waste tank fluid was trapped in the lower level of affected area, and the concentration of Chlorine was increased by evaporating of water. It induced corrosion to the detriment of the fuselage skin. The residual strength of the skin was not of sufficient to endure the hoop-wise stress resulted from flight operation. Finally the fuselage skin fractured to a 30 in (77 cm) crack due to the overstress. (2.1) (2.2)

3.2 Findings Related to Risk

1. In accordance with the current MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether the damage on structure was existed or not is unknown. Therefore, either structural inspection program or zonal inspection program can not detect and make prevention of similar structural corrosion. (2.4.3)
2. CAL developed its AMP completely referring to Boeing MPD together with FAA issued MRBR and ADs to form a fully workable Aircraft Maintenance Program. However, CAL did not have any similar experience before the occurrence. As a result, CAL's AMP could not detect and prevent similar failure from happening.
3. The AMP number of the inspection of waste tank compartment is AMP 53-838-00. This task is performed in zone number 141. The AMP number of the inspection of area below aft cargo compartment is AMP 53-840-00. This task is performed in zone number 143. These two works are performed neither at the same zone nor at the same time. Unusual situations occurred due to leveling difference and curved structure surface when these two tasks were performed. The structure at higher place (zone 141) where waste water leakage occurred was not corroded. Corrosion came into existence due to the leaked waste water accumulated at lower place (zone 143) which located at right and front side to the adjacent compartment. Since the insulation blankets needed not to be removed during general zonal visual inspection, structural abnormality could not be detected either. (2.4.1.2)

3.3 Other Findings

1. An installation quality check of 737-800 fleet on the coupling showed that there were unmatched centerlines, skewed centerlines between waste tank outlet and its adjacent short tube. (2.3.1)
2. There were no definite modes or relations between the damaged locations and conditions on the flanges of three damaged waste tanks. This indicates the failures of waste tank outlet flanges were affected by the combination of multiple stresses. (2.3.1.3)
3. On site measurement revealed that some of the gap dimensions between the waste tank outlet and the connecting tube satisfied the

specification: “as long as the clamp can be installed in fixed position,” but not satisfy Boeing’s document. There are no evidences that the crack on the flanges were resulted from the contradiction. (2.3.1.4)

4. The Ion Chromatography test results show that the leaked fluid from waste water tank is the main effective factor that induced corrosion fracture to the detriment of the fuselage skin. (2.4.4)

5. The compromised belly skin panel was chemically milled by the manufacturer, which resulted in the removal of the pure Aluminum cladding and inherent deficiency of corrosion resistance. Though corrosion protection coating and anti-corrosion treatment were applied, these countermeasures to corrosion did not eliminate the effect of long time soaking of leaked waste tank fluid at the lower portion of the aft cargo compartment structure, in addition, the concentration of the waste tank fluid was further increased as water vaporized over time, resulted in the high concentration of Chlorine Ion penetrating all the corrosion protection measurements and heavy corrosion of the base material thereafter. (2.4.4)

6. ASC could not measure the amount and the consistency of the leaked fluid from waste tank, and the information for the amount of vaporization of leaked fluid and the variation of Chlorine Ionic during the period of leakage of waste tank are not achieved. As a result, it is difficult to estimate the corrosion rate of the skin, and determine the possible timeline while the waste tank leaked. (2.4.4)

7. There were no abnormal maintenance records. Scheduled zonal inspections were all finished within intervals. (1.6.3)(1.6.3.3)

8. After the flight occurrence happened, CAL didn’t comply with the regulation to ensure the CVR power off procedure performed to preserve the integrity of the CVR data. (2.5)

9. The flight crew were properly certificated and qualified in accordance with applicable CAA regulations. (2.6)

10. This occurrence bears no relationship with flight operations and weather. (2.7)

11. There was no evidence from ground video recording to prove that the aircraft’s crack was caused by the ramp operation of the Taoyuan international airport. (1.10.1)

Intentionally Left Blank

4. Safety Recommendations

In this chapter, the Interim Flight Safety Bulletin which was issued to the stakeholder, while investigation was still in progress, is listed in Section 4.1. The safety recommendations derived as the result of this investigation are listed in Section 4.2. The safety actions that have been accomplished, or are currently being planned by the stakeholders as the result of the investigation process are also listed by following associated recommendations.

4.1 Interim Flight Safety Bulletin

Reference No.：ASC-IFSB-07-12-002

Date : December 26, 2007

1. Make sure that leakage of the waste water system is properly controlled, and aircraft structural integrity is well maintained at locations where the possible leakage fluid from waste-tank system flows over and/or accumulates.
2. Review and draw up a policy in order to prevent the same type of event from recurring.

4.2 Safety Recommendations

To China Airlines

1. When performing AMP 53-838-00, general visual inspection of waste tank compartment at zone 141, once dirty stains were found on the insulation blanket right below waste tank outlet, the structural inspection of the area below aft cargo compartment at zone 143 should be performed immediately. To perform AMP 53-840-00, general visual inspection of area below aft cargo compartment at zone 143, a direct visual inspection of the skin structure located on the lower surface should be applied. (ASC-ASR-09-09-001)
2. In accordance with Boeing's MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on

structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. CAL developed its AMP completely referring to Boeing MPD to form a fully workable Aircraft Maintenance Program. As a result, CAL's AMP could not detect and prevent similar failure from happening. Based on the experience of the occurrence, CAL should initiate a strategy to make up the deficiency of current AMP. (ASC-ASR-09-09-002)

The operator responded to this Recommendation by stating:

'Perform leakage test for 737-800 waste tank at every RE (500 Flight Hours) check. (refer to Appendix 10); Revise the interval of 737-800 AMP 53-838-00 from 24 months to 12 months and require the removal of insulation blankets to gain the access to the structure. (refer to Appendix 11); Revise the interval of 737-800 AMP 53-840-00 from 60 months to 24 months and require the removal of insulation blankets to gain the access to the structure. (refer to Appendix 11)'(translated text)

3. Amend the Article 12 of Aviation Occurrence Investigation Act and the Article 111 of Aircraft Flight Operation Regulation to ensure the CVR power off procedure performed when flight occurrence happened. (ASC-ASR-09-09-003)

To Taiwan Civil Aeronautics Administration

1. In accordance with Boeing's MPD, structure inspection requires the removal of the insulation blankets and maintenance personnel can detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. CAL developed its AMP completely referring to Boeing MPD to form a fully workable Aircraft Maintenance Program. As a result, CAL's AMP could not detect and prevent similar failure from happening. Based on the experience of the occurrence, CAA should supervise CAL to initiate a strategy to make up the deficiency of current AMP.(ASC-ASR-09-09-004)

Taiwan Civil Aeronautics Administration responded to this Recommendation by stating:

'CAA approved the modifications of CAL's Aircraft Maintenance Program on

February 12, 2008. Time interval of AMP 53-838-00 has changed from 24 months to 12 months, and insulation blankets need to be removed for inspection. Time interval of AMP 53-840-00 has changed from 60 months to 24 months, and insulation blankets need to be removed for inspection. CAL has executed the revised inspections since then.'(translated text)

2. Supervise CAL to ensure the CVR power off procedure performed when flight occurrence happened. (ASC-ASR-09-09-005)

   Taiwan Civil Aeronautics Administration responded to this Recommendation by stating:

   'CAA requested the operation of Flight Data Recorder by following the standards specified in Regulation 111-2 of Aircraft Flight Operational Rule. Flight Data Recorder needs to be turned on before flight and can not be turned off during flight. After aircraft accident, serious incident or incident, Flight Data Recorder needs to be turned off after the termination of flight operation. Flight Data Recorder can not be turned on again before it is removed from aircraft. CAL also asked his flight crews to comply with the rules specified on the Enterprise Safety Manual 8.2.2 and Flight Operation Manual Chapter 10.2.'(translated text)

To The Boeing Company

1. Require to improve the material of waste tank outlet flanges to sustain pre-stress resulting from the installation of coupling tubes. Before final fix the material, require to make sure to correct the unmatched and skewed centerlines problem during the installation of the waste tank outlet and the short tube to reduce pre-stress and to avoid the resultant damage to the waste tank outlet flanges. The AMM should use a practical instruction and specific tolerance to install the flanges of waste tank outlets instead of using the theoretical 0.1500 in gap dimension between the flanges of waste tank outlet and the short tub. (ASC-ASR-09-09-006)

2. In accordance with the current MPD, structure inspection requires the removal of the insulation blankets to allow maintenance personnel to detect structure failure directly. But the 8 years threshold is not yet reached, corrosion on the structure can not be detected early. Zonal inspection was executed once before the occurrence. Since the inspection did not require the removal of insulation blankets, whether damage on structure was existed or not was unknown. Therefore, either structural inspection program or zonal inspection program could not detect and make prevention of similar structural corrosion. Based on the experience of the occurrence, Boeing company should initiate a strategy to make up the deficiency of current MPD. (ASC-ASR-09-09-007)

   Prior to this recommendation, the aircraft manufacturer released a Multi Operator Message, MOM no. 1-725906264-1, on January 03, 2008, with subject: Vacuum Waste Tank Drain Fitting Inspection. This message provided a timely advisory all 737 -600/700/800/900 operators for one time inspection and recommended temporary action. Detailed contents referred to Appendix 12.

To United States Federal Aviation Administration

1. Require the MRB to review the B737 series aircrafts MRBR and modify as necessary to ensure that leaks from the waste water system are detected before similar structural corrosion can occur. The review should include an analysis of the inspection intervals, the need for changes to inspection procedures (i.e. removal of insulation blankets), and the need for more detailed description of inspection criteria (i.e. task cards). (ASC-ASR-09-09-008)

Appendix- 1：Boeing 737 series aircrafts maintemance planning documents

1-1. FAA MRBR 53-250-00

BOEING

737-600/700/800/900 MAINTENANCE REVIEW BOARD REPORT

STRUCTURAL MAINTENANCE PROGRAM

MRB ITEM NUMBER	PGM	ZONE	ACCESS	INTERVAL		APPLICABILITY		TASK DESCRIPTION
				THRESHOLD	REPEAT	APL	ENG	
53-250-00	S	143 144	S1402 NOTE	8 YR 24000 FC NOTE	6 YR 18000 FC NOTE	ALL	ALL	*INTERNAL - GENERAL VISUAL:* Aft Bilge Inspect aft bilge skin panels (skins, frames, stringers), longitudinal lap splices, circumferential skin and stringer splices, (note: located at Sta 727I for -900 and 727L for -900ER models); Sta 727 bulkhead and pressure web, and cargo door cutout surround structure in bilge. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Remove cargo floor panels and scuff plates. Remove/Displace insulation blankets as required.
53-260-00	S	145 146	S1403 NOTE	12 YR 36000 FC NOTE	8 YR 24000 FC NOTE	ALL NOTE	ALL	*INTERNAL - GENERAL VISUAL:* Area Aft of Cargo Compartment Inspect area aft of cargo compartment, including: 1. Skin panels (skins, frames, stringers), longitudinal lap splices, circumferential skin and stringer splices; 2. Aft entry and galley door cutout surround structure in lower lobe; 3. STA 1016 bulkhead, including chords, pressure web, stiffeners, chord/web attachments; 4. Stringer splice fittings and tension bolts at STA 1016. AIRPLANE NOTE: Task not applicable to -900ER and -800 with Flat Pressure Bulkhead installed. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Remove aft cargo compartment aft bulkhead panel and potable water tank. Remove/displace insulation blankets as required.

Feb 05/2007 D626A001-MRBR STRUCTURES PAGE 3.1-17

1-2. Boeing MPD 53-250-00

MPD ITEM NUMBER	AMM REFERENCE	PGM	ZONE	ACCESS	INTERVAL THRES.	INTERVAL REPEAT	APPLICABILITY APL	APPLICABILITY ENG	MAN-HOURS	TASK DESCRIPTION
53-250-00	51-05-01-210 53-05-03-210	S	143 144	S1402 NOTE	8 YR 24000 FC NOTE	6 YR 18000 FC NOTE	ALL	ALL	2.50	*INTERNAL - GENERAL VISUAL:* Aft Bilge Inspect aft bilge skin panels (skins, frames, stringers), longitudinal lap splices, circumferential skin and stringer splices, (note: located at Sta 727l for -900 and 727L for -900ER models); Sta 727 bulkhead and pressure web, and cargo door cutout surround structure in bilge. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Remove cargo floor panels and scuff plates. Remove/ Displace insulation blankets as required.

1-3. CAL AMP 53-250-00

0F	ITEM NO	TSCODE	JOB TITLE	INTERVAL	SOURCE	EFFECTIVITY	REV DATE
09	53-250-00	E2	INTERNAL - GENERAL VISUAL: AFT	T:	MRB	ALL	NOV 27/06
		CP	BILGE	8 YR	CPC		
				24000 FC			
			INSPECT AFT BILGE SKIN PANELS	I:			
			(SKINS, FRAMES, STRINGERS),	6 YR			
0			LONGITUDINAL LAP SPLICES,	18000 FC			
			CIRCUMFERENTIAL SKIN AND STRINGER	NOTE			
			SPLICES, (NOTE: LOCATED AT STA				
			727I FOR -900 AND 727L FOR -900ER				
			MODELS); STA 727 BULKHEAD AND				

2-1. FAA MRBR 53-838-00

MRB ITEM NUMBER	ZONE	ACCESS	INTERVAL		APPLICABILITY		TASK DESCRIPTION
			THRESHOLD	REPEAT	APL	ENG	
53-834-00	141 142	822 NOTE	36000 FC 12 YR NOTE	36000 FC 12 YR NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Aft Cargo Compartment Perform an internal zonal inspection (gv) of the aft cargo compartment - section 46 and 47 (part), sta 727 to sta 947.5. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Sidewall panels removal required.
53-836-00	142	822	1500 FC 180 DY NOTE	1500 FC 180 DY NOTE	ALL	ALL	*EXTERNAL - ZONAL (GV):* Aft Cargo Door Surround Structure Fittings and Stops Perform an external zonal inspection (gv) of the aft cargo door surround structure fittings and stops - section 46, sta 827. INTERVAL NOTE: Whichever comes first.
53-838-00	141	822 NOTE	5500 FC 24 MO NOTE	5500 FC 24 MO NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Aft Cargo Compartment Vacuum Waste Compartment Perform an internal zonal inspection (gv) of the aft cargo compartment vacuum waste compartment. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Vacuum waste compartment panels removal required.
53-840-00	143 144	822 NOTE	13000 FC 60 MO NOTE	13000 FC 60 MO NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Area Below Aft Cargo Compartment Perform an internal zonal inspection (gv) of the area below the aft cargo compartment - section 46 and 47 (part), sta 727 to sta 947.5. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Center floor panels removal required. Cargo loading system removed/ displaced as required.

2-2. Boeing MPD 53-838-00

MPD ITEM NUMBER	AMM REFERENCE	ZONE	ACCESS	INTERVAL		APPLICABILITY		MAN-HOURS	TASK DESCRIPTION
				THRES.	REPEAT	APL	ENG		
53-838-00	05-41-01-210	141	822 NOTE	5500 FC 24 MO NOTE	5500 FC 24 MO NOTE	ALL	ALL	0.25	*INTERNAL - ZONAL (GV):* Aft Cargo Compartment Vacuum Waste Compartment Perform an internal zonal inspection (gv) of the aft cargo compartment vacuum waste compartment. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Vacuum waste compartment panels removal required.

2-3. CAL AMP 53-838-00

OF	ITEM NO	TSCODE	JOB TITLE	INTERVAL	SOURCE	EFFECTIVITY	REV DATE
09	53-838-00	E2	INTERNAL - ZONAL (GV): AFT CARGO	5500 FC	MRB	ALL	JUL 15/03
0			COMPARTMENT VACUUM WASTE	24 MO			
			COMPARTMENT	NOTE			
0			PERFORM AN INTERNAL ZONAL				
			INSPECTION (GV) OF THE AFT CARGO				
			COMPARTMENT VACUUM WASTE				
			COMPARTMENT. ZONE: 141				
0			INTERVAL NOTE:				
			WHICHEVER COMES FIRST.				
0			ACCESS NOTE:				
			VACUUM WASTE COMPARTMENT PANELS				
			REMOVAL REQUIRED.				

2-4 AMP 53-838-00 Records of Execution
Date of Execution:Nov.24,2006

CHINA AIRLINES

135

JOB CARD

WORK ORDER NUMBER	A/C-TYPE	A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
5B1769	738	B16805	INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT	J.H. LIANG FEB 10, 2006	P-1410-30-11
COST ENTER/ SKILL	CREW SIZE / DOWN TIME / MHRS			CHECKED BY	PAGE 1 OF 3
QC	1 / 1 / 1		AMP 53-838-00		EVENT AV 2

PFM. BY	INSP.	JOB DESCRIPTION
	CAL I-352 11/24/06	

ZONAL

MPD ITEM: 53-838-00

INTERNAL - ZONAL (GV) AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT

ACCESS PANELS/DOORS: 822

ACCESS PANELS NOTE:

VACUUM WASTE COMPARMENT PANELS REMOVAL REQUIRED.

5B1769ZP-0135
B16805

DEFINITION OF ZONAL VISUAL INSPECTION

A GENERAL VISUAL INSPECTION OF:

(1) ALL VISIBLE PARTS OF STRUCTURE BY LOOKING FOR DEGRADATION SUCH AS DAMAGE, CHAFING, DEFORMATION, CORROSION, LEAKS, CRACKS, AND GENERAL CONDITION OF FASTENERS.

(2) ALL VISIBLE SYSTEM INSTALLATIONS (E.G. WIRING, DUCTING, TUBING, PLUMBING, PULLEYS, BEARINGS, FITTINGS, BRACKETS, ELECTRICAL BONDING, ETC.) AND COMPONENTS, (E.G. ACTUATORS, ACCUMULATORS, VALVES, LIGHTS, ETC.) FOR DETERIORATION/IRREGULARITY SUCH AS DAMAGE, FAILURE LEAKS, MISSING PARTS, CORROSION AND PROPER ATTACHMENT.

(3) ALL OPENED AND REMOVED ACCESS DOORS AND PANELS WHERE LISTED.

(4) WHENEVER PHYSICALLY POSSIBLE, THE ZONAL INSPECTIONS WILL BE CONDUCTED WITHIN TOUCHING DISTANCE UNLESS OTHERWISE STATED.

THE INSPECTION TASK DOES NOT PROVIDE A SUMMATION OF ALL ITEMS TO BE INSPECTED WITHIN EACH ZONE BOUNDARY, BECAUSE IT IS CONSIDERED THAT THE PERSON HAS ADEQUATE LEVEL OF KNOWLEDGE OF THE AIRFRAME AND SYSTEM INSTALLATION. HOWEVER, THE EXTENT OF THE INTENDED AREA OF THE INSPECTION IS DEFINED BY THE ACCESS, IF ANY, LISTED WITH INSPECTION ITEM.

DEFINITION OF EXTERNAL/INTERNAL

INSPECTIONS ARE CLASSIFIED AS "INTERNAL" OR "EXTERNAL".

AN INSPECTION OF THE AIRCRAFT IS CONSIDERED **"EXTERNAL"** PROVIDED THAT:

A) IT IS A VISUAL INSPECTION

B) ACCESS IS GAINED THROUGH A DOOR OR HATCH. **NO TOOLS REQUIRED**

C) NO REMOVAL OF FAIRINGS, LININGS, INSULATION, EQIPMENT OR STRUCTURAL COMPONENTS ARE REQUIRED

D) IT IS NOT INSIDE THE WING, FIN OR STABILIZER BOX STRUCTURE.

ALL OTHER INSPECTIONS NOT COVERED BY THE ABOVE DEFINITION ARE **"INTERNAL"**.

STATION	DATE	ACCOMPLISHED
TPE	11-24-2006	CAL I-352

QP08MN082F1R2

CHINA AIRLINES

JOB CARD

WORK ORDER NUMBER	A/C-TYPE		A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
581769	738		B16805	INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT	J.H. LIANG FEB 10, 2006	P-1410-30-11
COST ENTER/ SKILL	CREW SIZE	DOWN TIME	MHRS		CHECKED BY	PAGE 2 OF 3
QC	1	1	1			EVENT
				AMP 53-838-00		AV 2

PFM. BY	INSP.	JOB DESCRIPTION
	I CAL I-352 11-24-06	E2 EXAMINATION 2 **GENERAL VISUAL INSPECTION** USING ACCESS MEANS: IT MAY REQUIRE FOR EXAMPLE THE USE OF WORKSTANDS, DOCKS, "SNORKEL" CRANE, AND IF NECESSARY OPENING OF SPECIFIC PANELS. THIS LEVEL OF INSPECTION DOES REQUIRE ACCESS MEANS AND IS MADE UNDER NORMAL LIGHTING CONDITIONS SUCH AS DAYLIGHT, HANGAR LIGHTING, OR FLASHLIGHT. CLEANING MAY BE REQUIRED. PERFORM AN INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT. (Figure 220) Inspection Result: SATISFACTORY

STATION	DATE	ACCOMPLISHED
TPE	11.24.2006	CAL I-352

QP08MN082F1R2

Date of Execution: Jan. 3, 2005

123

CHINA AIRLINES

JOB CARD

WORK ORDER NUMBER	A/C-TYPE		A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
4B1016	738		B16805	INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT	J.H. LIANG NOV 05, 2004	P-1410-30-11
COST ENTER/ SKILL	CREW SIZE	DOWN TIME	MHRS		CHECKED BY	PAGE 1 OF 3
QC	1	1	1	AMP 53-838-00	[redacted]	EVENT AV 2

PFM. BY	INSP.	JOB DESCRIPTION
	I	

ZONAL

MPD ITEM: 53-838-00

INTERNAL -ZONAL (GV): AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT

ACCESS PANELS/DOORS: 822

4B1016TM-0123
B16805

CAL I-347 JAN 02 2005

ACCESS PANELS NOTE:

VACUUM WASTE COMPARMENT PANELS REMOVAL REQUIRED.

DEFINITION OF ZONAL VISUAL INSPECTION

A GENERAL VISUAL INSPECTION OF:

(1) ALL VISIBLE PARTS OF STRUCTURE BY LOOKING FOR DEGRADATION SUCH AS DAMAGE, CHAFING, DEFORMATION, CORROSION, LEAKS, CRACKS, AND GENERAL CONDITION OF FASTENERS.

(2) ALL VISIBLE SYSTEM INSTALLATIONS (E.G. WIRING, DUCTING, TUBING, PLUMBING, PULLEYS, BEARINGS, FITTINGS, BRACKETS, ELECTRICAL BONDING, ETC.) AND COMPONENTS, (E.G. ACTUATORS, ACCUMULATORS, VALVES, LIGHTS, ETC.) FOR DETERIORATION/IRREGULARITY SUCH AS DAMAGE, FAILURE LEAKS, MISSING PARTS, CORROSION AND PROPER ATTACHMENT.

(3) ALL OPENED AND REMOVED ACCESS DOORS AND PANELS WHERE LISTED.

THE INSPECTION TASK DOES NOT PROVIDE A SUMMATION OF ALL ITEMS TO BE INSPECTED WITHIN EACH ZONE BOUNDARY, BECAUSE IT IS CONSIDERED THAT THE PERSON HAS ADEQUATE LEVEL OF KNOWLEDGE OF THE AIRFRAME AND SYSTEM INSTALLATION. HOWEVER, THE EXTENT OF THE INTENDED AREA OF THE INSPECTION IS DEFINED BY THE ACCESS, IF ANY, LISTED WITH INSPECTION ITEM.

DEFINITION OF EXTERNAL/INTERNAL

INSPECTIONS ARE CLASSIFIED AS "INTERNAL" OR "EXTERNAL".

AN INSPECTION OF THE AIRCRAFT IS CONSIDERED **"EXTERNAL"** PROVIDED THAT:

A) IT IS A VISUAL INSPECTION

B) ACCESS IS GAINED THROUGH A DOOR OR HATCH. **NO TOOLS REQUIRED**

C) NO REMOVAL OF FAIRINGS, LININGS, INSULATION, EQIPMENT OR STRUCTURAL COMPONENTS ARE REQUIRED

D) IT IS NOT INSIDE THE WING, FIN OR STABILIZER BOX STRUCTURE.

ALL OTHER INSPECTIONS **NOT COVERED BY THE ABOVE DEFINITION ARE "INTERNAL".**

STATION	DATE	ACCOMPLISHED
TPE	JAN. 03 '05	CAL A637741

QP08MN082F1R2

CHINA AIRLINES

JOB CARD

WORK ORDER NUMBER	A/C-TYPE		A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
	738		B16805	INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT	J.H. LIANG NOV 05, 2004	P-1410-30-11
COST ENTER/ SKILL	CREW SIZE	DOWN TIME	MHRS		CHECKED BY	PAGE 2 OF 3
QC	1	1	1			EVENT
				AMP 53-838-00		AV 2

PFM. BY	INSP.	JOB DESCRIPTION
	! CAL 1-847 JAN 02 2005	E2 EXAMINATION 2

E2 EXAMINATION 2

GENERAL VISUAL INSPECTION USING ACCESS MEANS: IT MAY REQUIRE FOR EXAMPLE THE USE OF WORKSTANDS, DOCKS, "SNORKEL" CRANE, AND IF NECESSARY OPENING OF SPECIFIC PANELS. THIS LEVEL OF INSPECTION DOES REQUIRE ACCESS MEANS AND IS MADE UNDER NORMAL LIGHTING CONDITIONS SUCH AS DAYLIGHT, HANGAR LIGHTING, OR FLASHLIGHT. CLEANING MAY BE REQUIRED.

PERFORM AN INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT.

Inspection Result SATISFACTORY

STATION	DATE	ACCOMPLISHED
TPE	JAN. 03'05	CAL A637741

QP08MN082F1R2

Date of Execution: Jan. 5, 2004

CHINA AIRLINES

JOB CARD 113

WORK ORDER NUMBER	A/C-TYPE	A/C-REG.		TITLE	ISSUED BY / DATE	JOB CARD NUMBER
3B1006	737-800	B16805		INTERNAL ZONAL: AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT	F.K.Su MAR 06/2001	Q-1410-30
COST CENTER / SKILL	CREW SIZE	DOWN TIME	MHRS		CHECKED BY	PAGE 1 OF2
ML/APG	1	0.75	0.75	AMP ITEM: 53-838-00		EVENT P7

3B1006CB-0113
B16805

PFM BY	INSP.	JOB DESCRIPTION
A1 CAL 637754 JAN-05-04		ACCESS PANELS NOTE: VACUUM WASTE COMPARTMENT PANELS REMOVAL REQUIRED. - Open aft cargo door.
A1 CAL 637754 JAN-05-04		- Gain access to the inspection area as shown in FIG 1.
A1 CAL 637754 JAN-05-04		-Perform an internal zonal inspection of the aft cargo compartment vacuum waste compartment.
A1 CAL 637754 JAN-05-04		- Close the access to the inspection area as shown in FIG 1.
A1 CAL 637754 JAN-05-04		- Close aft cargo door.

STATION	DATE	ACCOMPLISHED
TPE	JAN-05-04	CAL 637754

QP08MB082F1R1

Date of Execution: Jul.9,2002

T.F

BOEING
737-600/700/800/900
TASK CARDS

P7

DATE	TAIL NUMBER	STATION	AIRLINE CARD NO.		BOEING CARD NO.
	B16805				53-838-00-00

SKILL	WORK AREA	RELATED TASK	VERSION	THRESHOLD	REPEAT	PHASE
AIRPL	FUSELAGE		1.1 1.2	4000 CYC 18 MOS	4000 CYC 18 MOS	

TASK	TITLE	APPLICABILITY AIRPLANE	APPLICABILITY ENGINE
GEN VISUAL INTERNAL	AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT	ALL	ALL

ZONES	ACCESS
141	822

MECH | INSP

ZONAL

INTERVAL NOTE:
WHICHEVER COMES FIRST.

ACCESS PANELS NOTE:
VACUUM WASTE COMPARMENT PANELS REMOVAL REQUIRED.

MPD ITEM: 53-838-00
INTERNAL - ZONAL (GV): AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT

PERFORM AN INTERNAL ZONAL INSPECTION (GV) OF THE AFT CARGO COMPARMENT VACUUM WASTE COMPARTMENT.

MECH	AUTHORITY/ INSP
CAL 635508 JUL 09 '02	CAL 527179 9 JUL '02

檢查結果	
NORMAL	SQUAWK NO.
✓	

CUSTOMER FLEET EFFECTIVITY	SOURCE	
ALL	MRB	AFT CARGO COMPARTMENT VACUUM WASTE COMPARTMENT PAGE 1 of 2 53-838-00-00 Oct 10/00

075

3-1. FAA MRBR 53-840-00

MRB ITEM NUMBER	ZONE	ACCESS	INTERVAL THRESHOLD	INTERVAL REPEAT	APPLICABILITY APL	APPLICABILITY ENG	TASK DESCRIPTION
53-834-00	141 142	822 NOTE	36000 FC 12 YR NOTE	36000 FC 12 YR NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Aft Cargo Compartment Perform an internal zonal inspection (gv) of the aft cargo compartment - section 46 and 47 (part), sta 727 to sta 947.5. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Sidewall panels removal required.
53-836-00	142	822	1500 FC 180 DY NOTE	1500 FC 180 DY NOTE	ALL	ALL	*EXTERNAL - ZONAL (GV):* Aft Cargo Door Surround Structure Fittings and Stops Perform an external zonal inspection (gv) of the aft cargo door surround structure fittings and stops - section 46, sta 827. INTERVAL NOTE: Whichever comes first.
53-838-00	141	822 NOTE	5500 FC 24 MO NOTE	5500 FC 24 MO NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Aft Cargo Compartment Vacuum Waste Compartment Perform an internal zonal inspection (gv) of the aft cargo compartment vacuum waste compartment. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Vacuum waste compartment panels removal required.
53-840-00	143 144	822 NOTE	13000 FC 60 MO NOTE	13000 FC 60 MO NOTE	ALL	ALL	*INTERNAL - ZONAL (GV):* Area Below Aft Cargo Compartment Perform an internal zonal inspection (gv) of the area below the aft cargo compartment - section 46 and 47 (part), sta 727 to sta 947.5. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Center floor panels removal required. Cargo loading system removed/ displaced as required.

3-2 Boeing MPD 53-840-00

MPD ITEM NUMBER	AMM REFERENCE	ZONE	ACCESS	INTERVAL		APPLICABILITY		MAN-HOURS	TASK DESCRIPTION
				THRES.	REPEAT	APL	ENG		
53-840-00	05-41-01-210	143 144	822 NOTE	13000 FC 60 MO NOTE	13000 FC 60 MO NOTE	ALL	ALL	1.50	*INTERNAL - ZONAL (GV):* Area Below Aft Cargo Compartment Perform an internal zonal inspection (gv) of the area below the aft cargo compartment - section 46 and 47 (part), sta 727 to sta 947.5. INTERVAL NOTE: Whichever comes first. ACCESS NOTE: Center floor panels removal required. Cargo loading system removed/displaced as required.

3-3 CAL AMP 53-840-00

OF	ITEM NO	TSCODE	JOB TITLE	INTERVAL	SOURCE	EFFECTIVITY	REV DATE
09	53-840-00	E2	INTERNAL - ZONAL (GV): AREA BELOW AFT CARGO COMPARTMENT	13000 FC 60 MO NOTE	MRB	ALL	JAN 07/05
			PERFORM AN INTERNAL ZONAL INSPECTION (GV) OF THE AREA BELOW THE AFT CARGO COMPARTMENT - SECTION 46 AND 47 (PART), STA 727 TO STA 947.5.				
0			ZONES: 143 144				
0			INTERVAL NOTE: WHICHEVER COMES FIRST.				
0			ACCESS NOTE: CENTER FLOOR PANELS REMOVAL REQUIRED. CARGO LOADING SYSTEM REMOVED/DISPLACED AS REQUIRED.				

3-4 AMP 53-840-00 Records of Execution

CHINA AIRLINES

JOB CARD

WORK ORDER NUMBER	A/C-TYPE		A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
	738		B16805	GENERAL VISUAL INTERNAL: AREA BELOW AFT CARGO COMPARTMENT	M.S.LO NOV.02'2004	E-1400-30-06
COST ENTER/ SKILL	CREW SIZE	DOWN TIME	MHRS		CHECKED BY	PAGE 1 OF 7
APG IMS	4	3.0	12	AMP 53-840-00	[redacted]	EVENT P 11 C'K

PFM. BY	INSP	JOB DESCRIPTION
A2		

ZONAL

MPD ITEM: 53-840-00

INTERNAL -ZONAL (GV): AREA BELOW AFT CARGO COMPARTMENT

4B1016TM-0338
B16805

DEFINITION OF
ZONAL VISUAL INSPECTION

A GENERAL VISUAL INSPECTION OF:

(1) ALL VISIBLE PARTS OF STRUCTURE BY LOOKING FOR DEGRADATION SUCH AS DAMAGE, CHAFING, DEFORMATION, CORROSION, LEAKS, CRACKS, AND GENERAL CONDITION OF FASTENERS.

(2) ALL VISIBLE SYSTEM INSTALLATIONS (E.G. WIRING, DUCTING, TUBING, PLUMBING, PULLEYS, BEARINGS, FITTINGS, BRACKETS, ELECTRICAL BONDING, ETC.) AND COMPONENTS, (E.G. ACTUATORS, ACCUMULATORS, VALVES, LIGHTS, ETC.) FOR DETERIORATION/IRREGULARITY SUCH AS DAMAGE, FAILURE, LEAKS, MISSING PARTS, CORROSION AND PROPER ATTACHMENT.

(3) ALL OPENED AND REMOVED ACCESS DOORS AND PANELS WHERE LISTED.

CAL 6320 01.01.05

AN INSPECTION OF THE AIRCRAFT IS CONSIDERED **"EXTERNAL"** PROVIDED THAT:

A. IT IS A VISUAL INSPECTION

B. ACCESS IS GAINED THROUGH A DOOR OR HATCH. NO TOOLS REQUIRED

C. NO REMOVAL OF FAIRINGS, LININGS, INSULATION, EQIPMENT OR STRUCTURAL COMPONENTS ARE REQUIRED

D. IT IS NOT INSIDE THE WING, FIN OR STABILIZER BOX STRUCTURE.

ALL OTHER INSPECTIONS NOT COVERED BY THE ABOVE DEFINITION ARE **"INTERNAL"**.

E2: EXAMINATION 2

GENERAL VISUAL INSPECTION USING ACCESS MEANS: IT MAY REQUIRE FOR EXAMPLE THE USE OF WORKSTANDS, DOCKS, "SNORKEL" CRANE, AND IF NECESSARY OPENING OF SPECIFIC PANELS. THIS LEVEL OF INSPECTION DOES REQUIRE ACCESS MEANS AND IS MADE UNDER NORMAL LIGHTING CONDITIONS SUCH AS DAYLIGHT, HANGAR LIGHTING, OR FLASHLIGHT. CLEANING MAY BE REQUIRED.

A. Consumable Materials

(1) A00247 Sealant, Pressure and Environmental-Chromate Type - BMS5-95

(2) B00083 Solvent, Aliphatic naphtha (for acrylic plastics) - TT-N-95, Type II

(3) G02471 Tape, Skyflex noise reduction - GUA1001-1

STATION	DATE	ACCOMPLISHED
TPE	01.01.05	CAL 320

QP08MN082F1R2

CHINA AIRLINES

JOB CARD

WORK ORDER NUMBER	A/C-TYPE	A/C-REG.	TITLE	ISSUED BY / DATE	JOB CARD NUMBER
	738	B16805	GENERAL VISUAL INTERNAL: AREA BELOW AFT CARGO COMPARTMENT AMP 53-840-00	M.S.LO NOV.02'2004	E-1400-30-06
COST ENTER/ SKILL	CREW SIZE / DOWN TIME / MHRS			CHECKED BY	PAGE 2 OF 7
APG IMS	4 / 3.0 / 12				EVENT: P 11 C'K

PFM. BY	INSP	JOB DESCRIPTION
A CAL 638056 2005.01.02		**1. Floor Panel Removal** (1) Remove the screws and bolts that attach the cap strips, tiedowns, and floor panel to the support structure. **NOTE:** The bolts in different locations are of different lengths. Make a note of the location of the bolts. (2) Remove the following floor panels from forward cargo compartment (Figure 4-20) 140AF, 140BF, 140CF, 140DF,
~~A2~~ 01.4.05 [illegible] 01.4.05	7	2. PERFORM AN INTERNAL ZONAL INSPECTION (GV) OF THE AREA BELOW THE AFT CARGO COMPARTMENT -SECTION 46 AND 47 (PART), STA 727 TO STA 947.5. (with the floor panels listed in step 1 (2) removed) Inspection Result NORMAL
B CAL A626291 01.06.05		Reinstall the following floor panels to forward cargo compartment by the Step 3 140AF, 140BF, 140CF, 140DF, **3. Floor Panel Installation** (Fig 401) (1) Make sure the tape, GUA1001-1, on the floor panels is in good condition. (2) If it is necessary to replace the tape, do the steps that follow: (a) Remove the tape from the floor panel. (b) Use the solvent, TT-N-95, Type II, to remove the remaining tape or adhesive from the floor panel. (c) Install the tape, GUA1001-1, on the edges of the floor panel. 1) Make sure there are no clearances (gaps) between the sections of tape. (3) Put the floor panel, cap strips, and tiedowns in the correct locations. (4) Apply sealant, BMS5-95, on the screws and bolts, and install the screws and bolts while the sealant is wet.

STATION	DATE	ACCOMPLISHED
TPE	01.06.05	CAL A626291

QP08MN082F1R2

Appendix- 2：Gap Measurement and Angle Calculation

To measure gap distance between two ends of waste tank outlet flange and adjacent short tube flange, four fixed points between two ends were selected to carry out the measurement on airplane #1, #2 and #3. During the measurement, ASC found that the gap distance would be affected by the distance between short tube and ball valve. The maximum or minimum gap distance between two ends might be not right at the measuring points as well. Therefore, ASC investigators chose four fixed points on 12, 3, 6 and 9 o'clock positions to perform the measurement. The measured gap distances were used to calculate skewed angle between two ends. The coupling status of waste tank outlet and the adjacent short tube can be determined based on the calculated skewed angle and the gap distances. Then, further analysis can be made. Detail steps of calculation are as follows.

- Step 1. Set the coordination system

Set the surface of waste tank outlet flange as y-z plane which perpendicular to airplane longitudinal direction x. The origin locates at the center of flange surface as shown in Figure 1.

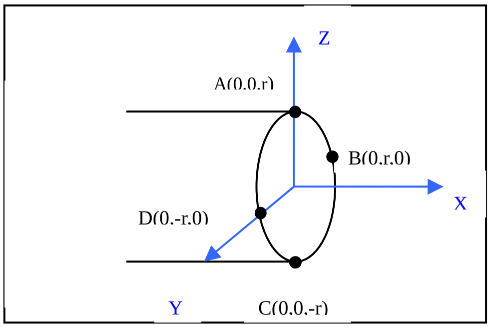


Figure 1 Coordination System

- Step 2. Determine relative position based on the coordination system

Based on the coordination system, the points at 12, 3, 6 and 9 o'clock position on the waste tank flange are designated as point A, B, C and D. The relative positions on the short tube are designaged as A', B', C' and D'. Gap dimension can be obtained by measureing the distance between each pairs of points as shown in Figure 2.

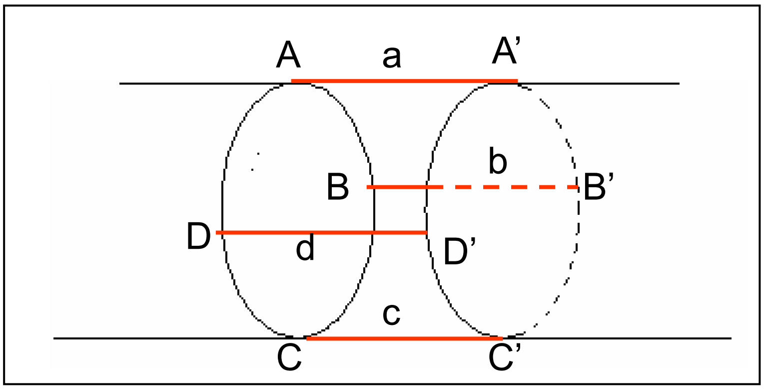


Figure 2 Relative Positions

• Step 3. Calculate normal vectors to the plane

Three non-collinear points can uniquely determine a plane. For example, choosing three points A, B and D located on the waste tank outlet flange and its corresponding three points A’, B’ and D’ on the short tube. Two normal vectors representing each planes can be uniquely determined as shown in Figure 3.

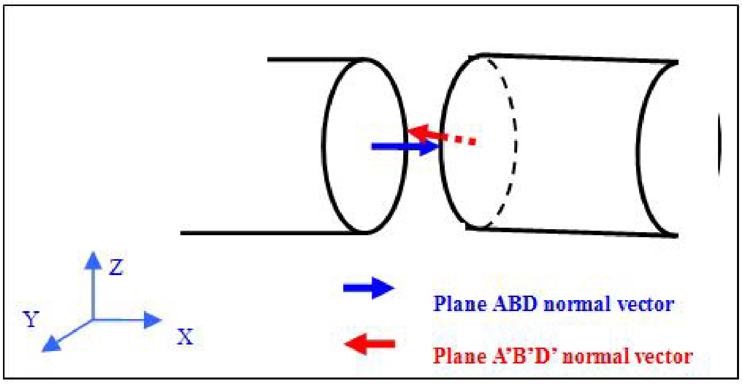


Figure 3 Plane Normal Vectors

• Step 4. Calculate skewed angle

In three dimensional space, a dihedral angle is the intersection of two non-colinear planes. Normal vectors to the planes are obtained from Step 3. The Cosine of two normal vectors is calculated by taking inner product of these two vectors. Then the angle can be obtained by taking arc Cosine of the above. The inner product formula is shown below, within which r represents the pipe radius.

$$\cos\theta = \frac{(\overrightarrow{AB}\times\overrightarrow{AD})\bullet(\overrightarrow{A'B'}\times\overrightarrow{A'D'})}{\left|\overrightarrow{AB}\times\overrightarrow{AD}\right|\times\left|\overrightarrow{A'B'}\times\overrightarrow{A'D'}\right|} = \frac{4r^4}{2r^2\times r\sqrt{4r^2+2b^2+2d^2+4(a^2-ab-ad)}}$$

$$= \frac{2r}{\sqrt{4r^2+2b^2+2d^2+4(a^2-ab-ad)}} = S \qquad \theta = \cos^{-1}S$$

The calculated angle is the same as the dihedral angle stated above. When using the inner product formula to calculate the angle, negative value may be existed due to the radical sign. If the value of inner product were negative (-S), its arc Cosine is the complemental angle of positive value (+S). The same intersection angle between two normal vectors can be obtained. For simplicity, positive value is choosen here.

- Step 5. Results

The results are shown in Table 1 and Table 2 by following the above procedures.

Table 1 Waste Tank to Short Tube

Airplane	d	b	a	COSθ	θ	Direction
#1	0.262	0.261	0.258	0.999997	0.129232	3~6 o'clock
#2	0.111	0.126	0.115	0.999986	0.302522	9~12 o'clock
#3	0.275	0.348	0.331	0.999652	1.512271	6~9 o'clock
#4	0.084	0.043	0.051	0.999883	0.877568	12~3 o'clock
#5	0.093	0.045	0.092	0.999775	1.214874	3~6 o'clock
#6	0.191	0.206	0.235	0.999718	1.361778	6~9 o'clock
#7	0.003	0.015	0.002	0.999983	0.336992	9 o'clock
#8	0.058	0.246	0.132	0.998126	3.508438	9~12 o'clock
#9	0.035	0.165	0.044	0.998505	3.132928	9~12 o'clock
#10	0.194	0.182	0.179	0.99976	0.395368	3~12 o'clock

Table 2 Short Tube to Ball Valve

Airplane	d	b	a	COSθ	θ	Direction
#4	0.021	0.069	0.066	0.999793	1.165509	6~9 o'clock
#5	0.061	0.051	0.042	0.999955	0.543373	12~3 o'clock
#6	0.122	0.184	0.118	0.999555	1.708486	9~12 o'clock
#7	0.08	0.03	0.018	0.999594	1.631775	12~3 o'clock
#8	0.437	0.001	0.042	0.98433	10.15644	12~3 o'clock
#9	0.391	0.006	0.227	0.992382	7.076814	12~3 o'clock
#10	0.147	0.169	0.129	0.999804	1.133564	9~12 o'clock

In Step 4, the angle by taking arc Cosine of a positive S must be an acute angle (< 90°). To judge the direction of skewness, the measurements listed in Table 1.6-4 are used. The direction of skewness will toward the point where the minimum gap distance existed.

- Step 6. Verification

To verify the above results, gap distances on 6, 12 and 9 o'clock positions from waste tank outlet to short tube and from short tube to ball valve are choosen. The results are shown in Table 3 and Table 4 respectively for comparison.

Table 3 Waste Tank to Short Tube

Airplane	c	a	d	COSθ	θ	Direction
#1	0.25	0.258	0.262	0.999984	0.32693	3~6 o'clock
#2	0.13	0.115	0.111	0.999962	0.501834	9~12 o'clock
#3	0.31	0.331	0.275	0.999557	1.706337	6~9 o'clock
#4	0.087	0.051	0.084	0.999888	0.856385	12~3 o'clock
#5	0.032	0.092	0.093	0.999622	1.576444	3~6 o'clock
#6	0.187	0.235	0.191	0.999801	1.14178	6~9 o'clock
#7	0.003	0.002	0.003	~1	0.025846	9 o'clock
#8	0.205	0.132	0.058	0.997256	4.245888	9~12 o'clock
#9	0.174	0.044	0.035	0.998032	3.595446	9~12 o'clock
#10	0.210	0.179	0.194	0.999951	0.566837	3~12 o'clock

Table 4 Short Tube to Ball Valve

Airplane	c	a	d	COSθ	θ	Direction
#4	0.041	0.066	0.021	0.999753	1.272578	6~9 o'clock
#5	0.09	0.042	0.061	0.999878	0.896018	12~3 o'clock
#6	0.203	0.118	0.122	0.999331	2.095175	9~12 o'clock
#7	0.103	0.018	0.08	0.999555	1.708681	12~3 o'clock
#8	0.249	0.042	0.437	0.981079	11.16327	12~3 o'clock
#9	0.508	0.227	0.391	0.995896	5.19268	12~3 o'clock
#10	0.135	0.129	0.147	0.999952	0.559125	9~12 o'clock

Appendix- 3：CI7552 CVR TRANSCRIPT

代號說明：

CAM　：座艙區域麥克風

CAM 之發話來源註解

-1：正駕駛員

-2：副駕駛員

-3：空服組員

-?：發話來源無法辨識

…　：無法辨識之發話

*　：與操作無關之發話

（）　：註解

hh	mm	ss	來源	內容
04	35	51.4		（座艙語音記錄開始）
04	36	24.4	CAM-1	…繞來繞去 …看不到跑道 也就…
04	36	26.4	CAM-2	對對 呵呵呵
04	36	29.0	CAM-?	…
04	36	30.4	CAM-?	…
04	36	38.5	CAM-2	剛剛這樣飛過去…
04	36	40.7	CAM-1	我跟你講不可以 這樣飛是要作 teardrop 進來 它的 holding pattern 在這邊對不對
04	36	45.9	CAM-2	對
04	36	46.1	CAM-1	作一個 teardrop 進來 然後 check out bound
04	36	49.0	CAM-1	我們不可能直接 這樣 turn 是轉不過來
04	36	49.1	CAM-2	喔

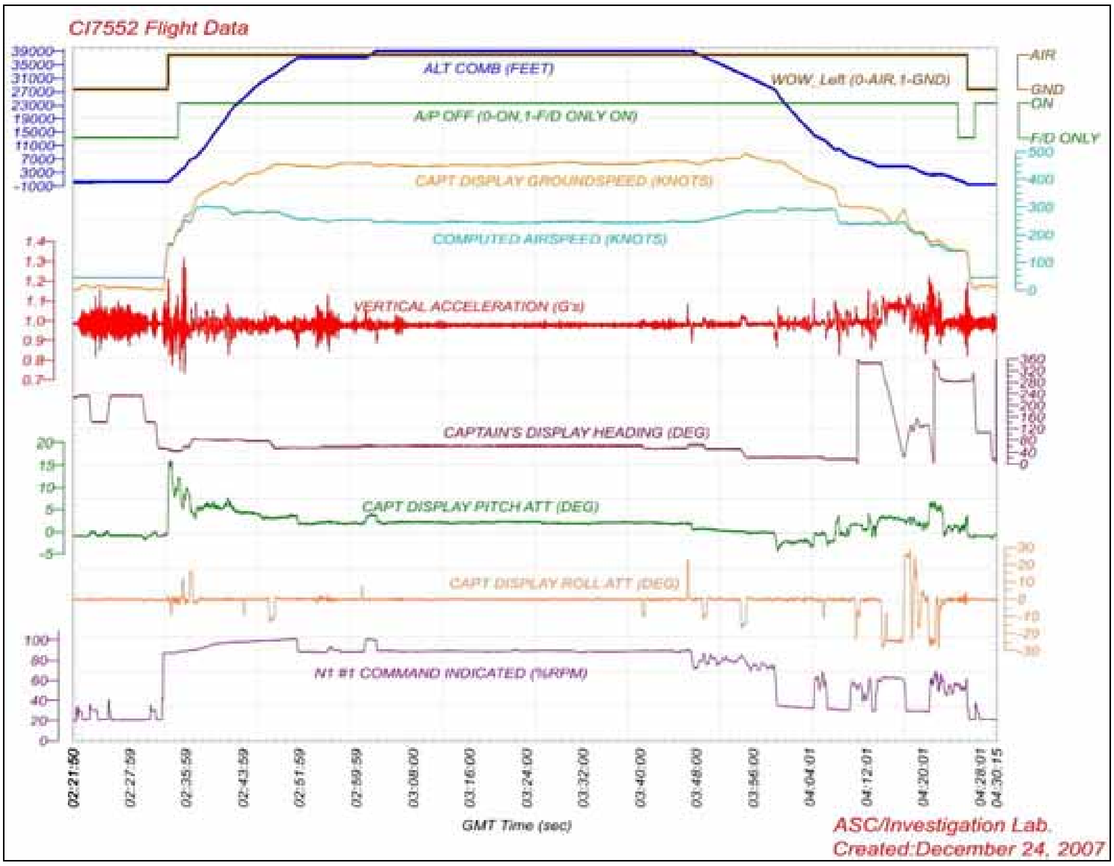
hh	mm	ss	來源	內容
04	36	52.0	CAM-2	對
04	36	52.6	CAM-1	所以說我 teardrop 就等於說我左轉一個 heading 這樣進來 擱一下擱它
04	36	56.6	CAM-2	嗯
04	36	59.9	CAM-2	可是剛剛這樣轉過來的時候　也已經到這邊了嘛
04	37	04.1	CAM-1	對呀 所以說就
04	37	04.6	CAM-2	可是它還是要 report high station
04	37	06.4	CAM-1	你還是要
04	37	06.7	CAM-2	還是要…
04	37	07.2	CAM-1	因為　你你你既然要飛這樣的話　就照他 他要　他要你 report over high station 嘛
04	37	13.2	CAM-2	對
04	37	13.7	CAM-1	那我們沒辦法 over 啊
04	37	16.1	CAM-2	…剛剛好像…
04	37	16.1	CAM-1	…所以說　我們已經飛到這邊來　然後我們叫沒辦法　就 check in bound 進去再 check out bound
04	37	21.7	CAM-2	喔
04	37	31.0	CAM-1	…以前也在那個哪裡　也是一樣
04	37	34.2	CAM-2	… asahikawa …
04	37	36.0	CAM-1	要 check out bound 他叫你先過 over 然後再 check out bound … 那都是一樣的道理 …你要 必須要作一個 teardrop

hh	mm	ss	來源	內容
04	37	49.1	CAM-1	看你從哪個方向 你這個方向進來一定是作這個 teardrop 這樣進來嘛 對不對 這樣最近 如果從這個方向 那當然不用呀 你就直接 check out bound over high station 直接 check out bound
04	37	59.9	CAM-2	對
04	38	00.5	CAM-1	對呀
04	38	01.8	CAM-1	那你如果這個方向進來 你要作一個 parallel 進去然後左轉 然後這樣轉進來還都是一樣啦
04	38	13.6	CAM-1	因為你不管從哪個方向 你要直接轉轉出去的話 絕對不能 over high station 因為你直接轉 那你就等於說 fly by path
04	38	23.6	CAM-1	你若從這邊進來直接轉這個 out bound 進去的話 你就必須要有攔截角度喔
04	38	39.9	CAM-?	…
04	38	57.4	CAM-1	好啦 飛完就好了 呵呵呵呵呵
04	39	00.1	CAM-2	…下次看怎麼飛
04	39	00.9	CAM-1	呵呵
04	39	04.0	CAM-2	上一次是直接 就是往 saga 然後叫我們 report airport insight 作 visual 么么
04	39	09.4	CAM-1	因為這個機場很平 你知道 看不出來
04	39	12.1	CAM-2	嗯 喔
04	39	14.8	CAM-2	所以這一次
04	39	17.0	CAM-1	我就直接打點
04	39	18.7	CAM-2	呵呵呵
04	39	19.4	CAM-1	好 那那那 那可以呀
04	39	20.2	CAM-2	直接 L-NAV 飛 *

<table>
<tr><th>hh</th><th>mm</th><th>ss</th><th>來源</th><th>內容</th></tr>
<tr><td>04</td><td>39</td><td>22.4</td><td>CAM-1</td><td>那可以呀</td></tr>
<tr><td>04</td><td>39</td><td>22.9</td><td>CAM-2</td><td>* 那個它也是</td></tr>
<tr><td>04</td><td>39</td><td>24.4</td><td>CAM-1</td><td>好像那時候 …好像也沒來幾次 也搞不清楚</td></tr>
<tr><td>04</td><td>39</td><td>28.8</td><td>CAM-2</td><td>所以還是先做好 比較保險 呵呵</td></tr>
<tr><td>04</td><td>39</td><td>36.1</td><td>CAM-1</td><td>*</td></tr>
<tr><td>04</td><td>39</td><td>39.2</td><td>CAM-2</td><td>呵呵呵</td></tr>
<tr><td>04</td><td>39</td><td>44.0</td><td>CAM-2</td><td>反正我們也都目視狀況嘛</td></tr>
<tr><td>04</td><td>39</td><td>45.7</td><td>CAM-2</td><td>對呀</td></tr>
<tr><td>04</td><td>39</td><td>46.0</td><td>CAM-1</td><td>對呀</td></tr>
<tr><td>04</td><td>39</td><td>51.5</td><td>CAM-1</td><td>你只要記得 airport 在哪裡就好了</td></tr>
<tr><td>04</td><td>39</td><td>53.7</td><td>CAM-2</td><td>嗯嗯</td></tr>
<tr><td>04</td><td>39</td><td>54.0</td><td>CAM-1</td><td>…orientation 不要 lost</td></tr>
<tr><td>04</td><td>39</td><td>56.0</td><td>CAM-2</td><td>對對對</td></tr>
<tr><td>04</td><td>39</td><td>56.3</td><td>CAM-1</td><td>大概知道 airport 現在正 正在哪個方向 不要轉呀轉轉昏頭了</td></tr>
<tr><td>04</td><td>39</td><td>58.7</td><td>CAM-2</td><td>嗯</td></tr>
<tr><td>04</td><td>40</td><td>00.5</td><td>CAM-2</td><td>對</td></tr>
<tr><td>04</td><td>40</td><td>01.3</td><td>CAM-1</td><td>對呀</td></tr>
<tr><td>04</td><td>40</td><td>03.9</td><td>CAM-1</td><td>管它 airport 在哪裡 對不對</td></tr>
<tr><td>04</td><td>40</td><td>05.3</td><td>CAM-2</td><td>呵呵呵 嗯</td></tr>
<tr><td>04</td><td>40</td><td>09.6</td><td rowspan="3">CAM</td><td rowspan="3">（本時段內之對話皆與飛航作業無關）</td></tr>
<tr><td colspan="3">|</td></tr>
<tr><td>04</td><td>43</td><td>52.3</td></tr>
<tr><td>04</td><td>43</td><td>52.3</td><td>CAM-1</td><td>好吧 下去吧 給你一響就 hydraulic 開了</td></tr>
<tr><td>04</td><td>43</td><td>54.8</td><td>CAM-2</td><td>謝謝 謝謝</td></tr>
<tr><td>04</td><td>43</td><td>55.1</td><td>CAM-1</td><td>好吧 嗯</td></tr>
<tr><td>04</td><td>43</td><td>59.3</td><td>CAM</td><td>（疑似座椅滑動聲響）</td></tr>
</table>

hh	mm	ss	來源	內容
04	44	08.8	CAM-?	*
04	44	51.2	CAM-?	*
04	44	53.7	CAM-1	*
04	44	54.9	CAM-2	*
04	46	14.1	CAM	（不明聲響）
04	46	18.2	CAM	噹（單聲訊息聲）
04	47	41.6	CAM	（不明聲響）
04	48	13.6	CAM	（不明聲響）
04	49	23.7	CAM-?	…
04	51	00.3	---	…
04	51	13.7	---	…
04	52	04.7	CAM-1	現在 我們現在發現喔 它機腹下面裂了
04	52	08.8	CAM-2	喔
04	52	09.5	CAM-1	裂痕很大 然後沒有辦法 … 沒有辦法加壓 然後加壓因為因為…因為它現在…
04	52	21.4	CAM-1	那 不是外傷 不是外面刮到的
04	52	25.0	CAM-1	不知道為什麼 它這樣… 先跟你講一下好不好…
04	52	35.3	CAM-?	...
04	52	45.6	CAM-1	對嘛 …
04	52	45.9	CAM-?	… 剛才 preflight… 台北出來的時候 有沒有發覺到
04	52	49.2	CAM-1	嗯
06	39	14.8		（座艙語音記錄終止）

Appendix- 4：CI7552 Flight Data Plot



Appendix- 5：METALLURGICAL REPORT (CSIST)

報告編號:960375
Report No.: 960375

材料試驗報告
Materials Test Report

委託單位：行政院飛航安全委員會
APPLICANT:
試驗名稱：華航客機蒙皮裂紋分析
TEST ITEM:
試驗日期:11/27/2007
TEST DATE:

1.測試報告內容如內頁。
The content of the test report is as the interior page.
2.本報告含封面共 35 頁，分開使用無效。
The test report includes 35 pages, being invalid if separated
3.本報告未經本實驗室同意，不得摘錄複製。
This report can't extract and duplicate without laboratory's consent.
4.本報告須有報告簽署人簽名，始生效。
This report is valid after signing by approval signatory.
5.本報告內容任意塗改，視為無效。
It is invalid if the content of the report is altered.
6.本報告僅對所測試的樣品有效。
This report is valid only to the testing specimen.

測試單位:中山科學研究院 航空研究所
結構與材料工程組 材料測試實驗室
Test By: CSIST/ASRD/AMS/Materials Test Laboratory
地 址: 台中郵政 90008 附 11-3 號信箱
Address: P.O.Box 90008-11-12 Taichung, Taiwan R.O.C.
電 話: 04-27023051 轉 503030
Tel: 04-27023051 Ext.503726

材料試驗報告(Materials Test Report)

中山科學研究院 Chung Shan Institute of Science and Technology 第一(航空)研究所 Aeronautical Systems Research Division 結構與材料工程組 Structure and Materials Section	工令報告編號 (Report No.) 960375 小組試驗編號 (Lab. No.)

專案名稱 (Project)		申請者/單位 (Applicant/Department)	
技服案(24)		[redacted]行政院飛航安全委員會	
物件名稱 (Part Name)		件　號 (Part No.)	序　號 (Serial No.)
華航 737-800 型客機機身蒙皮裂紋		------	------
材　料 (Material)	規　範 (Specification)	批　號 (Lot No.)	爐　號 (Heat No.)
2024-T3	------	------	------
試驗方法 (Test Method)			
破損分析			

試驗結果 (Results)

一、說明

隸屬中華航空公司編號 B-16805 之波音 737-800 型客機，於日本佐賀機場落地後，發現機身有長達 77 公分之裂紋。該機於 96.10.11 飛返國內，96.10.16 由行政院飛航安全委員會協同交通部民航局、波音公司及華航公司代表等人，親將該破損蒙皮送至本組，擬委請本組進行破損分析，以期釐清肇因。

依據華航公司提供之藍圖顯示，該破損蒙皮材質為 2024-T3 Clad 之鋁合金，內表面經化學蝕銑處理。平時維護清洗飛機廢水系統管路時，以 10% 醋酸與冰混合後，進行清洗。

二、試驗步驟

試驗者 (Tested by)／日期(Date)	審查者 (Reviewed by)／日期(Date)	核准者(Approved by)／日期(Date)
[redacted] 11 / 26 / 2007 (MM) (DD) (YY;西元)	/ / (MM) (DD) (YY;西元)	[redacted] 8 / 07 (MM) (DD) (YY;西元)

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

FORM 140-069
本報告分開使用無效

1、外觀分析。

2、破斷面掃描式電子顯微鏡(SEM)觀察。

3、化學成份分析。

4、硬度及導電度測試

5、金相組織觀察。

6、基材厚度及鍍鋁層(Clad Layer)厚度量測。

7、腐蝕後殘存厚度量測。

8、腐蝕物離子層析(Ion Chromatography)及比對試驗。

三、試驗結果與討論

1、外觀分析

圖 1 與圖 2 分別為華航公司編號 B-16805 波音 737-800 型客機送檢機身蒙皮之內側與外側外觀，箭頭所指為裂紋，此區段內之破斷面粗糙，並有腐蝕生成物附著。除斷面以外，在內側表面亦發現有大面積之腐蝕生成物，如圖 1 灰色區塊。

圖 3~圖 12 為將圖 1 內側表面分成 10 段放大觀察之圖片，其相對編號位置標示於圖 1，由這些圖片可以更明顯地發現斷面呈現崎嶇不平並有腐蝕生成物之外觀破壞特徵。這些腐蝕生成物已造成鋁合金基材剝離(Exfoliation)，可輕易地以外力刮下。

2、破斷面掃描式電子顯微鏡(SEM)觀察

以掃描式電子顯微鏡檢視編號 1 號試片整個斷面如圖 13、圖 14，圖中顯示蒙皮外側表面還存在有較完好的面漆保護，但內側表面則呈現嚴重表面剝離的情形，破斷表面皆已遭非金屬物質覆蓋，無法辨識基材之破壞結構。

編號 9 號試片斷面之電子顯微鏡觀察結果如圖 15，在蒙皮厚度方向可以清楚區隔為兩個斷面特徵(如圖 15(a))，靠蒙皮內側的斷面顯現的是延晶破裂的模式(如圖 15(b))，而靠蒙皮外側的斷面則顯現強制破裂的模式(如圖 15(c))，前者為主要破斷因素，所佔之面積遠較後者為廣。為了確認延晶破壞以及破斷面表面覆蓋物質與腐蝕之關聯性，以掃描式電子顯微鏡能量散佈光譜(SEM/EDS)分析該等物質之組成，結果如圖 15(d)，顯示除了一般可能來自於外界之污染物質之外，還有少許之氯(Cl)元素，氯是造成鋁合金腐蝕的重要元素，不過考量儀器之精確度以及可能來自大氣環境影響的因素，將另以離子層析儀來檢定其腐蝕物型態。

編號 5 號試片斷面之電子顯微鏡觀察結果如圖 16，整個斷面之形貌與前述 9 號試片完全相同。另外再選擇靠蒙皮內側之一處已經剝離之表面來觀察，其破斷特徵如圖 17，顯示同樣為極典型之延晶破壞之模式，顯見這一種破裂模式由蒙皮內側表面往蒙皮厚度方向不斷成長延伸，直到受力面積不足以承受負載後，產生過載破壞(Overload)，並於殘存面積遺留下凹渦特徵(Dimples)，如圖 16 之(b)圖所示。另由

凹渦微觀剪力唇(Shear Lip)近乎垂直於斷面研判，其受力應以垂直於斷面的力量型態為主。

3、化學成份分析

表一為蒙皮基材之 SPARK 化學成份分析結果，經比對其成份符合 AMS-QQ-A-250/5A 規範需求之 2024 鋁合金。

4、硬度及導電度測試

蒙皮基材硬度測試結果，平均值為 75.9 HRB，配合導電度的測試平均值 29.8 IACS，研判其熱處理狀態應為 T3 熱處理。符合 AMS 2658B 對 2024 鋁合金 T3 熱處理狀態之要求，即導電度介於 27.5～32.5 IACS；硬度大於 63 HRB。

5、金相組織觀察

圖 18 與圖 19 分別為蒙皮基材 L 方向和 T 方向的金相組織觀察，為固溶+冷加工的組織，屬典型之 2024-T3 金相組織。

圖 20~圖 22 分別為編號 4 蒙皮裂紋 L 方向和 T 方向的剖面金相觀察，無論從 L 方向或 T 方向觀察均能發現明顯的沿晶裂紋，且其內面外緣的孔蝕從 T 方向觀察更明顯。

6、基材厚度及鍍鋁層(Clad Layer)厚度量測

圖 23~圖 26 分別為鋁合金基材(含鍍鋁層)和鍍鋁層厚度量測，量測結果為: 鋁合金基材 L 方向厚度為 0.0644 英吋(1635 μm)、T 方向

厚度為 0.0625 英吋(1587μm)；鍍鋁層 L 方向厚度為 0.0056 英吋(141μm)、T 方向厚度為 0.0054 英吋(137μm)。

7、腐蝕後殘存厚度量測

圖 27~圖 30 分別為編號 1、4、7、10 蒙皮裂紋 T 方向的殘存基材厚度量測結果，編號 1 為 0.024 英吋 (604μm)、編號 4 為 0.019 英吋(494μm)、編號 7 為 0.023 英吋(584μm)、編號 10 為 0.024 英吋(615μm)。(另加鍍鋁層厚度量測值以作為結論之依據)

8、腐蝕物離子層析(Ion Chromatography)及比對試驗

以美工刀刮取蒙皮上腐蝕物粉末共 2.26 克，將腐蝕粉末分成兩等份(A) & (B)，每份 1.13 克，如圖 31。本試驗共計執行 5 種試樣，如下

(1)溶液(a)

將上述(A)粉末浸於 50cc 去離子水 18 小時→過濾→取濾液→稀釋至 1000cc。

(2) 溶液(b)

將上述(B)粉末浸於 50cc 去離子水，加熱(60℃)1 小時 →過濾 →取濾液→稀釋至 1000cc。

(3) 溶液(c)

直接取用飛安會檢送之清洗用稀釋醋酸溶液(10% Acetic acid)再稀釋 1/10000，濃度相當於 10 ppm 為溶液(c)。

(4) 溶液(d)

配置 Cl^{-}，$SO_4^{=}$，PO_4^{-3}，飛安會檢送之 10% Acetic acid，各為濃度 10ppm 之溶液為(d)。

(5) 溶液(e)

以 MERCK 公司化學試藥級 Acetic acid 純度>99.8%，稀釋 1/100000，濃度相當於 10 ppm 為溶液(e)。

以離子層析儀檢測 (a)、(b)、(c)、(d)、(e) 等溶液內各離子滯留時間(Retention Time)，測試結果分別溶液(a)如圖 32、溶液(b)如圖 33、溶液(c)如圖 34、溶液(d)如圖 35、及溶液(e)如圖 36。

由溶液(d)圖 35 獲知各離子滯留時間約分別為 CH_3COO^{-}：0.996 min.，Cl^{-}：1.329 min.，PO_4^{-3}：3.538 min.，$SO_4^{=}$：4.904 min. 。

由溶液(c)圖 34 及溶液(e)圖 36 比對顯示，純醋酸根離子($CH3COO^{-}$, 99.8% Merck Acetic acid)滯留時間應只有 0.992~1.004 min.之 Peak，顯示飛安會檢送之醋酸溶液中，除醋酸根離子(CH_3COO^{-})外，尚含有其它陰離子。

由溶液(a)圖 32、溶液(b)圖 33、溶液(c)圖 34、及溶液(d)圖 35 比對顯示，飛安會檢送之醋酸溶液與由腐蝕物淬取(室溫或加熱)之溶液 IC 圖譜幾乎完全相同。且經比對，飛安會檢送之醋酸溶液及淬取液中，除醋酸根離子(CH_3COO^{-})外，尚含有氯離子(Cl^{-})及極微量硫酸根離子($SO4^{=}$)，但無發現磷酸根離子(PO_4^{-3})或其他陰離子。

註：離子層析儀廠牌：Dionex-dx-120;
Column：Ion Pac AS4A-SC
Fluent：1.8mM Na_2CO_3/1.7mM $NaHCO_3$
Flow Rate：2.0 ml/min.

(6).定量分析(僅供參考)

因無醋酸根離子之標準濃度溶液可供比對，以下定量計算僅供參考。以標示濃度 99.8%之 MERCK 醋酸(已使用一段時間，濃度僅供參考)配置成 10ppm 之溶液(e).為比對之標準相對濃度，(a),(b),(c),(d)各溶液之陰離子相對濃度及腐蝕物內醋酸及氯離子含量計算如下表。

溶液編號		圖譜面積	相對濃度	含量(%)	計算方式	
a	CH_3COO^-	8.93×10^7	28.1 ppm	2.5	8.93/(3.18x1.13x10)	
	Cl^-	3.15×10^7	1.83 ppm	0.16	3.15/(17.24x1.13x10)	
b	CH_3COO^-	17.35×10^7	54.6 ppm	4.83	17.35/(3.18x1.13x10)	
	Cl^-	4.02×10^7	2.33 ppm	0.21	4.02/(17.24x1.13x10)	
c	CH_3COO^-	3.85×10^7	12.1 ppm	12.1		
	Cl^-	1.03×10^7	0.6 ppm	0.6		
d	CH_3COO^-	3.70×10^7	11.6 ppm	11.6		
	Cl^-	17.24×10^7	10 ppm			
	$SO_4^{=}$	3.88×10^7	10 ppm			
	PO_4^{-3}	12.16×10^7	10 ppm			
e	CH_3COO^-	3.18×10^7	10 ppm			

四、結果與討論

由化學成份分析及金相、硬度及導電度試驗結果顯示，送檢鋁合金蒙皮屬 2024-T3 Clad 鋁合金，原材內表面因化學蝕銑已將鍍鋁層去除，但此為波音公司律定製程，即原材符合藍圖需求。

在 SEM 觀察結果中，未被腐蝕生成物覆蓋的破斷面呈現典型的沿晶破壞模式，破裂由蒙皮內側表面往蒙皮厚度方向不斷成長延伸，並在斷面上偵測到氯等腐蝕元素。相同的沿晶破壞模式亦在破斷面金相觀察中發現:沿晶腐蝕次裂縫(Secondary Crack)並繼續延伸至基材。因此，由 SEM/EDS 及金相試驗之分析結果判定，送檢蒙皮之破壞機制為腐蝕所造成。

此等由蒙皮內側開始的剝離腐蝕現象使得受力面積減小，最後因不足以承受外載而產生裂紋，並於後段斷面上遺留下凹渦特徵，由凹渦特徵的微觀剪力唇型態研判，其受力型態應以垂直於斷面的力量為主。

為確認腐蝕物來源，本案執行包括自蒙皮取下之腐蝕物粉末、飛安會檢送之稀釋醋酸(廢水系統清洗液)及標準液等五種溶液之離子層析試驗。分析結果顯示，由蒙皮腐蝕粉末所淬取的溶液中，主要為醋酸根離子及氯離子，未無發現其他陰離子，故醋酸根離子或氯離子為主要腐蝕因子，對金屬材料而言，此兩者又以氯離子造成的腐蝕危害最大，為主要關鍵。

另由飛安會檢送之廢水系統清洗液中發現，除醋酸根離子外，

尚含有氯離子，且其 IC 圖譜與由蒙皮腐蝕粉末淬取之溶液中的陰離子成份相同。

五、結論

1. 送檢中華航空公司編號 B-16805 客機蒙皮，材質為 2024-T3 Clad 鋁合金，符合華航公司所提供之藍圖需求。
2. 腐蝕為造成蒙皮裂紋的主要機制，其型態屬於剝離(Exfoliation)腐蝕。腐蝕由無鍍鋁層的內側蒙皮表面開始，逐漸往蒙皮外側擴展，最後因有效截面積不足，無法承受外載力量而出現過載破壞裂紋。
3. 由蒙皮腐蝕粉末所淬取的溶液中，發現主要為醋酸根離子及氯離子。此兩者中，又以氯離子造成的腐蝕危害最大，為主要關鍵。
4. 離子層析結果發現，飛安會檢送的廢水系統清洗液與由蒙皮腐蝕粉末所淬取的溶液，兩者的陰離子成份相同。

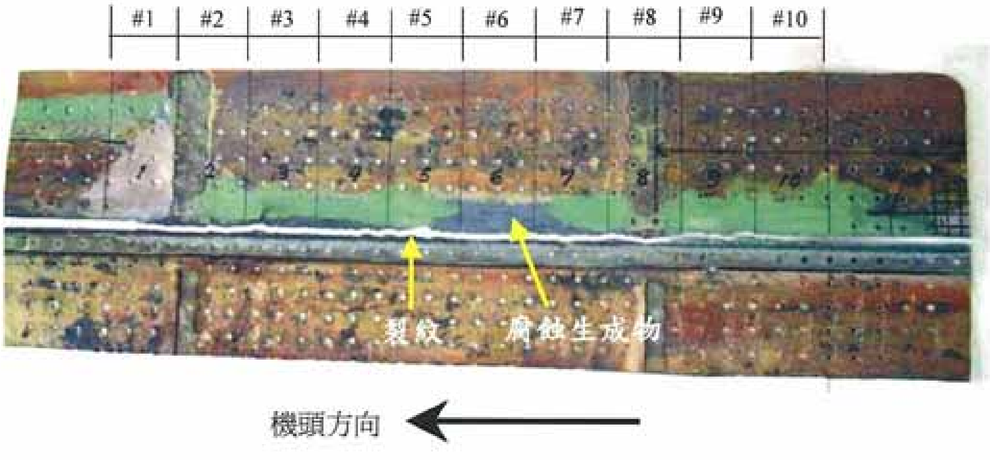


圖 1、波音 737-800 型客機機身蒙皮裂紋的外觀觀察(內側表面)

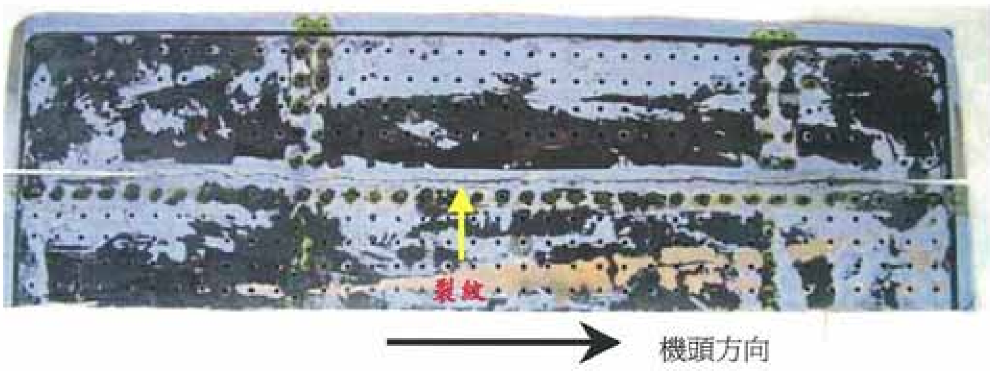


圖 2、波音 737-800 型客機機身蒙皮裂紋的外觀觀察(外側表面)

圖 3、編號 1 蒙皮試片巨觀觀察(下圖為斷面正視)。

圖 4、編號 2 蒙皮試片巨觀觀察(下圖為斷面正視)。

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

圖 5、編號 3 蒙皮試片巨觀觀察(下圖為斷面正視)。

圖 6、編號 4 蒙皮試片巨觀觀察(下圖為斷面正視)。

圖 7、編號 5 蒙皮試片巨觀觀察(下圖為斷面正視)。

圖 8、編號 6 蒙皮試片巨觀觀察(下圖為斷面正視)。

圖 9、編號 7 蒙皮試片巨觀觀察(下圖為斷面正視)。

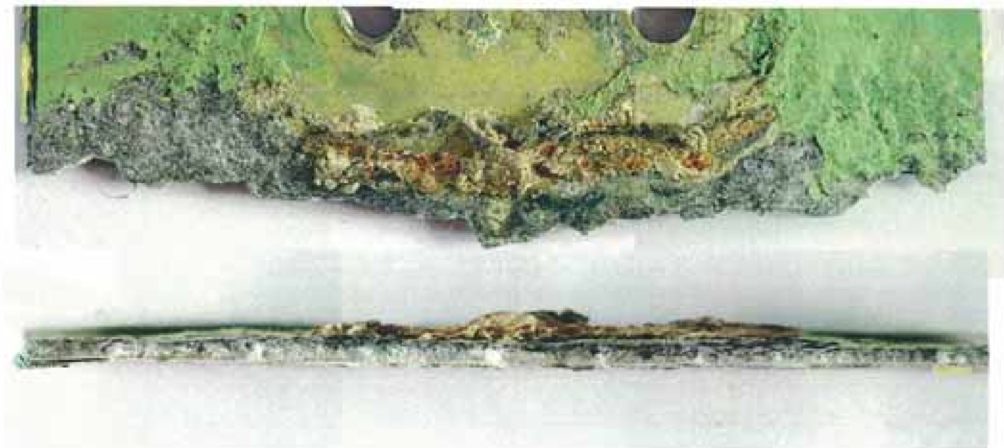


圖 10、編號 8 蒙皮試片巨觀觀察(下圖為斷面正視)。

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

圖 11、編號 9 蒙皮試片巨觀觀察(下圖為斷面正視)。

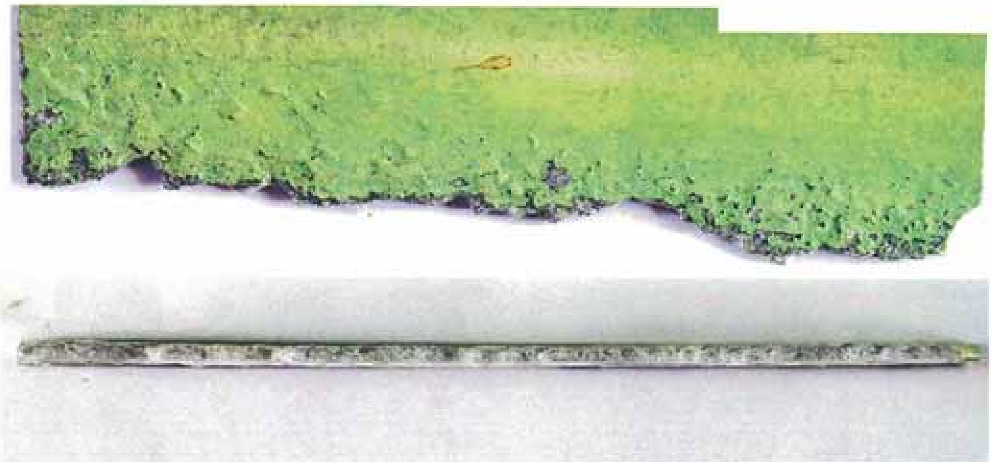
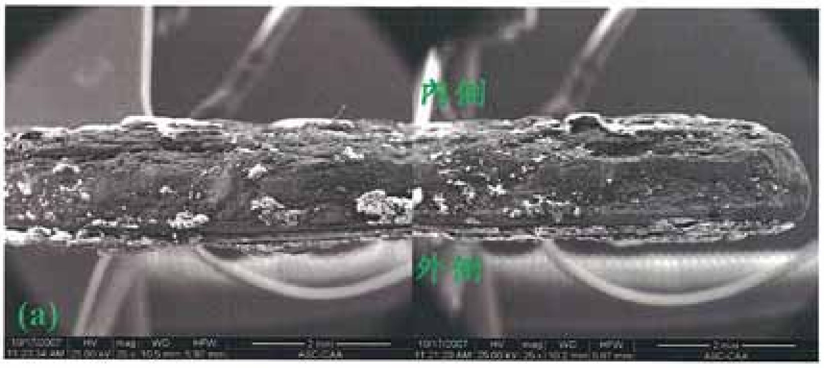
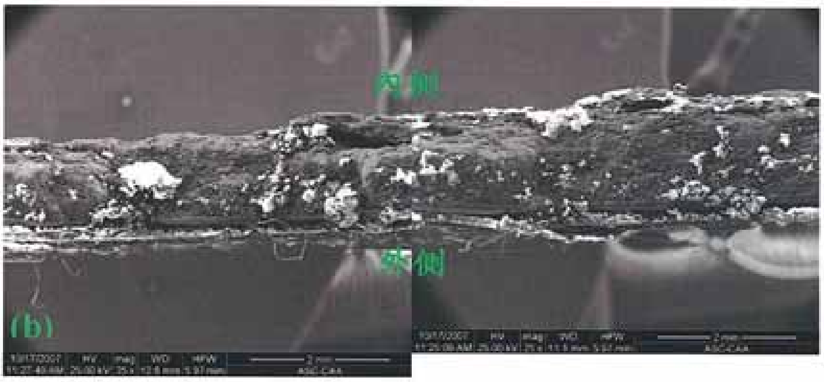


圖 12、編號 10 蒙皮試片巨觀觀察(下圖為斷面正視)。

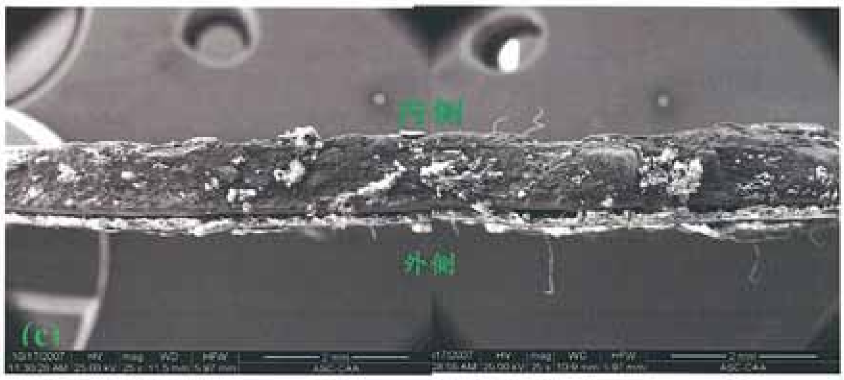
台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548



內側
外側
(a)



內側
外側
(b)



內側
外側
(c)

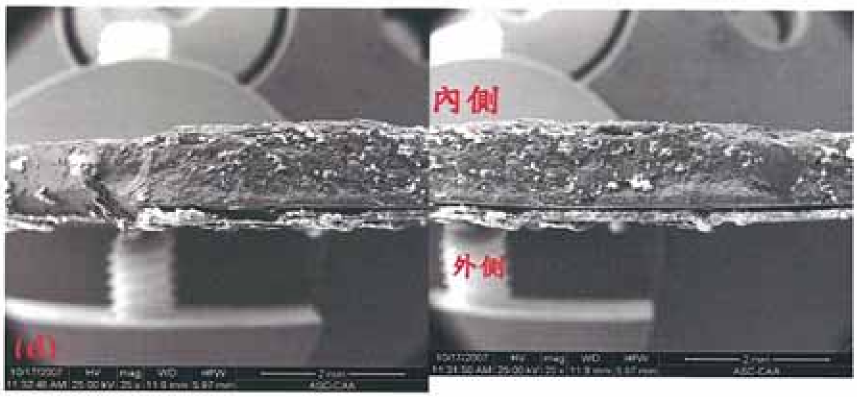


圖 13、編號 1 號試片整個破斷面特徵觀察。

圖 14、編號 1 號試片 SEM 下之破斷面微觀特徵觀察。

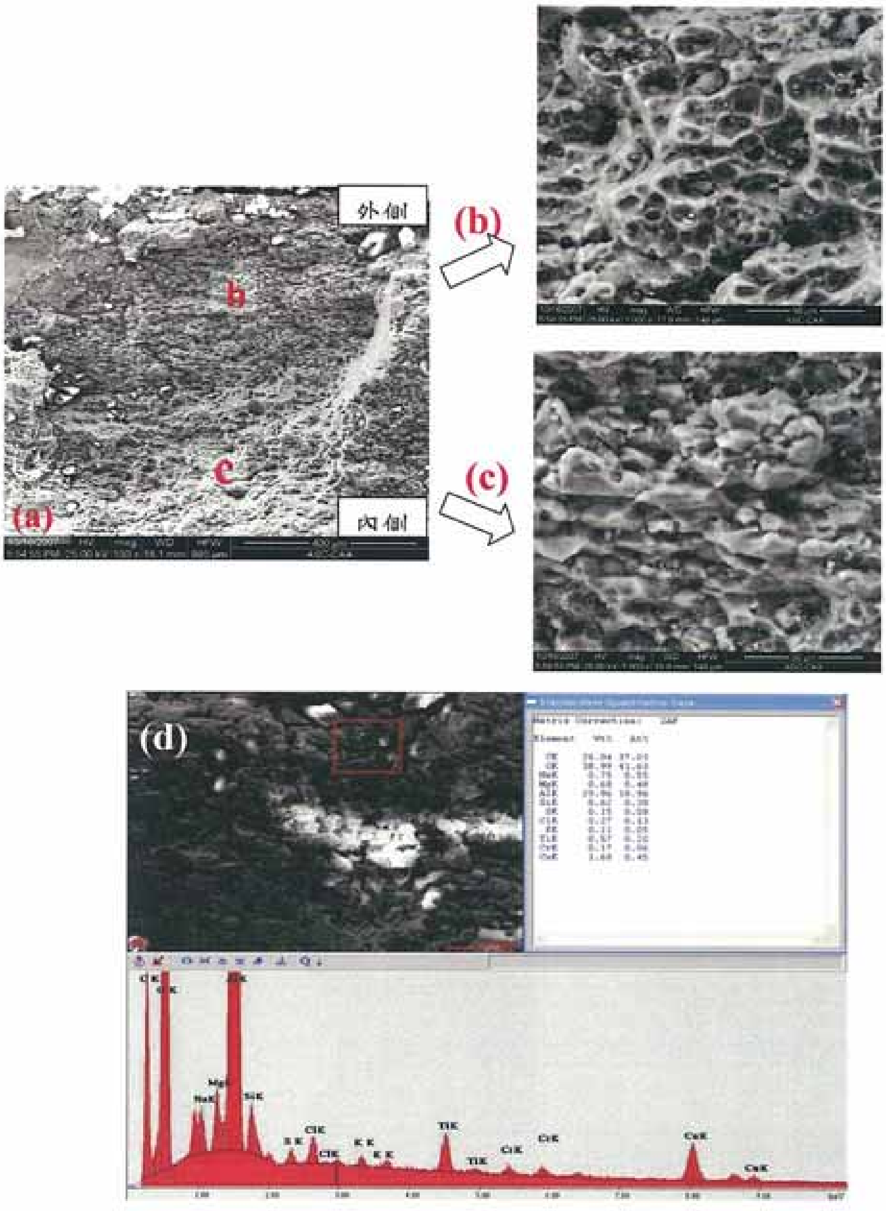


圖 15、編號 9 號試片 SEM/EDS 下之破斷面微觀特徵觀察。

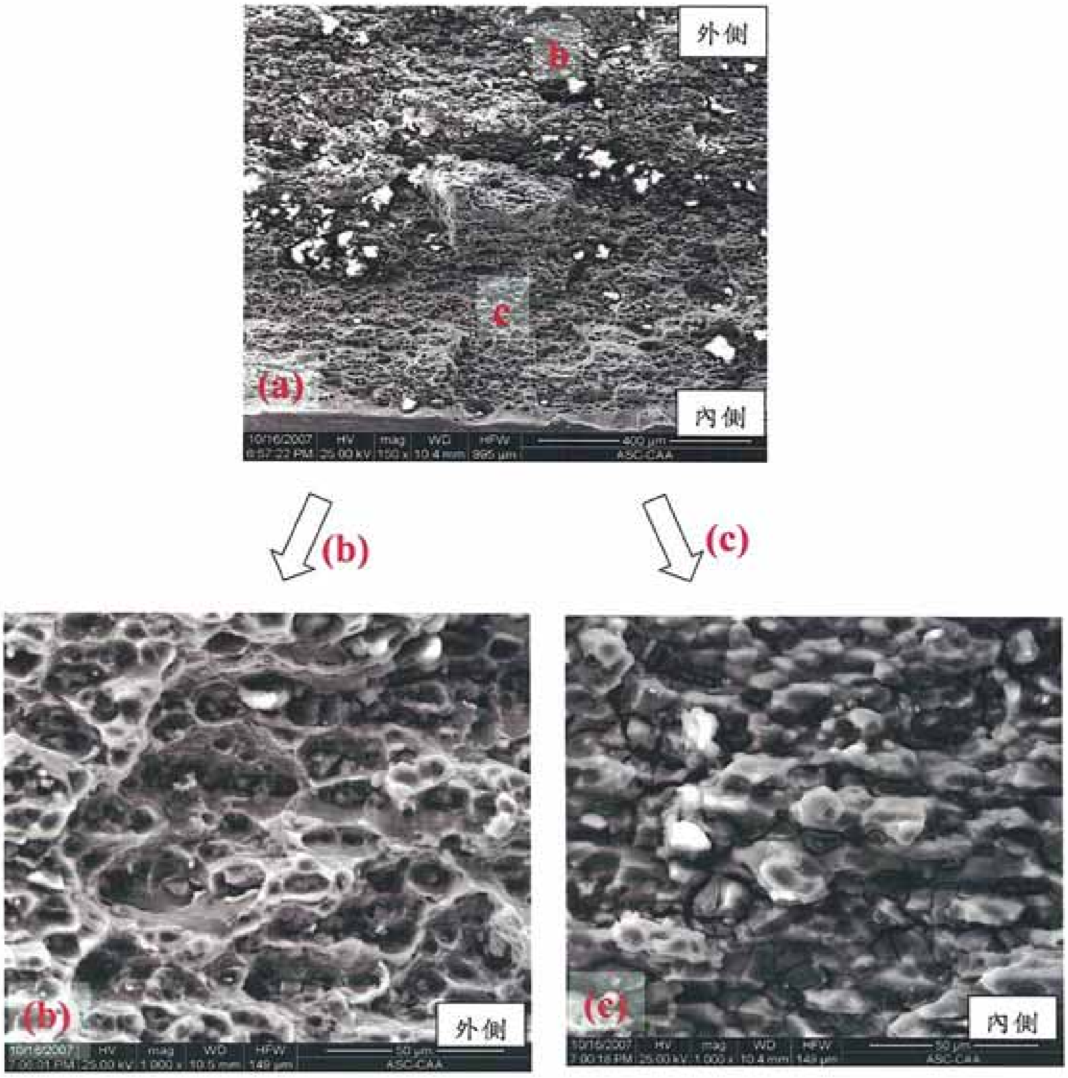


圖 16、編號 5 號試片 SEM 下之破斷面微觀特徵觀察。

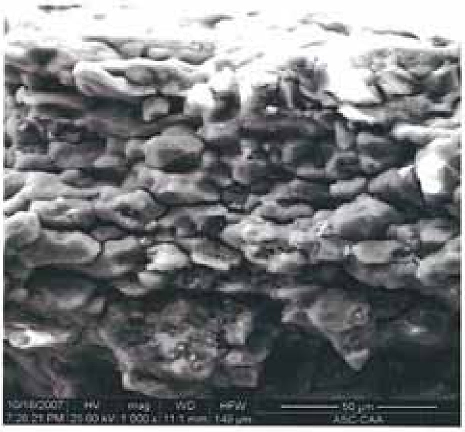



圖 17、編號 5 號試片鄰近內側表面之破斷面微觀特徵觀察。

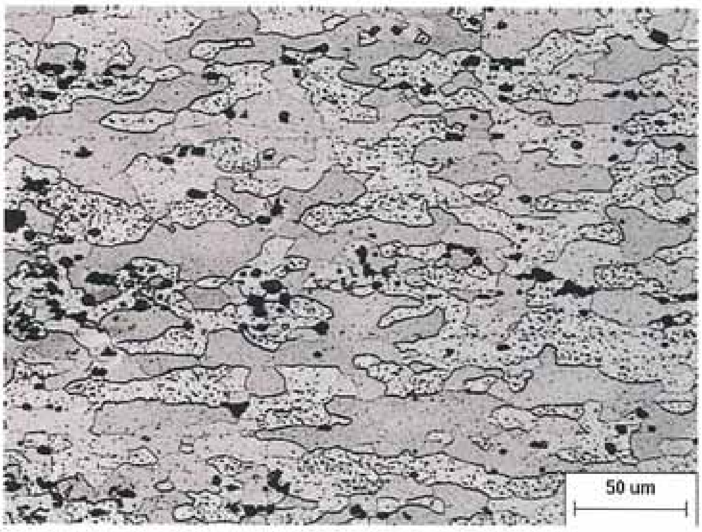


圖 18、機身蒙皮 L 方向的金相觀察。

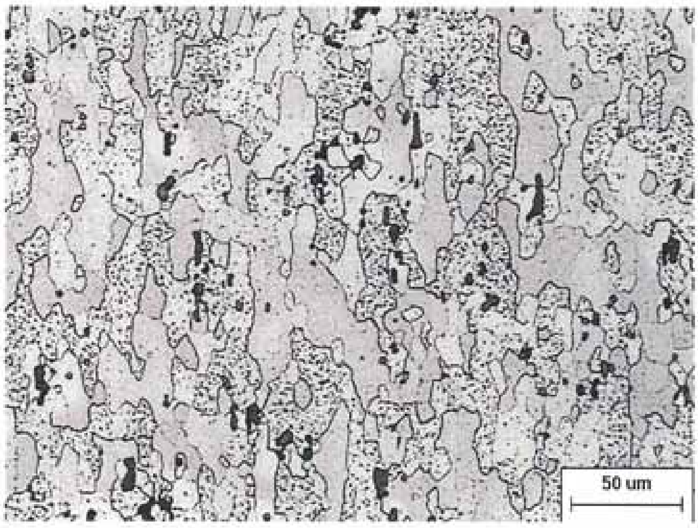


圖 19、機身蒙皮 T 方向的金相觀察。

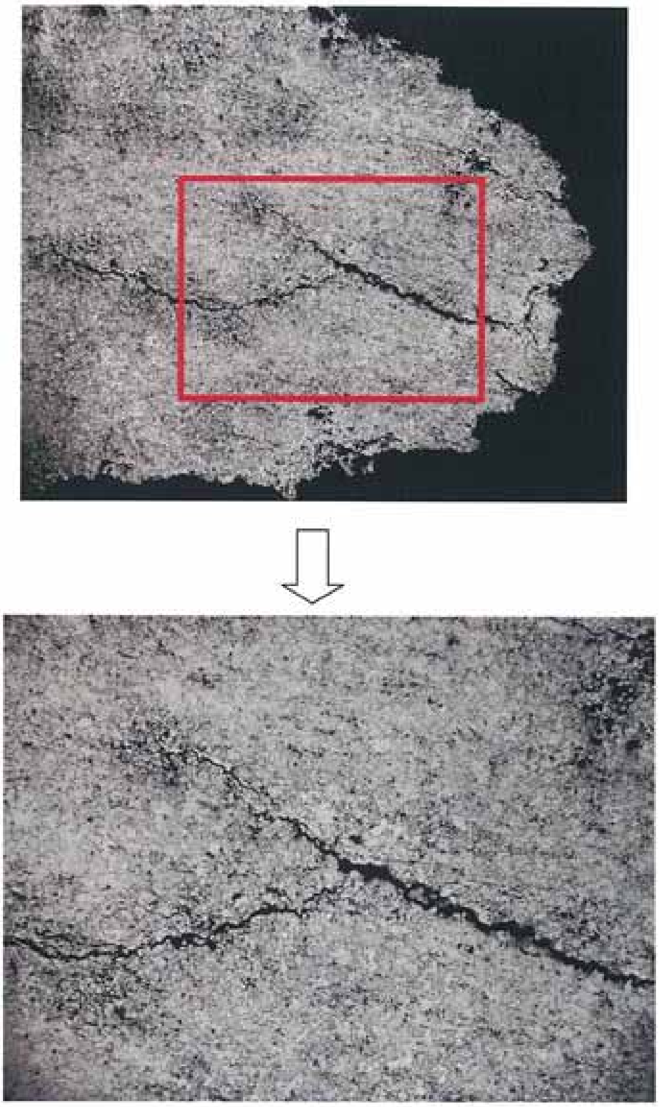
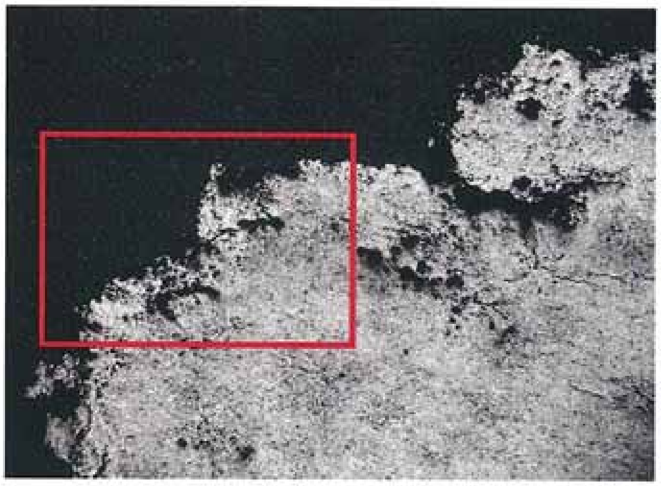


圖 20、編號 4 試片 L 方向剖面金相觀察。

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548



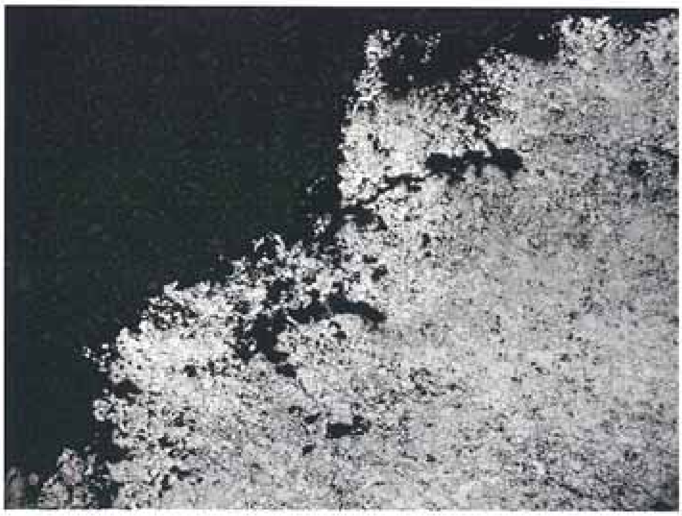


圖 21、編號 4 試片 L 方向另一處剖面金相觀察。。

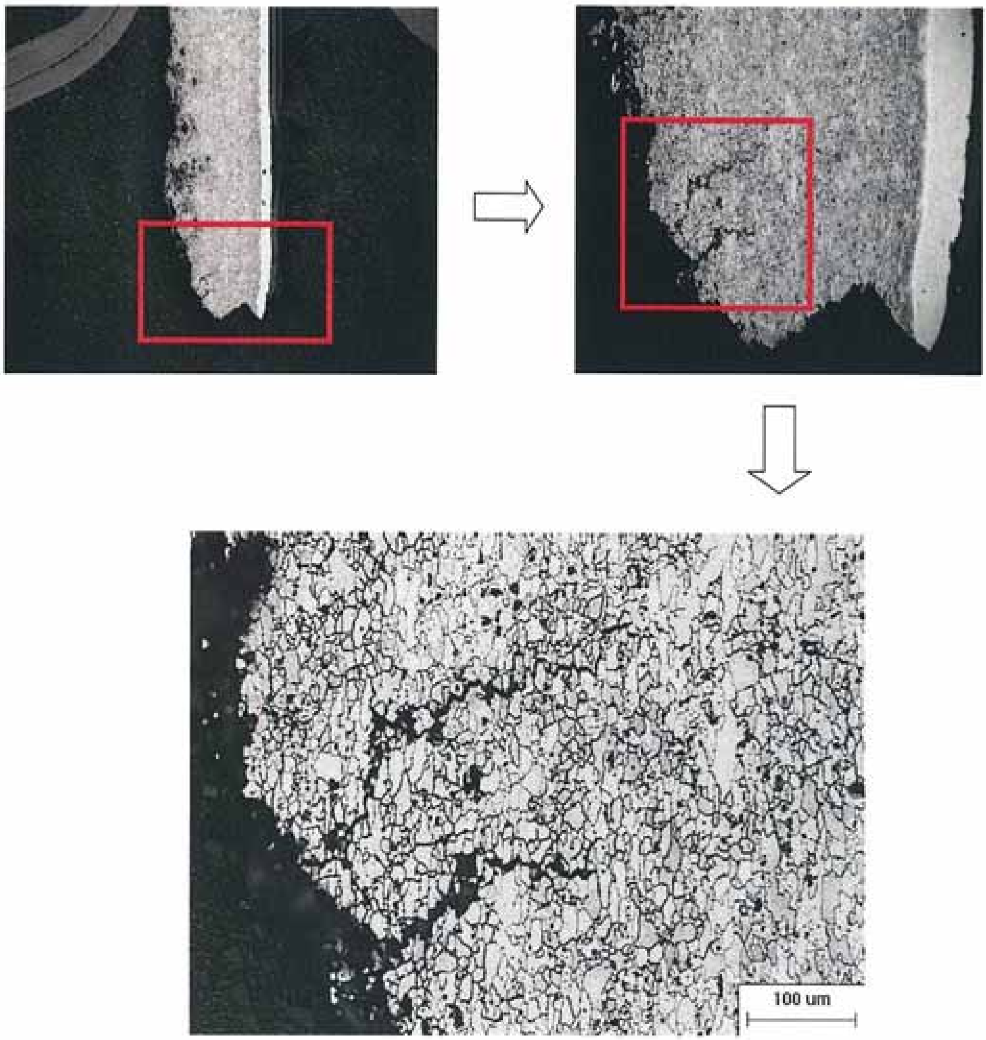


圖 22、編號 4 試片 T 方向剖面金相觀察。

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

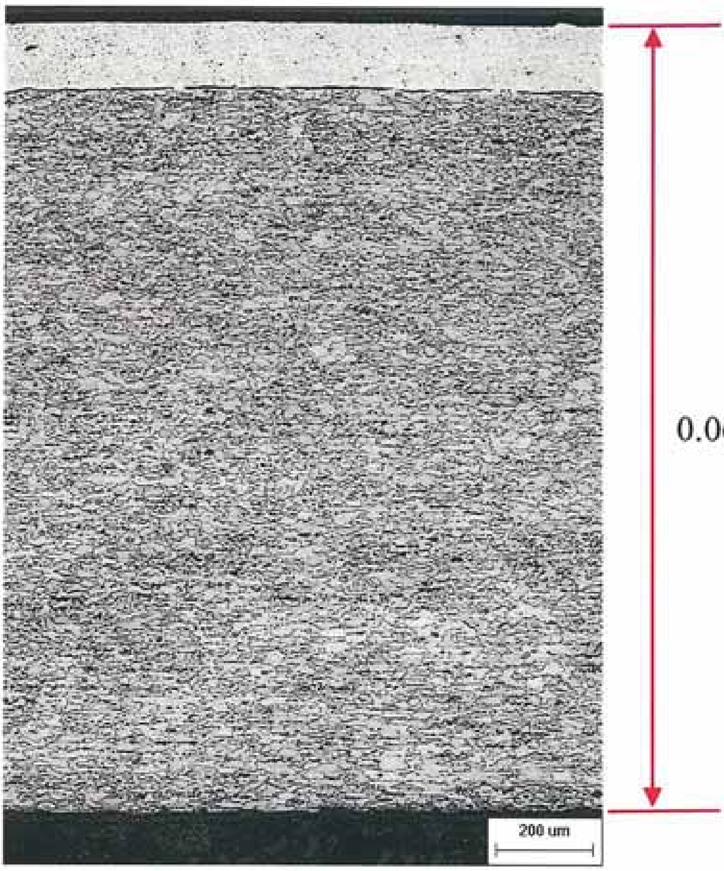


圖 23、鋁合金片材厚度量測。

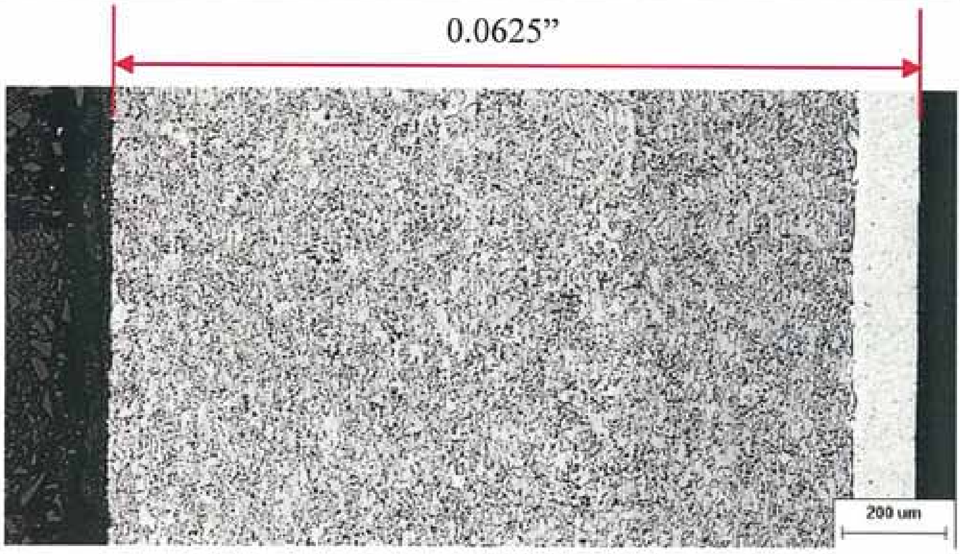


圖 24、另一處鋁合金片材厚度量測。

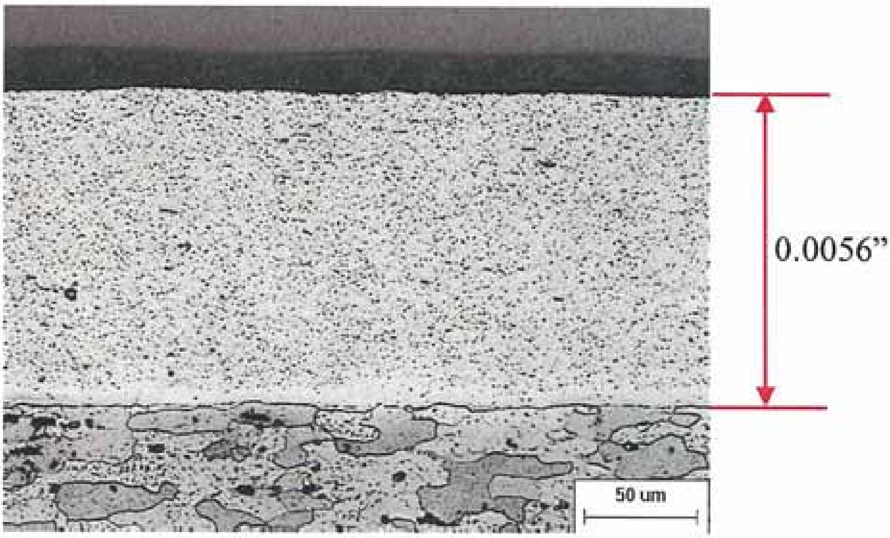


圖 25、鍍鋁層厚度量測。

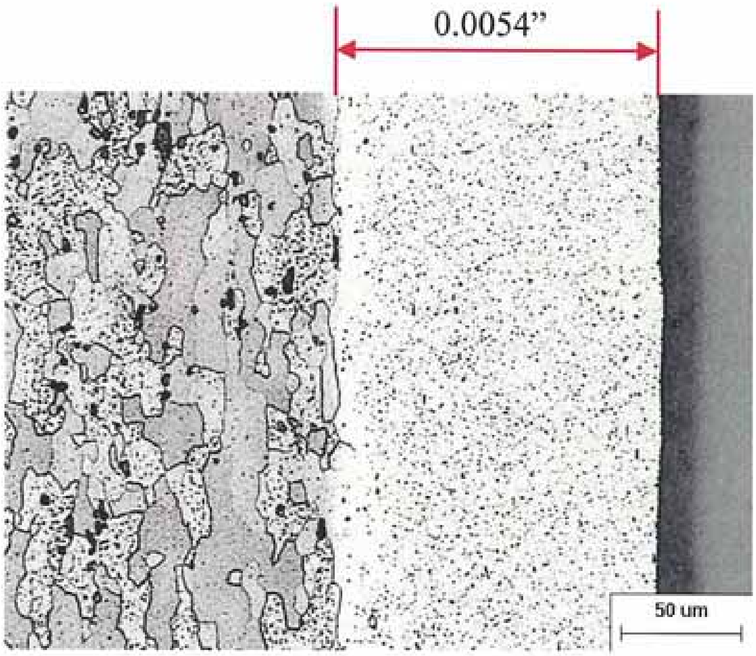


圖 26、另一處鍍鋁層厚度量測。

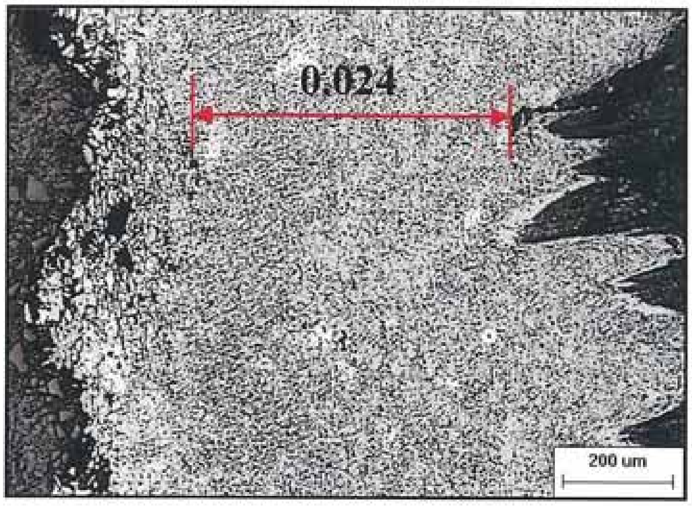


圖 27、編號 1 試片 T 方向的腐蝕殘餘厚度量測結果。

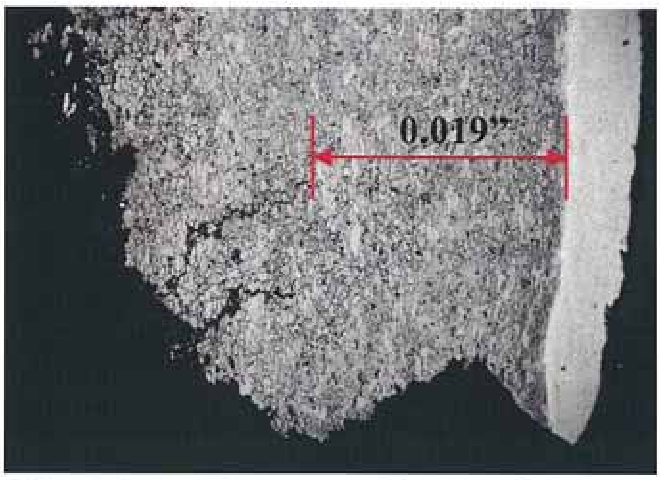


圖 28、編號 4 試片 T 方向的腐蝕殘餘厚度量測結果。

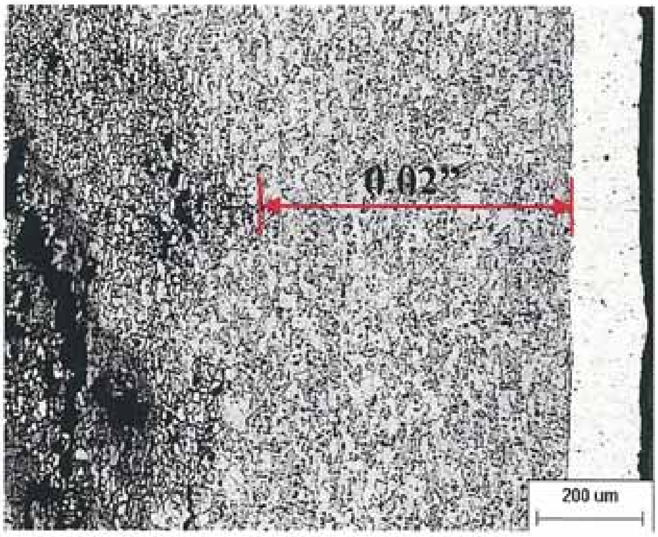


圖 29、編號 7 試片 T 方向的腐蝕殘餘厚度量測結果。

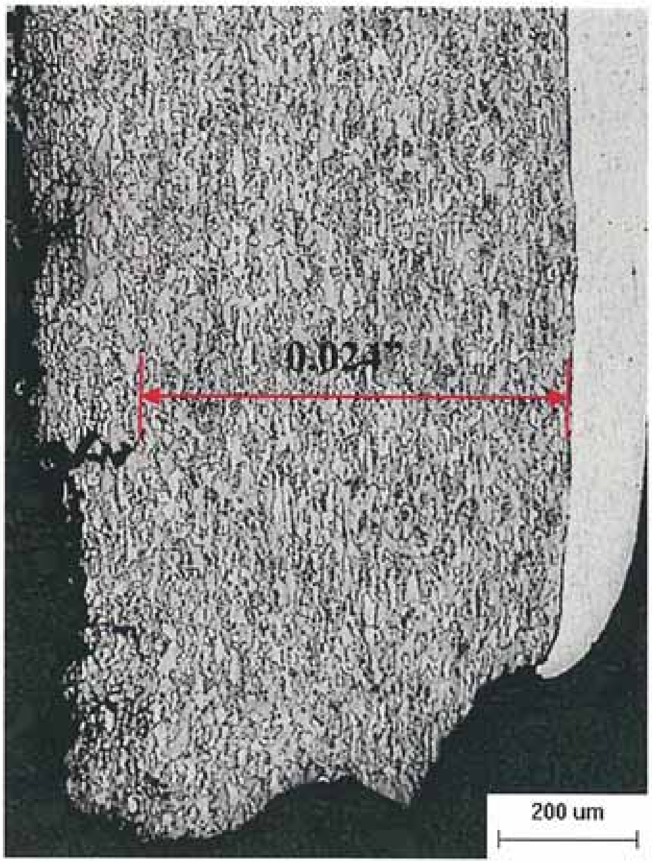


圖 30、編號 10 試片 T 方向的腐蝕殘餘厚度量測結果。

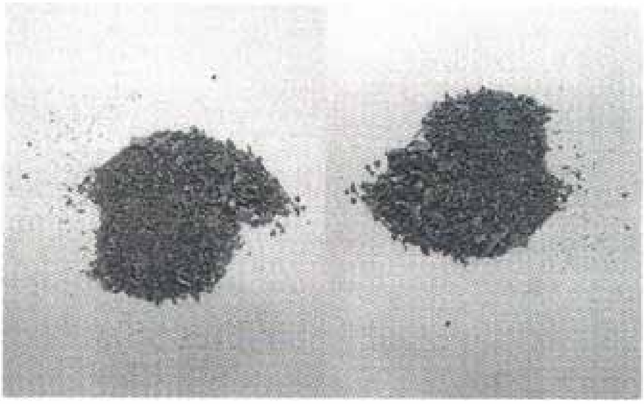


圖 31、自送檢蒙皮取下之腐蝕粉末，分成兩等份---(a) & (b)

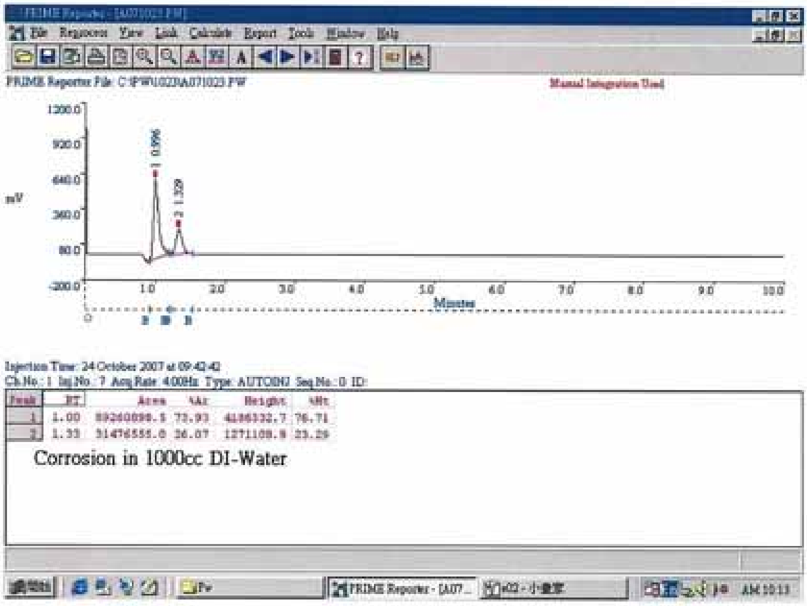


圖 32、腐蝕粉末以去離子水淬取溶液(a)之 IC 圖譜

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

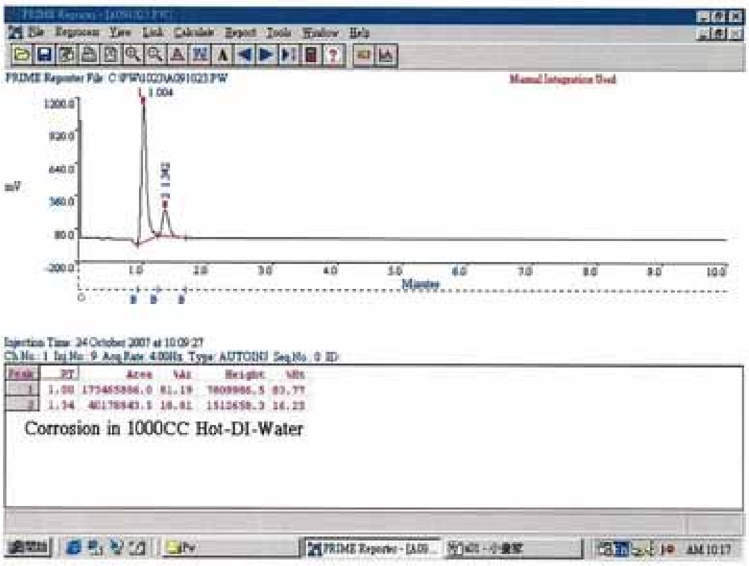


圖 33、腐蝕粉末以熱去離子水淬取溶液(b)之 IC 圖譜

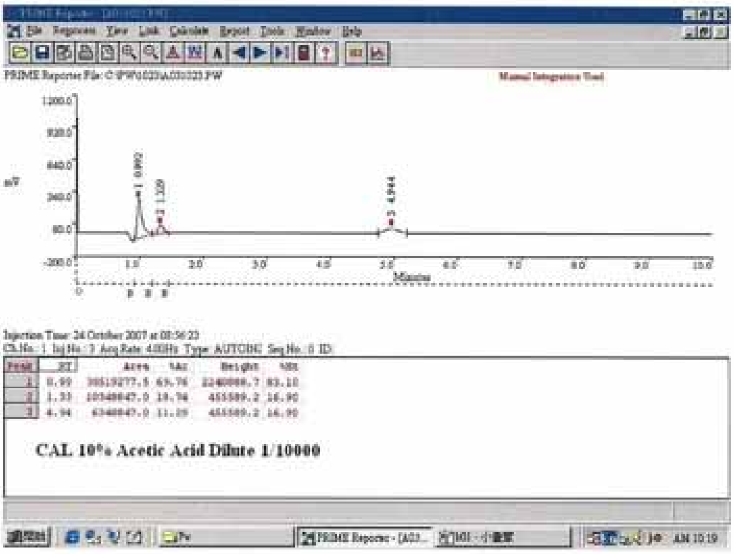


圖 34、飛安會檢送 10% Acetic acid 稀釋 1/10000 溶液(c)之 IC 圖譜

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

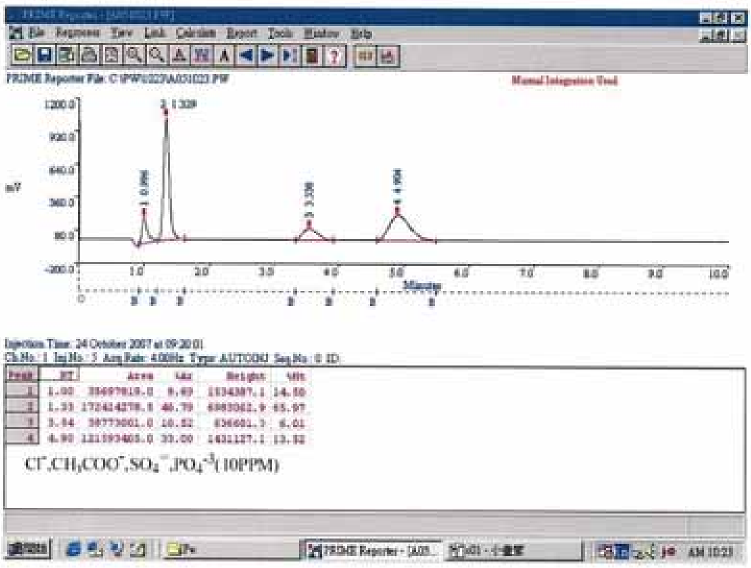


圖 35、Cl⁻，SO4⁼，PO4⁻³ 及飛安會檢送之醋酸配置 10ppm 溶液(d)IC 圖譜

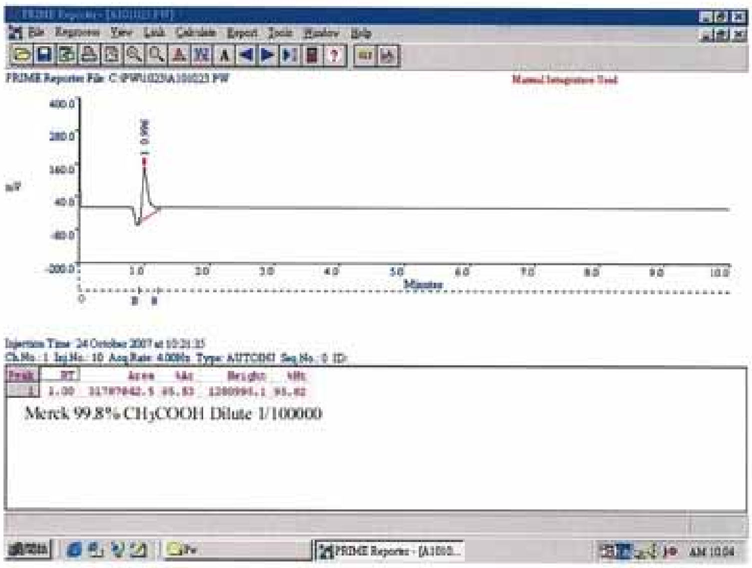


圖 36、以 Merck 99.8%醋酸配置 10ppm 溶液(e)之 IC 圖譜

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

材料試驗報告(Materials Test Report)續頁

Accredited Nadcap

中山科學研究院 Chung Shan Institute of Science and Technology
第一(航空)研究所 Aeronautical Systems Research Division
結構與材料工程組 Structure and Materials Section

工令報告編號 (Report No.) 960375
小組試驗編號 (Lab. No.) 96A0520

專案名稱 (Project)		申請者/單位 (Applicant/Department)	
技服(24)		行政院飛航安全委員會	
物件名稱 (Part Name)		件 號 (Part No.)	序 號 (Serial No.)
737-800 型客機機身蒙皮		N/A	N/A
材 料 (Material)	規 範 (Specification)	批 號 (Lot No.)	爐 號 (Heat No.)
2024-T3	AMS-QQ-A-250/5A	N/A	N/A
試驗方法 (Test Method)			
ASTM E1251			

試驗結果 (Results)

Si : 0.0444%	Fe : 0.0787%	Cu : 4.50%
Mn : 0.600%	Mg : 1.45%	Zn : 0.0460%
Ni : 0.0065%	Cr : 0.0040%	Ti : 0.0195%
Al : Rem.		

依成份分析結果，材質符合規範。

★本報告僅對樣品負責。
★完整報告始屬有效。

表一、送檢蒙皮之 SPARK 化學成份分析結果

台中郵政 90008-11-3 號信箱 (P.O. Box 90008-11-3, Taichung, Taiwan, R.O.C.)
Tel: 04-27023051 Ext.503030
Fax: 04-22846548

Appendix- 6：METALLOGRAPHIC PHOTOGRAPHS OF DAMAHED SKIN

截取方法：一片試片分為前、中、後三部份，各截取一小片製作金相，某些試片先前已經截切過，因此避開截切處，在其它位置另外截取。

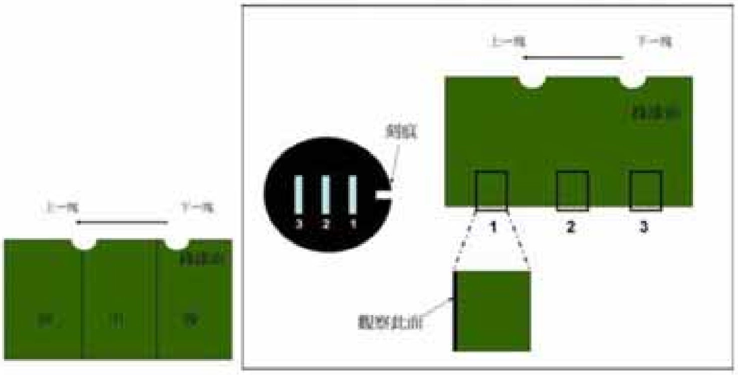


圖 1 金相試片截取示意圖

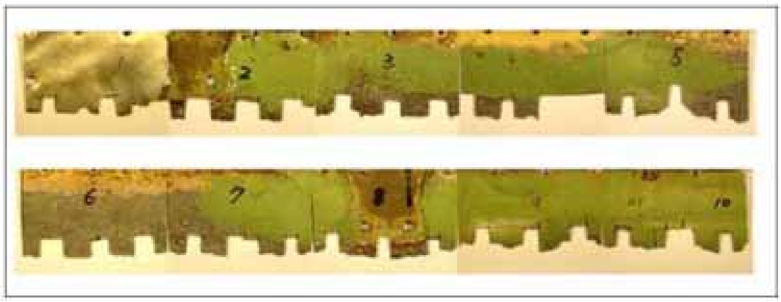
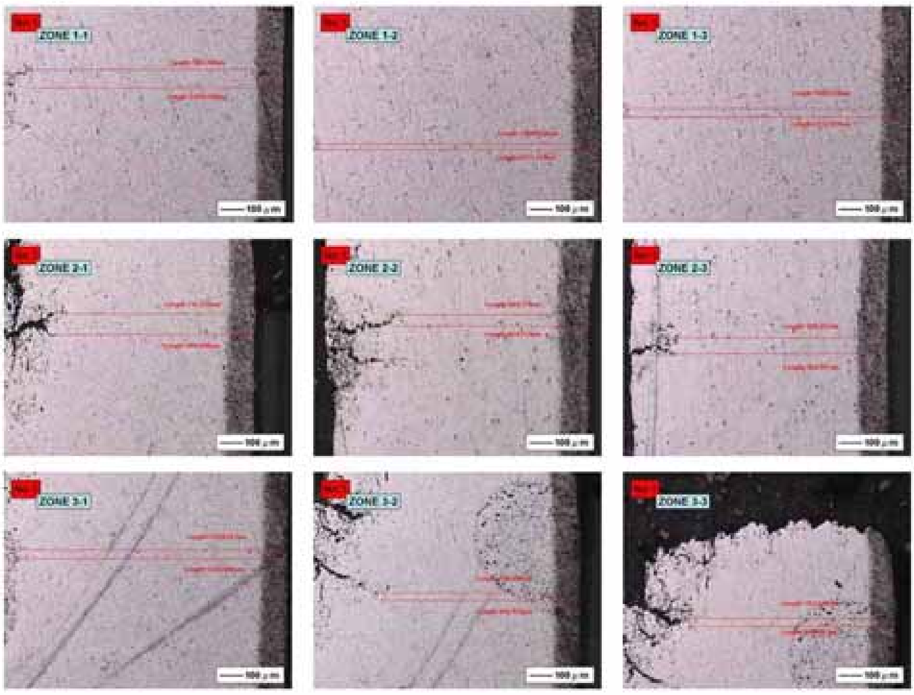
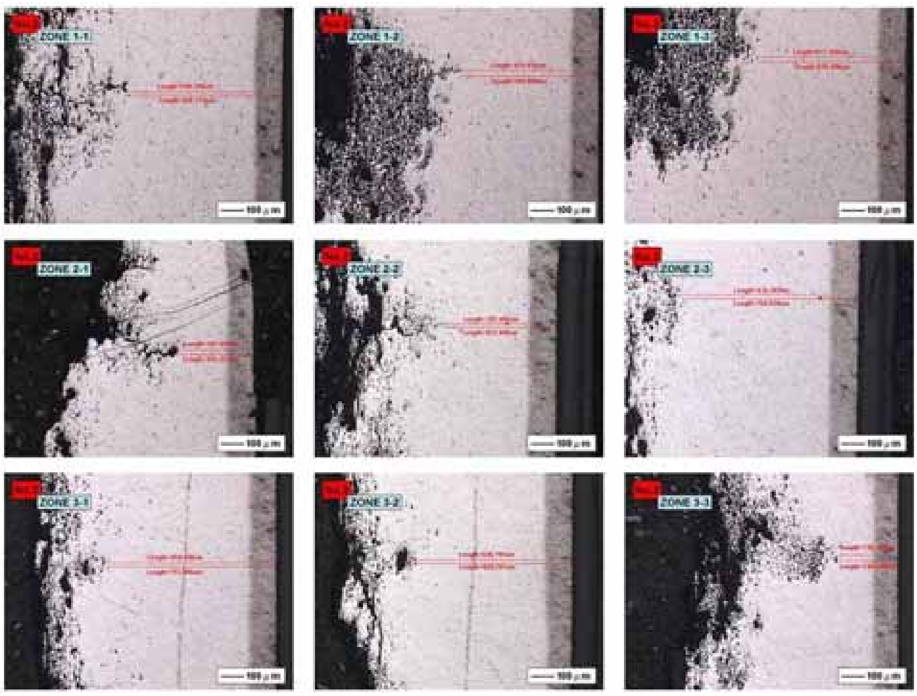


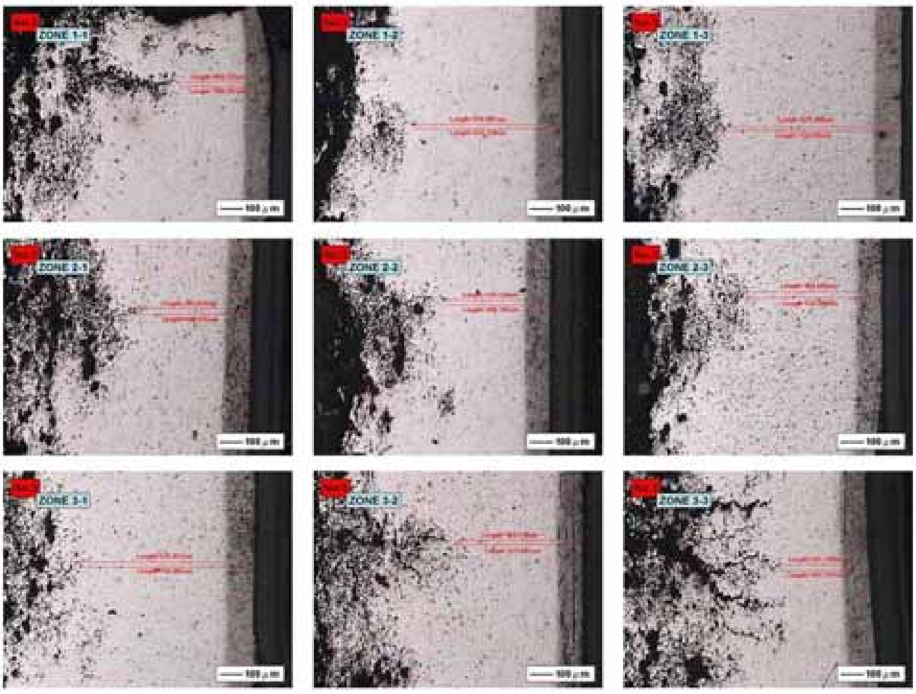
圖 2 截取金相試片之相對位置

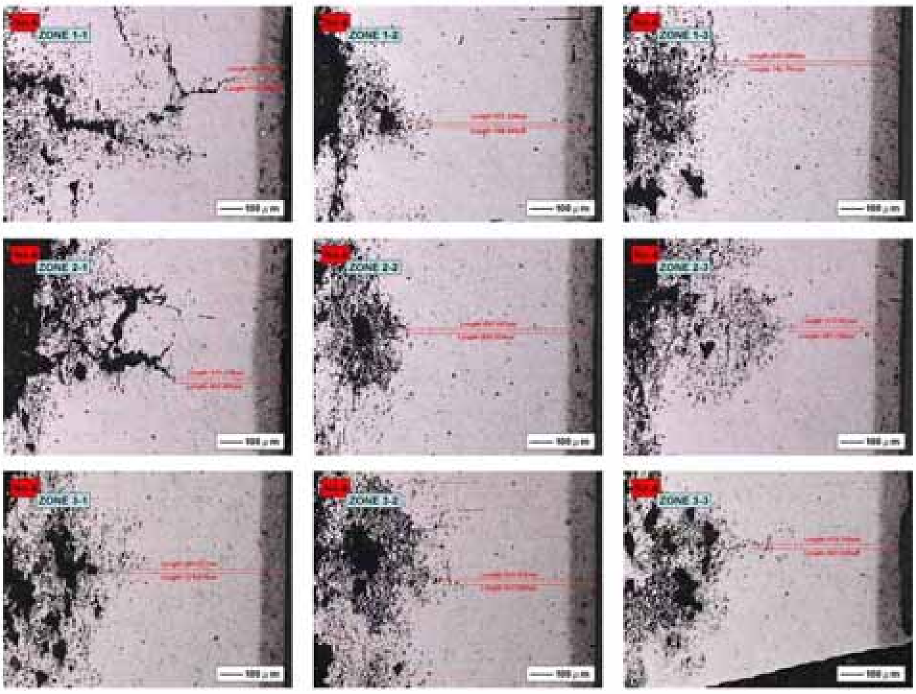
試片標號 X-Y-Z：X 表 1-10 蒙皮編號、Y 表示區域相對位置(如上所示)、Z 表示隨機取樣腐蝕區域(取腐蝕深度的三點)

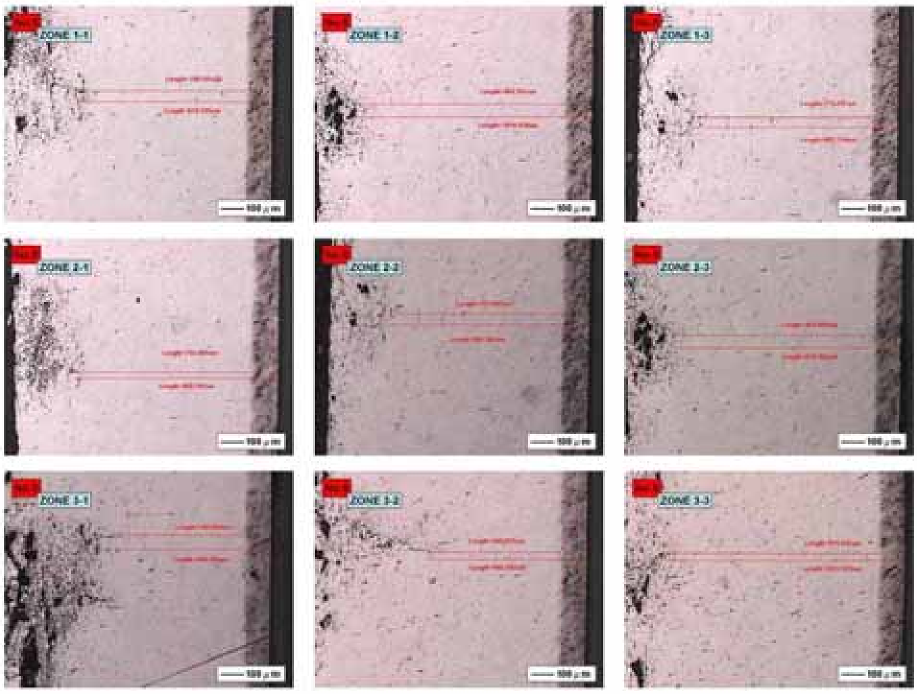
編號 7-3 試片厚度太厚，改用 SEM(HITACHITM-1000)作測量。
編號 8-2 試片，僅靠近斷裂面有腐蝕區域，其餘則無腐蝕特徵。
標號 10-2、10-3 試片，沒有明顯的腐蝕特徵。

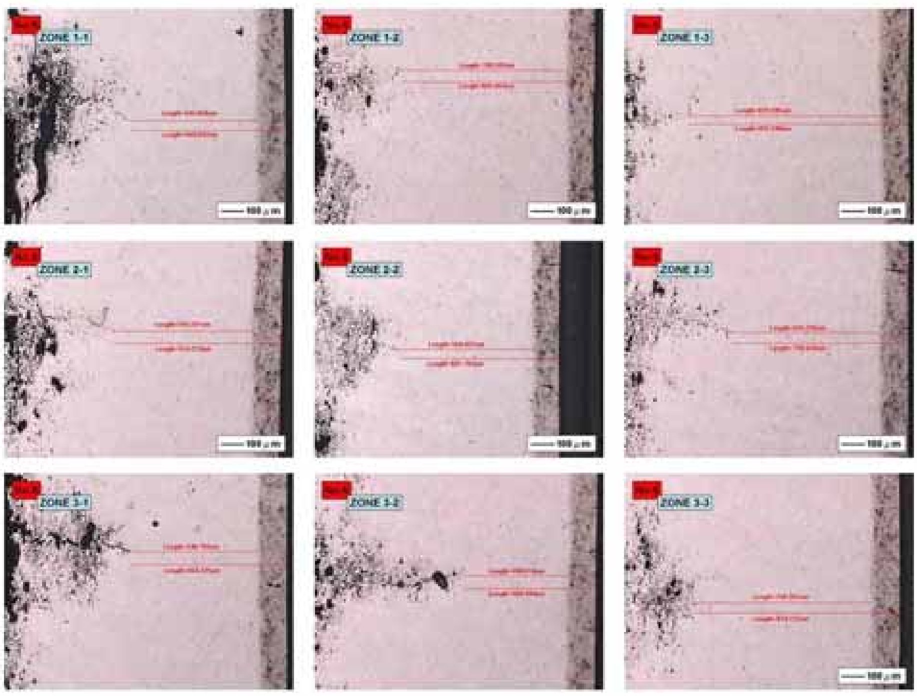

ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3

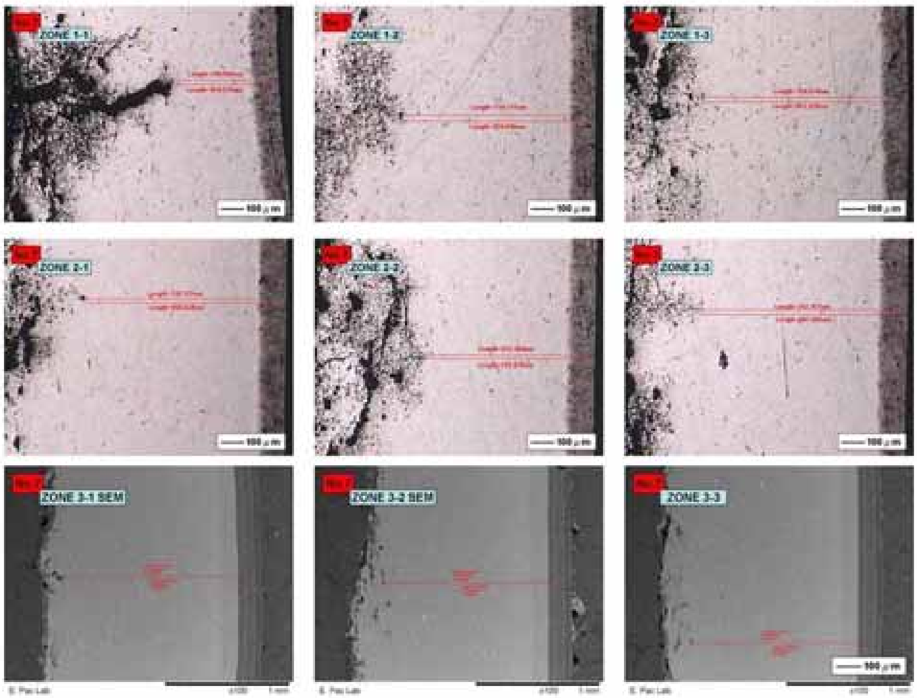

ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3

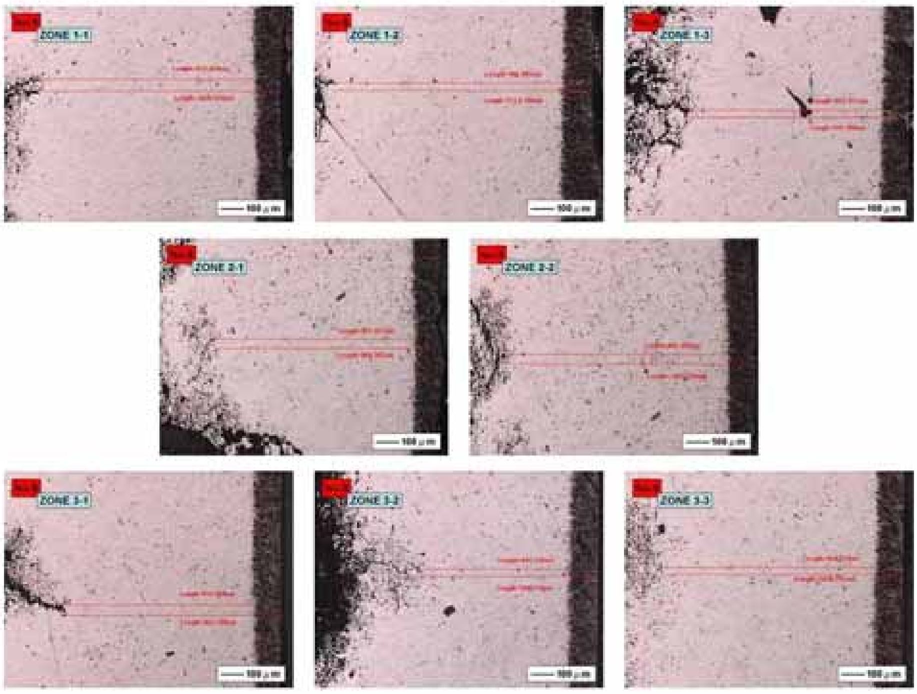

ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3
100 μm

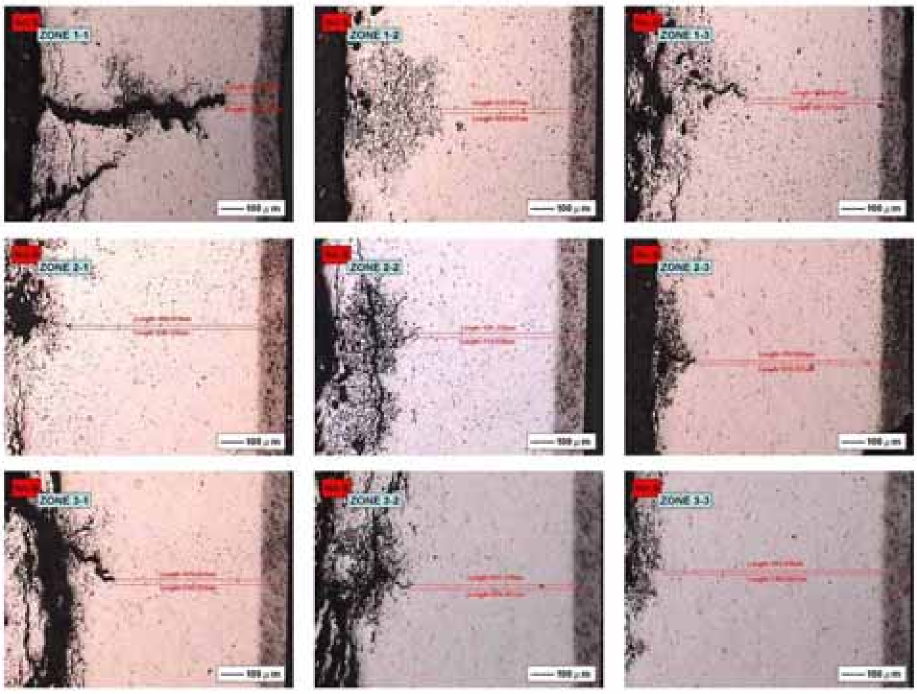

ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3
100 μm

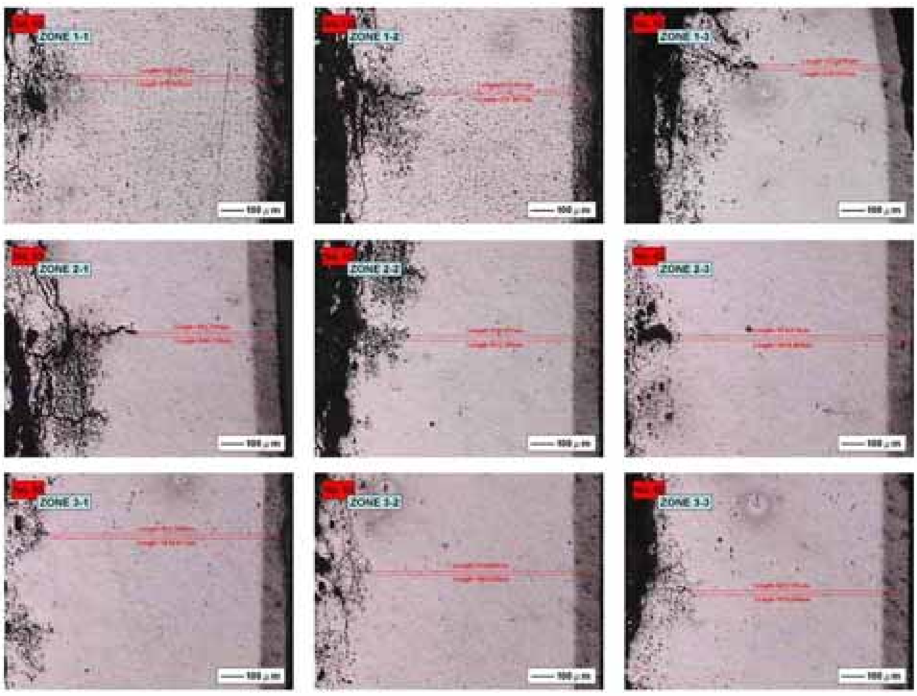

ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3


ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3


ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1 SEM
ZONE 3-2 SEM
ZONE 3-3
100 µm


ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 3-1
ZONE 3-2
ZONE 3-3
100 µm


ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3


ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 3-1
ZONE 3-2
ZONE 3-3

Appendix- 7：EXAMINATION REPORT OF PURGER FOR WASTE TANK

工業技術研究院
Industrial Technology Research Institute

分析測試報告

ANALYSIS/TESTING REPORT

委託單位：行政院飛航安全委員會
Applicant

地 址：台北縣新店市北新路3段200號11樓
Address

樣品名稱：樣品A—10%醋酸溶液
樣品B—稀釋用之地下水
Test item(s)

測試名稱：Cl^-、SO_4^{-2}、pH
Test(s)

1. 本報告含本封面共2頁，分離使用無效。
This report includes 2 pages (including this page), being invalid if separated.
2. 本報告需加蓋本單位檢驗章及簽名始生效。
The report is valid after signing and affixing the inspection seal of this institute.
3. 本報告僅對檢送樣品負責。
The report refers only to the specimen(s) submitted to testing.
4. 本報告內容以任何方式塗改、翻製、複印部份或全部無效。
This report will be invalid if obliterated modified, duplicated on photocopy in any part or in whole.
5. 本報告僅供委託者參考，不作任何證明或推銷廣告之用。
The content of this report is for reference only, but not for advertising or other commercial purpose.
6. 樣品保存自簽發日起30天。
The tested specimen(s) will be preserved thirty days from the date issued.

工服編號：D9642061
Application No.

申請人：[redacted]
Applicant

登錄編號：
Registration No.

核准簽名：[redacted]
Approved by

委託日期：96.11.15
Date Received

授權簽發：
Authorized by

檢驗報告專用章

新竹市300-11光復路2段321號 電話：03-5721321 傳真：03-5732352
321 Kuang Fu Road, Section 2, Hsinchu, Taiwan 300-11, R.O.C.

工業技術研究院
Industrial Technology
Research Institute

試驗項目 Item(s)	方法 Method(s)	結果 Result(s)		備註 Remark(s)
		樣品A	樣品B	報告日期: 96.11.23
pH	pH meter	2.18	7.05	以下空白
Cl^- ppm	自動電位滴定儀	12.7	14.9	
SO_4^{-2} ppm	離子層析儀	7.5	50.6	

工業技術研究院
Industrial Technology Research Institute

分析測試報告

ANALYSIS/TESTING REPORT

委託單位：中華航空股份有限公司修護工廠
Applicant

地　　址：臺北市松山區敦化北路 405 巷 123 弄 10 號
Address

樣品名稱：5%漂白水、純冰醋酸
Test Item(s)

測試名稱：總氯、有效氯、Cl^-、SO_4^{2-}
Test(s)

1. 本報告含本封面共 2 頁，分離使用無效。
   This report includes 2 pages (including this page), being invalid if separated.
2. 本報告需加蓋本單位檢驗章及簽名始生效。
   The report is valid after signing and affixing the inspection seal of this institute.
3. 本報告僅對檢送樣品負責。
   The report refers only to the specimen(s) submitted to testing.
4. 本報告內容以任何方式塗改、翻製、複印部份或全部無效。
   This report will be invalid if obliterated, modified, duplicated or photocopy in any part or in whole.
5. 本報告僅供委託者參考，不作任何證明或推銷廣告之用。
   The content of this report is for reference only, but not for advertising or other commercial purpose.
6. 樣品保存自簽發日起 30 天。
   The tested specimen(s) will be preserved thirty days from the date issued.

工服編號：Application No.	D9711102	申請人：Applicant	[redacted]
登錄編號：Registration No.		核准簽名：Approved by	[redacted]
委託日期：Date Received	97.01.16	授權簽發：Authorized by	

檢驗報告專用章

新竹市 300-11 光復路 2 段 321 號 電話：03-5721321 傳真：03-5732…
321 Kuang Fu Road, Section 2, Hsinchu, Taiwan 300-11, R.O.C.

工業技術研究院
Industrial Technology Research Institute

試驗項目 Item(s)		方法 Method(s)	結果 Result(s)	備註 Remark(s)
5%漂白水:				報告日期: 97.02.15
總氯	w%	ASTM D2022	3.5±0.1	以下空白
有效氯	w%	ASTM D2022	2.4+0.1	
冰醋酸:				
SO_4^{2-}	ppm	ICP-AES	11.3±0.1	
Cl^-	ppm	濁度法	<1	

Appendix- 8：EXAMINATION REPORT OF WASTE TANK (EDO)

REVISION			
LTR	DESCRIPTION	DATE	APPROVED
-	Initial Release per ECN A9517		

Proprietary Notice

This document and the information herein disclosed is proprietary property of EDO Fiber Science. Reproduction of the document or use or disclosure of its contents beyond the specific limited purposes for which the document was delivered is prohibited by EDO Fiber Science.

DEPARTMENT	SIGNATURE	DATE				
DRAWN			**EDO FIBER SCIENCE** 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116			
CHECK						
STRESS			TITLE:			
WEIGHT			Investigation report on 737X Drain fitting failures			
Q. C.						
MFG. ENGR						
PROJ. ENGR			SIZE	CODE IDENT	REPORT NO.	REVISION
APPROVAL			A	32500	20110	-
APPROVAL			SCALE	WEIGHT		
RELEASE DATE			N/A	N/A	SHEET (S) 1 OF 22	

FORM REVISED: 7 Dec 2000

1. SCOPE

China Airlines reported that a 737NG waste tank was leaking at the drain interface. They subsequently inspected 12 aircraft and found 3 were leaking at the drain interface. These three tanks were removed and sent to EDO for examination and repair. This report documents the results of the investigation conducted on the 3 returned tanks. A physical examination of the fittings was conducted, as well as an analysis.

2. APPLICABLE DOCUMENTS

The following documents of the latest issue in effect form a part of this specification to the extent they are specified herein:

2.1. Customer

None

2.2. Fiber Science

01930-007 Waste Tank, 737-600, 700, 800, 60 gal. Final Assembly

3. PHYSICAL EXAMINATION

A physical examination of all 3 drains was conducted. This examination involved pictures of the tanks as received from China Air, removal of the end of the drain fitting from the tanks, dimensional comparison, and detailed documentation of the features of each drain.

3.1. General observations

The following observations were made during the physical examination and are common to 2 or more of the drains. Pictures of each drain are included in the appendix. The black permanent marker line in the pictures indicates the bottom mold line of the fittings. To aid in examination, the end of the fitting was cut off just behind the aft flange.

Physical dimensions were taken of the flange area on all three fittings, as well as on 3 production fittings for comparison. The inner diameter does not appear to be warped or deformed on any of the returned tanks. However, the measured dimension are smaller than the drawing due to waste buildup on the inside diameter of the fitting.

The aft flange is intact in 2 of the 3 fittings. Measurements show the aft flange varies in thickness on the returned tanks more than the uninstalled drains; however the dimensions is within drawing tolerance. On all 3 fittings there is some evidence of damage to the aft flange. The forward upper corner of the aft flange is rounded in several places.

Forward flange is cracked on all three drains, and parts of it are missing in two of the three drains. The cracks occur mostly in the lower outboard quadrant (figure 7) from 70 to 200 degrees. The cracks in the forward flange occur in two different and distinct forms. The most common crack method, from hereon referred to as crack mode 1, is a diagonal crack face beginning at the inside of the o-ring groove and progressing forward and inwards, as shown in figure 8. Failure mode 1 cracks have a dark discolored face, like that of the inside diameter of the fitting. The crack face is relatively smooth and regular, with small concentric ridges (figure

3). The ends of the crack are white in two of the 3 fittings. Notches, as labeled in figures 4 and 5, are seen in the concentric ridges on the crack face in 2 of the 3 drains investigated. Failure crack mode 2 is less common but distinctly different than crack mode 1. Crack mode 2 begins at the forward surface of the fitting and progresses inwards towards the corner of the o-ring groove (figure 8).

The o-ring groove is discolored in spots, as shown in figure 5 and figures 9 through 11. The majority of the discoloration is not in the area of forward flange cracking indicated in figure 7.

3.2. Detailed Observations

Detailed observations were made on each drain and are documented in the following sections, as well as diagramed in figures 9 through 11.

3.2.1. Observations on S/N 09-00-777

Measurements were taken of the drain flange on S/N 09-00-777 on 11/4/07.

- Inner Diameter
  - Drawing States Should Be = 3.135 +/- 0.015
  - Production Parts ARE = 3.135 to 3.121
  - Damaged Drain IS = 3.111 3.112 3.105 3.097
- Aft flange
  - Drawing States Should Be = 0.065 +/- 0.010
  - Production Parts ARE = 0.064 to 0.061
  - Damaged Drain IS = 0.059 0.067 0.064 0.071 0.067
- Forward Flange
  - Drawing States Should Be = 0.065 +/- 0.010
  - Production Parts ARE = 0.065 to 0.062
  - Damaged Drain IS = 0.068 0.068 0.068 0.067 0.065 0.067

Figure 9 is a diagram of the damage to the S/N 09-00-777 fitting. Cross sections of the fitting were drawn at various locations around the circumference to highlight features of interest.

Cross-section AA: There is no pronounced rounding of aft flange corners. The forward flange is broken off at a sharp angle in a mode 1 crack, but the flange piece is still attached. Forward flange is tilted forward.

Cross-section BB: The forward corner of aft flange is rounded. The forward flange is broken off in a mode 1 crack but still attached. The broken piece of flange spirals forward and inward.

Cross-section CC: There is no pronounced rounding of aft flange corners. The forward flange is partially broken in a mode 2 crack. The forward flange is bent aft, the opposite direction shown in cross-section BB.

Cross-section DD: The forward corner of aft flange is rounded. The forward flange is partially broken and bent forward. The crack is mode 1 and the angle of the crack face approximately matches that of sections AA and BB.

The aft flange has some evidence of small nicks. The aft flange varies in thickness, as can be seen in the measurements listed above.

The forward flange is broken in one location, on the bottom of the fitting (figures 1, 2, and 9). The flange is cracked over 200 degrees, from 20 degrees to 220 degrees. The remaining flange is also bent forward at 320 degrees as shown in cross -section DD. One end of crack is still white, near cross-section CC.

3.2.2. Observations on S/N 10-00-789

Measurements were taken of the drain flange on S/N 10-00-789 on 11/4/07

Inner Diameter
- Drawing States Should Be= 3.135 +/- 0.015
- Production Parts ARE = 3.135 to 3.121
- Damaged Drain IS = 3.113 3.108 3.111 3.107

Aft Flange
- Drawing States Should Be= 0.065 +/- 0.010
- Production Parts ARE = 0.064 to 0.061
- Damaged Drain IS = 0.071 0.066 0.067 0.065 0.068

Forward Flange
- Drawing States Should Be = 0.065 +/- 0.010
- Production Parts ARE = 0.065 to 0.062
- IS = 0.066 0.063 0.065 0.066

Figure 10 is a diagram of the damage to the S/N 10-00-789 fitting. Cross sections of the fitting were drawn at various locations around the circumference to highlight features of interest.

Cross-section AA: The forward corner of aft flange is rounded. The forward flange is partially broken in a Mode 2 crack. The forward flange is bent aft, into the o-ring groove.

Cross-section BB: The forward corner of the aft flange is rounded. This is the location of the worst rounding.

Cross-section CC: The forward corner of the aft flange is rounded. The forward flange is partially broken in crack mode 2.

Cross-section DD: There is no pronounced rounding of the aft flange. The forward flange is broken off completely at a sharp angle in crack mode 1.

Cross-section EE: The forward corner of the aft flange is rounded. The aft flange is cracked at this location in crack mode 2. The aft flange is pushed aft along the crack face.

The aft flange is chipped in several places. The damage faces are very rough, jagged, and whiter than the aged but uncontaminated faces of the fitting. The aft flange varies in thickness, as can be seen in the measurements listed above. The edge of the aft flange is rounded in places on the on the o-ring side, with the worst rounding on the top of the fitting. There is a clear, flexible adhesive substance on the outside of the fitting just beyond the aft flange.

The right side of the forward flange is broken off completely in a mode 1 crack, covering approximately 255 degrees extending from 10 to 265 degrees. The edges of the forward flange appear to be rounded, although not as rounded as the aft flange mentioned previously. One end of the cracked flange is white, as can be seen in figure 3. The mode 1 crack face has one large notch centered at 140 degrees.

3.2.3. Observations on 04-02-1226

Measurements were taken of the drain flanges on S/N 04-02-1226 on 11/4/07

Inner Diameter

Drawing States Should Be = 3.135 +/- 0.015
Production Parts ARE = 3.135 to 3.121
Damaged Drain IS = 3.118 3.121 3.120 3.120

Aft flange

Drawing States Should Be = 0.065 +/- 0.010
Production Parts ARE = 0.064 to 0.061
Damaged Drain IS = 0.068 0.071 0.071 0.067 0.063

Forward Flange

Drawing States Should Be = 0.065 +/- 0.010
Production Parts ARE = 0.065 to 0.062
Damaged Drain IS = 0.066 0.067 0.066 0.068

Figure 11 is a diagram of the damage to the S/N 04-02-1226 fitting. Cross sections of the fitting were drawn at various locations around the circumference to highlight features of interest.

Cross-section AA: The forward corner of aft flange is rounded.

Cross-section BB: There is no pronounced rounding of aft flange corner. The forward flange is broken off completely at a sharp angle in crack mode 1.

The aft flange is intact, although there is evidence of damage (figure 6). The aft flange varies in thickness, as seen in the measurements listed above. The edge of the flange is rounded, most noticeably at the top centered at 345 degrees, which corresponds to the smallest measurement 0.063". The aft flange is also noticeably rounded at 270 and at 115 in the area of the forward flange crack.

The right side of the forward flange is broken off, cracked through approximately 145 degrees, from 65 to 210 degrees. The crack face is slanted in a mode 1 crack. Both ends of the mode one crack on the forward flange are whiter in color. The crack face has two notches, one at 115 and the other at 170 degrees.

4. FINITE ELEMENT ANALYSIS

A finite element analysis model was created of a cross-section of the drain flange. The model was then analyzed to determine stress patterns under different loading conditions. This analysis will help to predict the loading method that may have caused the cracks seen in the physical examination.

4.1. Model Construction

The objective of the finite element analysis was to analyze the distribution and gradients of stresses in the cross section of the drain fitting. The drain fitting cross section was meshed with plane strain plate elements, as shown in Figure 12. The trends obtained from the finite element analysis helped to understand how the cross section of the drain flange behaved due to its geometry. The actual magnitude of stresses will scale linearly with the assumed thickness of the plane strain elements, with the material properties, and with the magnitude of the load applied to the model. Therefore the exact thickness and material properties of the plane strain elements are not relevant to this type of analysis, and are not discussed. Any isotropic material can be used so long as it behaves in the elastic range.

The plane strain elements were constrained on the inside diameter to simulate the inherent stability of a circular fitting, as represented by the blue triangles on the cross section in figure 12. Three load cases of forward, aft, and down, were analyzed, both individually and in combination. The load cases are illustrated by the green arrows in figures 13 through 20. These three load cases were judged to be the most likely methods by which the forward flange could be loaded.

4.2. Anlysis Results

Figures 13 though 20 show the maximum and minimum principal stresses from all the load cases analyzed. The most likely crack origin under any loading is at a position of pure tensile stress, as any compressive stress will tend to close a crack rather than open it. Furthermore, cracks are also more likely to occur in locations of rapidly changing stresses and geometry, such as at a corner or radius. Once a crack has started, they grow away from their origin along a line of approximately equal stress; if stress is higher on one side of the progressing crack than the other it will bend away from the high stress in order to equalize stress. On figures 13 through 20 the position of the maximum tensile stress is circled and labeled as the crack origin. The dotted arrow in each figure illustrates the most likely direction for the crack to grow from its origin.

5. DISCUSSION OF RESULTS

5.1. Results of Physical Examination

From the physical examination of each drain, conclusions can be drawn as to what may have occurred to cause the damage seen.

The forward surface of the fitting shows no signs of contact with the adjacent tube in the assembly. Possible signs of contact would include rubbing, scratching, or thinning of the forward flange.

The variation in thickness of the aft flange seen on all three drains could be indicative of rubbing or chaffing. The rounding of the aft flange corner could also be evidence of this. The rounding of the aft flange is predominately in the 270 to 20 degree area, which is approximately opposite the forward flange mode 1 cracking in all three drains examined. There is no clear indication of what may have caused the rubbing seen. However, components of the attachment clamp, including the sleeve or o-ring, are likely candidates.

The damage to the aft flange could be due to removal of the clamp attached to the drain, especially the jagged damage seen on SN 10-00-789 in figure 4. Removing the drain clamp after time in service has been shown to be difficult in the past, and damage to the aft flange is likely if the procedure is not done with care. Furthermore, the clear, flexible adhesive substance on the outside of drain fitting SN 10-00-789 could be evidence of an attempt to repair the leaking fitting after installation into the aircraft. This possible repair method is not standard EFS procedure or per the CMM, which would entail replacement of the entire drain fitting.

The dark brown or black discoloration of the plastic in areas is an indication of exposure to waste. The plastic fittings are a bright white color when installed, and under normal conditions the outer surface of the plastic turns a light grey color because it is slightly porous and will absorb microscopic particles of dirt and dust over time. Therefore, a bright white surface on a part indicates recent damage. The forward flange mode 1 crack faces on all 3 fittings are a dark brown/black color, indicating they were exposed to waste and therefore occurred over an extended period of time. Furthermore, the two tanks manufactured in 2000 have substantially larger mode 1 cracks than the one tank manufactured in 2002. The comparative length of the cracks also suggests the damage was progressive and occurred over a long period of time. The ends of several of the crack faces are white, indicating recent damage that may have occurred during removal.

The relative smoothness of the mode 1 crack faces in the forward flange, combined with the small concentric ridges or "beach marks", all suggest a fatigue failure mode. The notches in the mode 1 crack faces, as seen in SN 10-00-789 figure 4 and SN 04-02-1226 figure 5, suggest the forward flange cracks contained more than one segment. These segments may have started independently of each other and grown into one large crack, started successively with one cascading into the next, or started simultaneously. Regardless of the timeline of the segments, the complexity of the mode 1 crack line indicates a complex loading situation. The mode 2 cracks in the forward flange are a distinctly different failure method. This failure method occurs in close proximity to the ends of mode 1 cracks, suggesting a pinch or pivot point.

The spots of discoloration in the o-ring grooves indicate contamination by waste. It is unclear if these are due to leaks or merely contamination from another cause. The majority of the discolorations are not in the area of the cracked forward flange, and therefore it is unlikely that the cracks leaked past the o-ring.

5.2. Comparison of Physical Examination and FEA results

The two crack modes seen in the physical examination and shown in figure 8 are very similar to the crack behavior suggested by the finite element analysis. The mode 1 crack suggests either a forward or forward plus down combined loading. The mode 2 cracks suggest the opposite, either a pure aft loading, or an aft plus down combined loading. These comparisons are confirmed by the direction of forward flange movement; the forward flange moves forward for a mode 1 crack (figure 1) and aft for a mode 2 crack (figure 2). None of the cracks suggest a pure down loading, as the finite element analysis suggests this type of crack face would not have a radius from the o-ring groove because the origin point would be well inside the groove, and some radius can be felt on all 3 drains. Furthermore, the close proximity of mode 1 and mode 2 cracks suggest the drain flange is under a bending loading with pivot points.

6. CONCLUSIONS

From the examination of the drain flanges, no definitive conclusions can be made. There is evidence that the drain flange was in a continual state of complex loading as applied by a component of the drain flange clamp. The failure appears to have been progressive and occurred over an extended period of time. The application of the clear sealant on SN 10-00-789 indicates that a leak was detected at one point and a repair was attempted. However, standard EFS procedure to repair a leaking drain would be replacement of the entire fitting.

Figure 1 – S/N 09-00-777 after removal

EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 8 OF 22	

FORM REVISED: 7 Dec 2000

Figure 2 – S/N 09-00-777 after removal

EDO FIBER SCIENCE	SIZE	CODE IDENT	DRAWING NO.	REVISION
506 NORTH BILLY MITCHELL ROAD	A	32500	20110	-
SALT LAKE CITY, UTAH 84116	SCALE - N/A	WEIGHT - N/A	SHEET (S) 9 OF 22	

FORM REVISED: 7 Dec 2000

Figure 3 – S/N 10-00-789 after removal

EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 10 OF 22	

FORM REVISED: 7 Dec 2000

Figure 4 – S/N 10-00-789 after removal

EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
SALT LAKE CITY, UTAH 84116	SCALE - N/A	WEIGHT - N/A	SHEET (S) 11 OF 22	

FORM REVISED: 7 Dec 2000

Figure 5 – S/N 04-02-1226 after removal

EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
SALT LAKE CITY, UTAH 84116	SCALE - N/A	WEIGHT - N/A	SHEET (S) 12 OF 22	

FORM REVISED: 7 Dec 2000

Figure 6 – S/N 04-02-1226 after removal

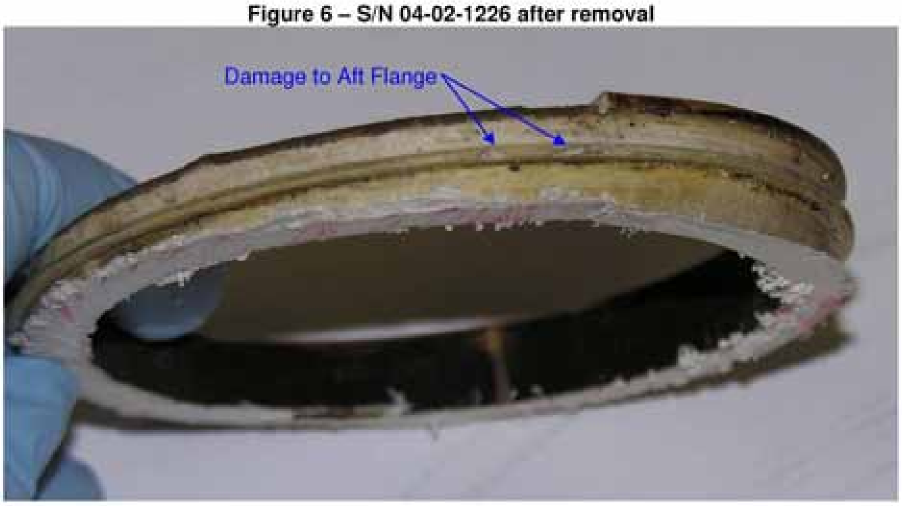
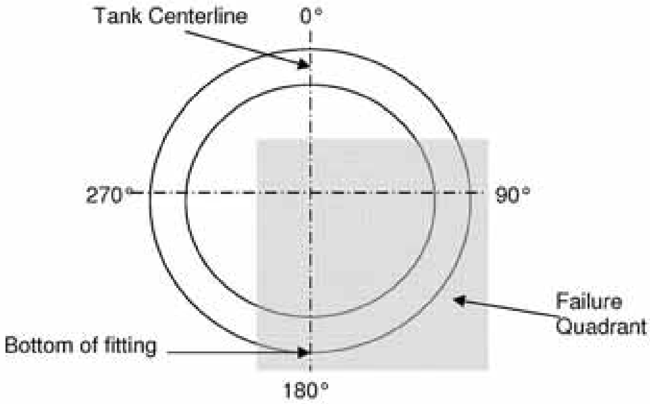


Figure 7 – Common Failure Quadrant



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 13 OF 22	

FORM REVISED: 7 Dec 2000

Figure 8 – Cross Section Failure Modes

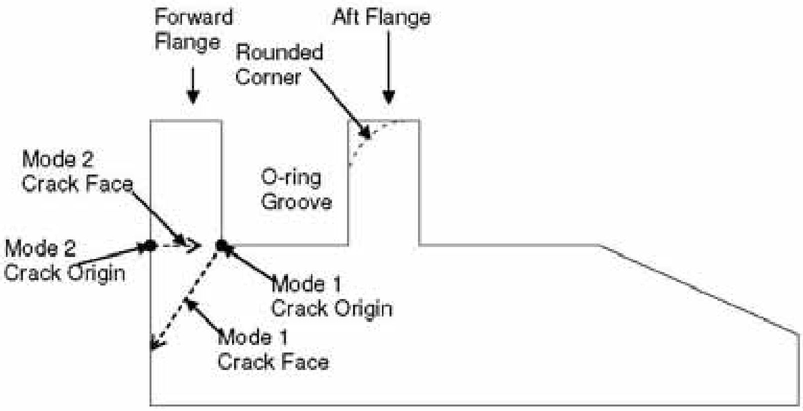
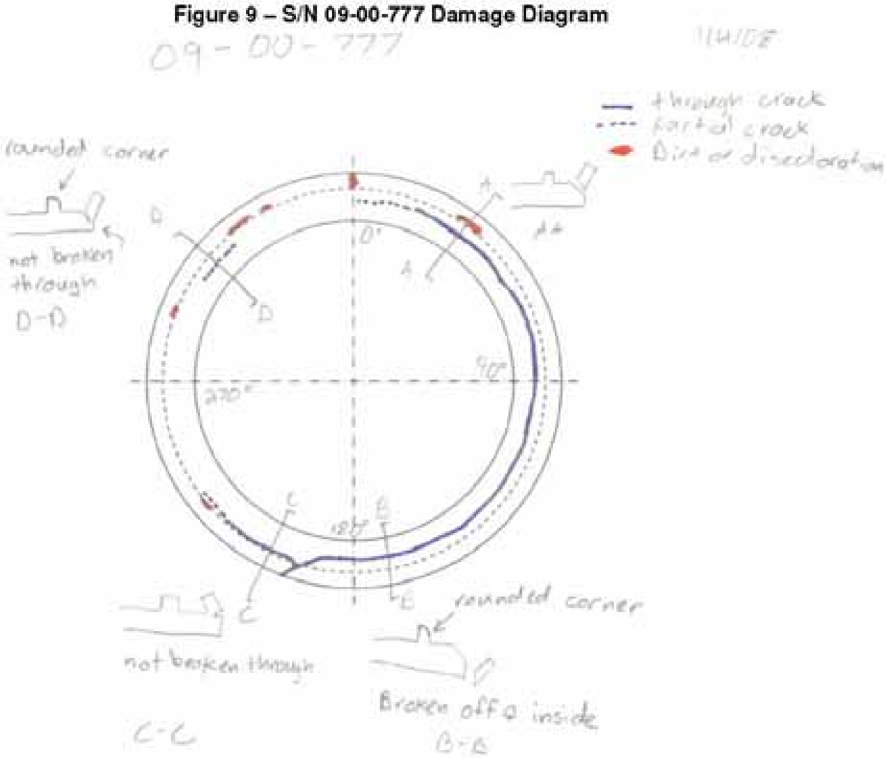


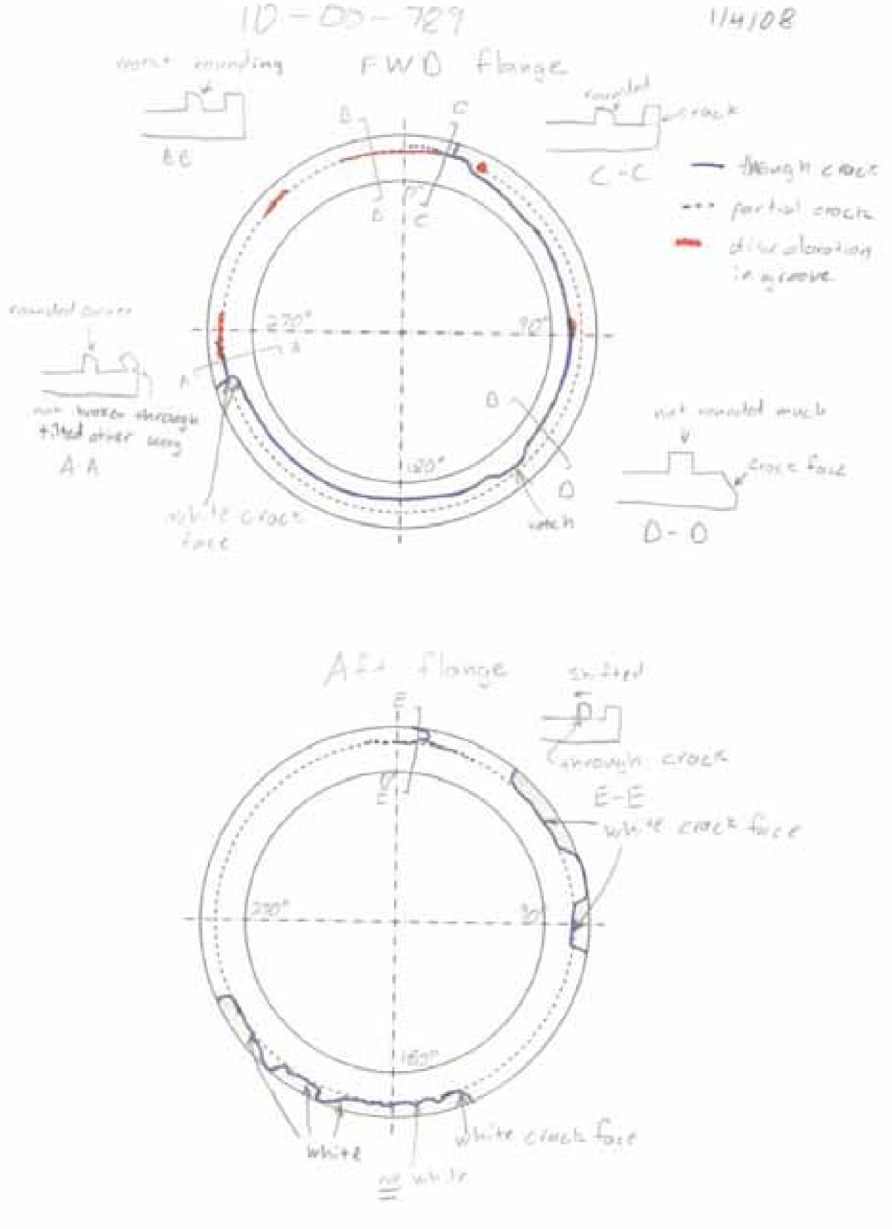
Figure 9 – S/N 09-00-777 Damage Diagram



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 14 OF 22	

FORM REVISED: 7 Dec 2000

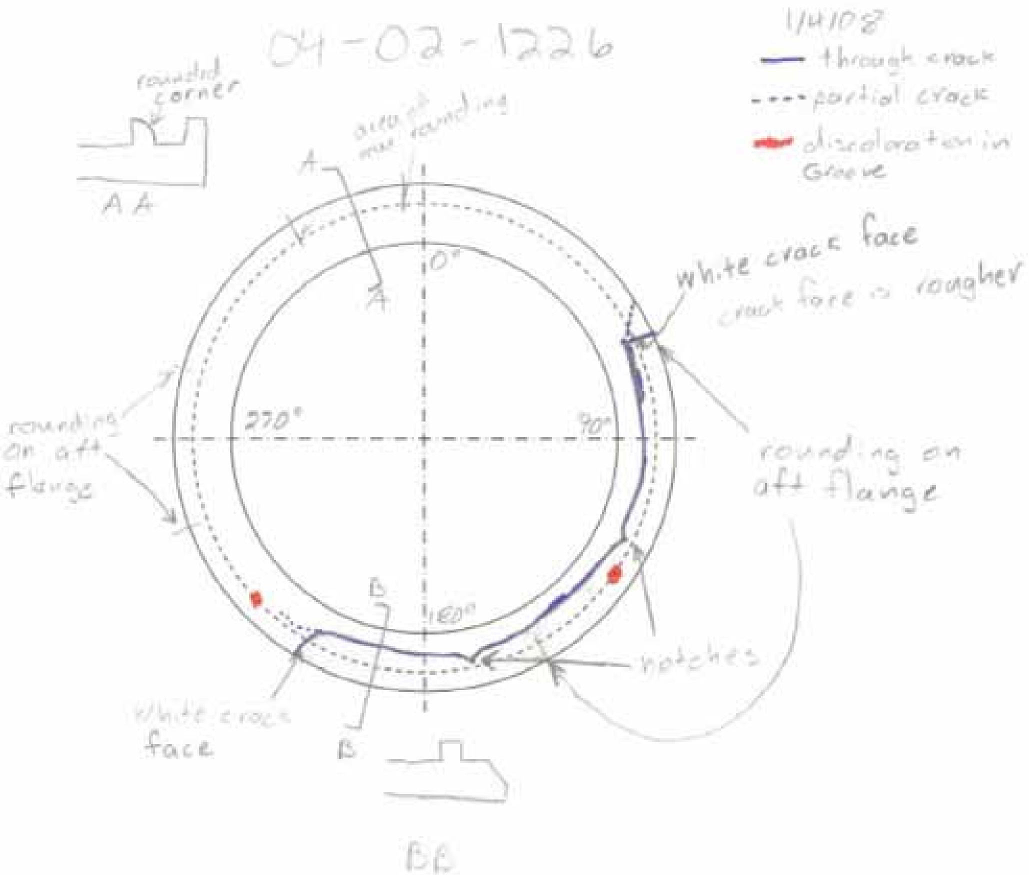
Figure 10 – S/N 10-00-789 Damage Diagram



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
SALT LAKE CITY, UTAH 84116	SCALE - N/A	WEIGHT - N/A	SHEET (S) 15 OF 22	

FORM REVISED: 7 Dec 2000

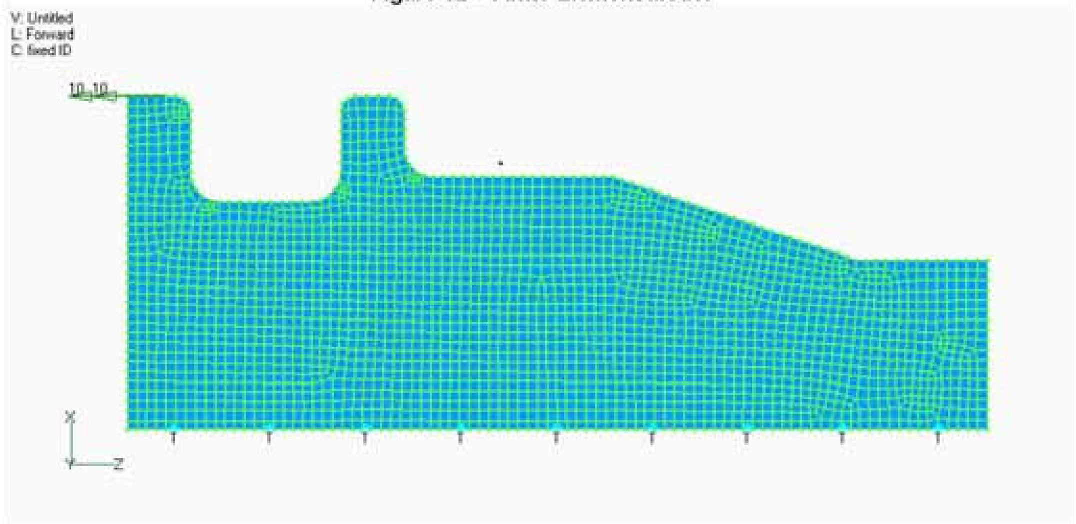
Figure 11 – S/N 04-02-1226 Damage Diagram



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 16 OF 22	

FORM REVISED: 7 Dec 2000

Figure 12 – Finite Element Model



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 17 OF 22	

FORM REVISED: 7 Dec 2000

Figure 13 – Finite Element Results, Forward Loading, Max Principal Stress

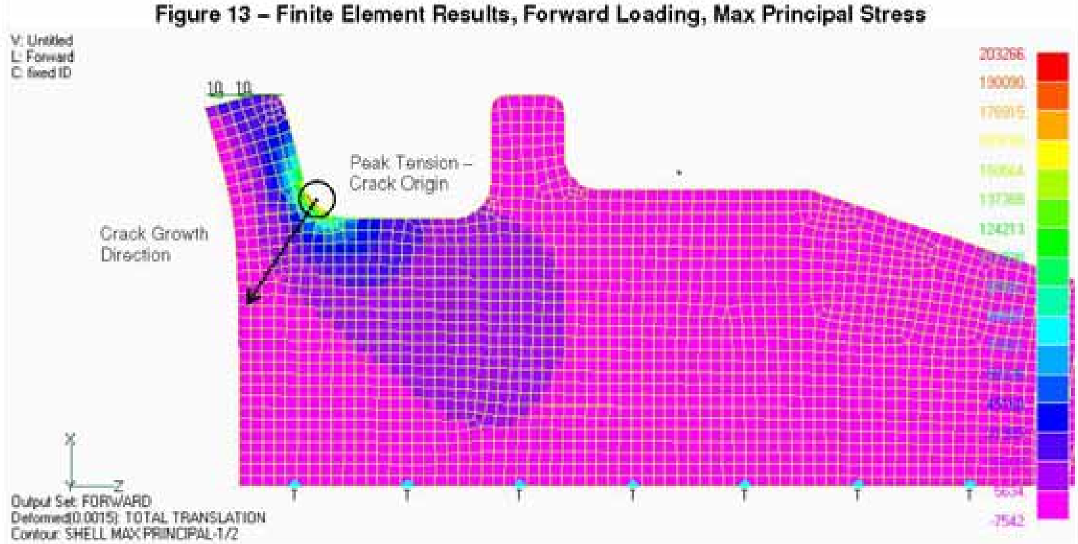
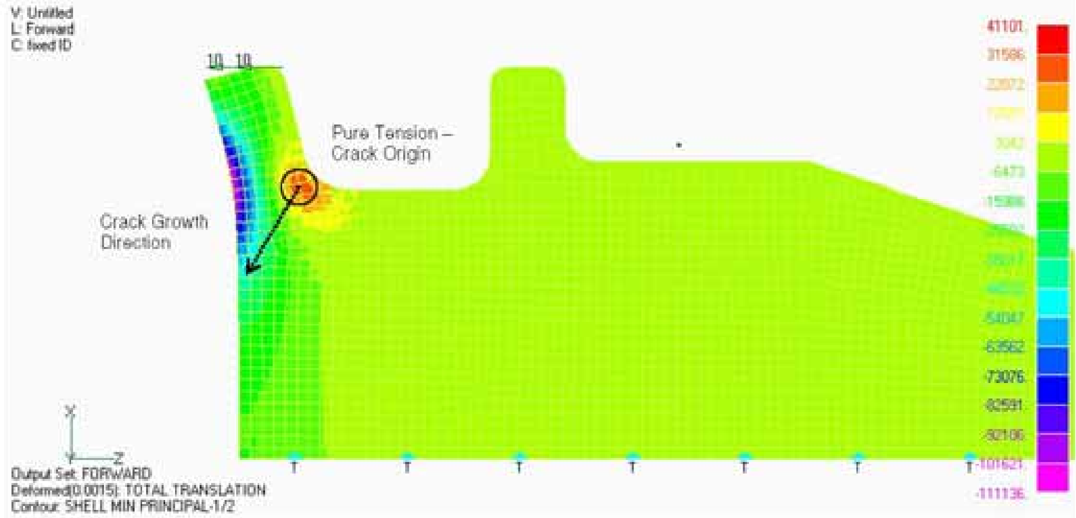


Figure 14 – Finite Element Results, Forward Loading, Min Principal Stress



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 18 OF 22	

FORM REVISED: 7 Dec 2000

Figure 15 – Finite Element Results, Aft Loading, Max Principal Stress

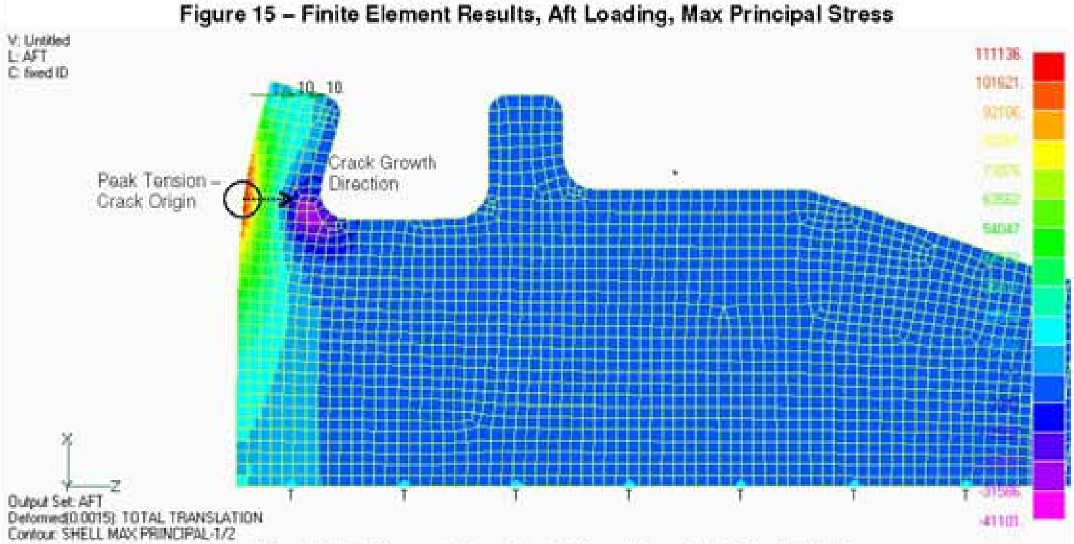
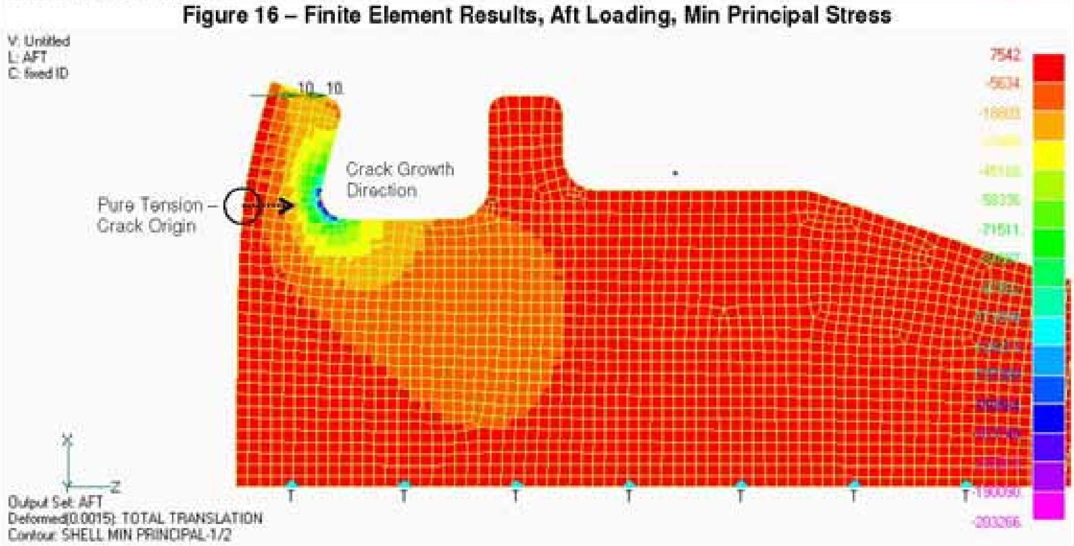


Figure 16 – Finite Element Results, Aft Loading, Min Principal Stress



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 19 OF 22	

FORM REVISED: 7 Dec 2000

Figure 17 – Finite Element Results, Down Loading, Max Principal Stress

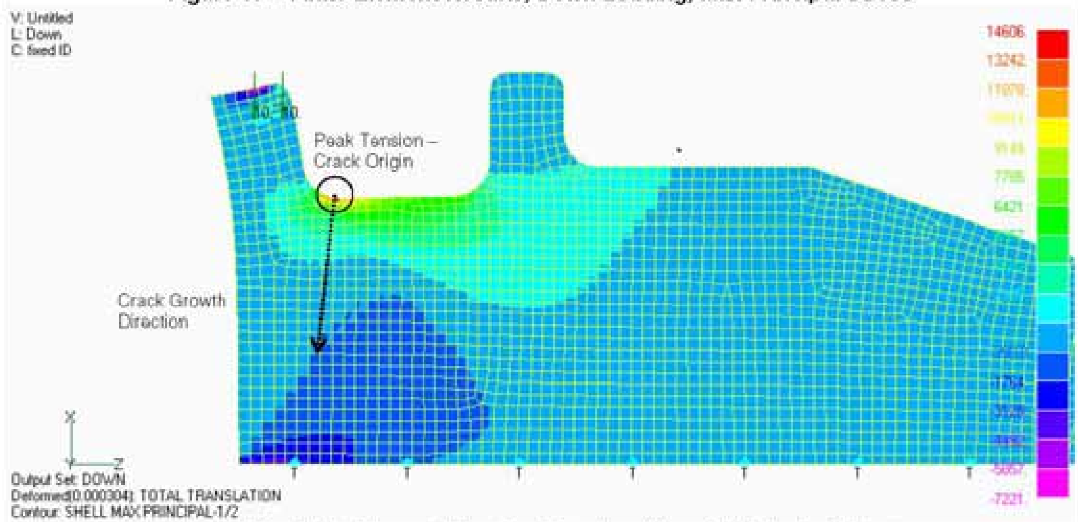
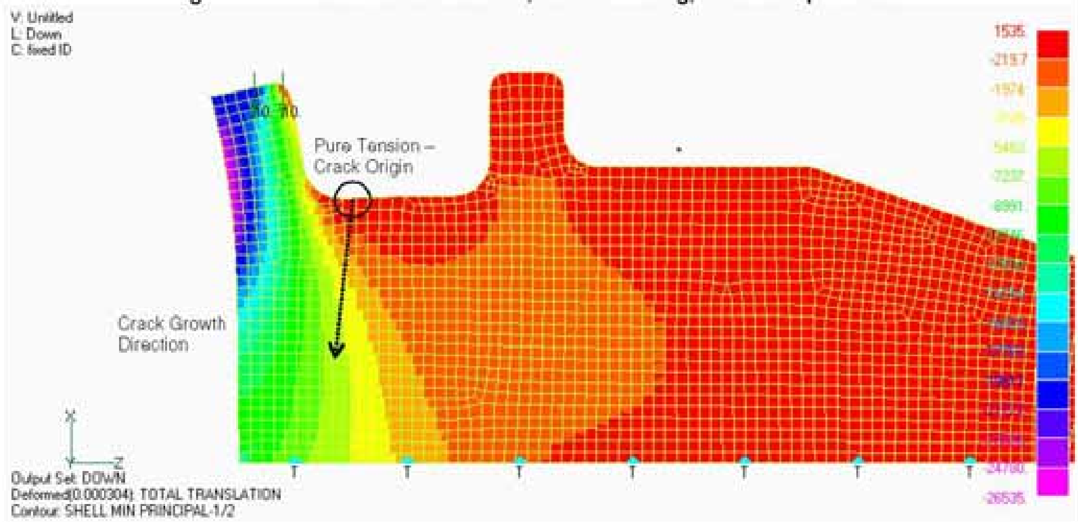


Figure 18 – Finite Element Results, Down Loading, Min Principal Stress



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE A	CODE IDENT 32500	DRAWING NO. 20110	REVISION -
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 20 OF 22	

FORM REVISED: 7 Dec 2000

Figure 19 – Finite Element Results, Forward + Down Combined Loading, Max Principal Stress

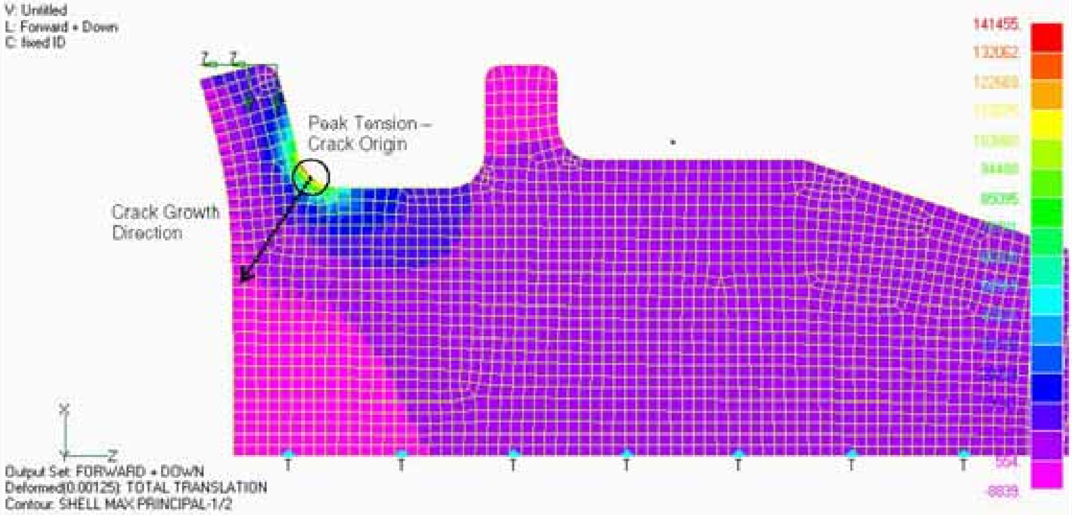
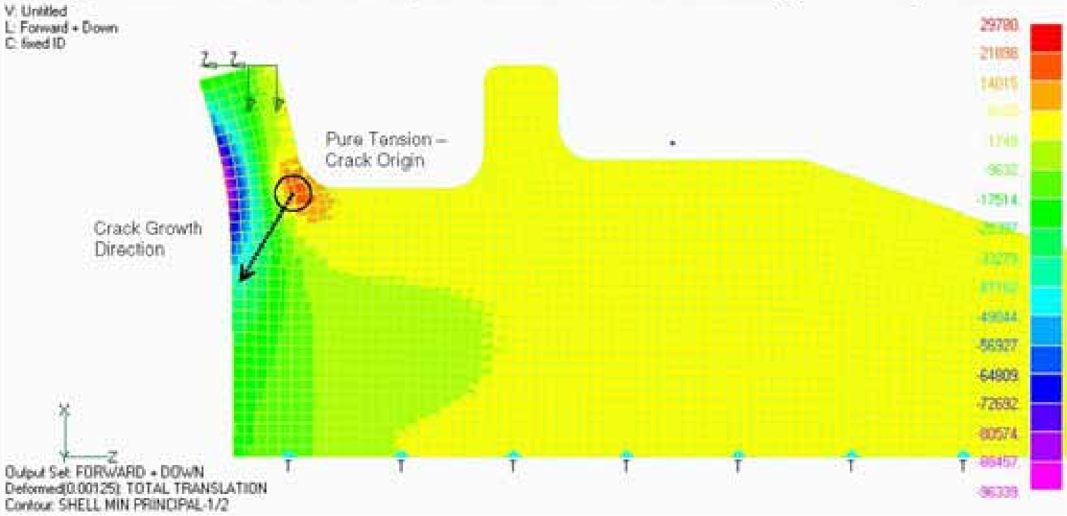


Figure 20 – Finite Element Results, Forward + Down Combined Loading, Min Principal Stress



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE	CODE IDENT	DRAWING NO.	REVISION
	A	32500	20110	-
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 21 OF 22	

FORM REVISED: 7 Dec 2000

Figure 21 – Finite Element Results, Aft + Down Combined Loading, Max Principal Stress

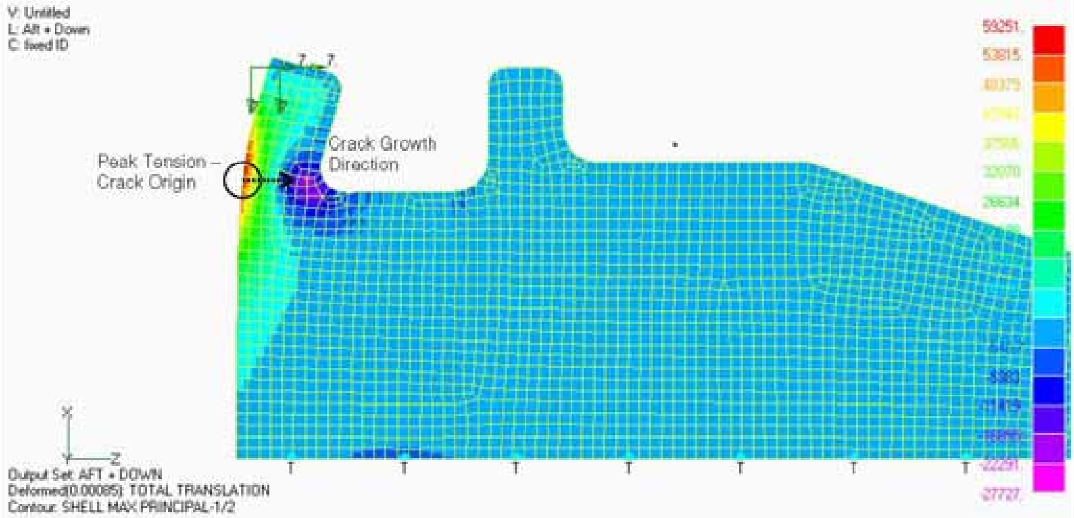
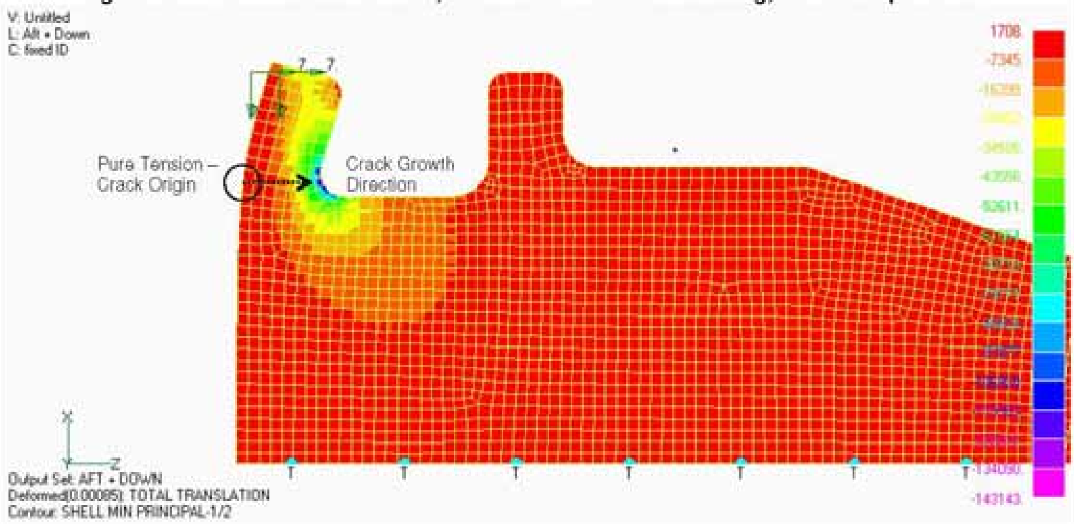


Figure 22 – Finite Element Results, Aft + Down Combined Loading, Max Principal Stress



EDO FIBER SCIENCE 506 NORTH BILLY MITCHELL ROAD SALT LAKE CITY, UTAH 84116	SIZE	CODE IDENT	DRAWING NO.	REVISION
	A	32500	20110	-
	SCALE - N/A	WEIGHT - N/A	SHEET (S) 22 OF 22	

FORM REVISED: 7 Dec 2000

Appendix- 9：Predicted Development History of Corrosion

Refer to figure 1.12-51 structure corrosion location, and the inspection results from paragraph 1.12.1 to 1.12.6, the prediction of corrosion development is canalized as follow:

1. The defective coupler of the waste water tank outlet was the source of waste water tank fluid which contaminated the insulation blanket underneath. (figure 1.12-5)
2. The leaked fluid penetrated the insulation blanket and reached the fuselage skin leaving dirt trace on it. (figure 1.12-6, figure 1.12-7)
3. The leaked fluid flowed toward the front side of airplane which is relatively lower, soaking the intercostal at BS867 ~ BS887 S-26L ~S-27L, caused the intercostals to corroded. (figure 1.12-46, figure 1.12-7)
4. The leaked fluid flowed through the damage web of the intercostals, draining to lower level to S-27L, then continued to flow forward lower, resulted in:
   A. Corrosion of the fuselage belly skin.
   B. Surface corrosion on the left side of S-27L
5. The leaked fluid flowed passed the drain hole on the left side of the S-27L and be trapped in the center groove of this stringer, causing corrosion in this area.
6. During flight while the attitude of airplane changed with increasing pitch angle, the leaked fluid then flowed along the S-27L toward higher water line portion of the belly area (at this time at relative lower level), causing the inner side corrosion of S-27L of fuselage section 47 and skin corrosion outboard of S-27L in fuselage section 47. See figure 2.2-A.

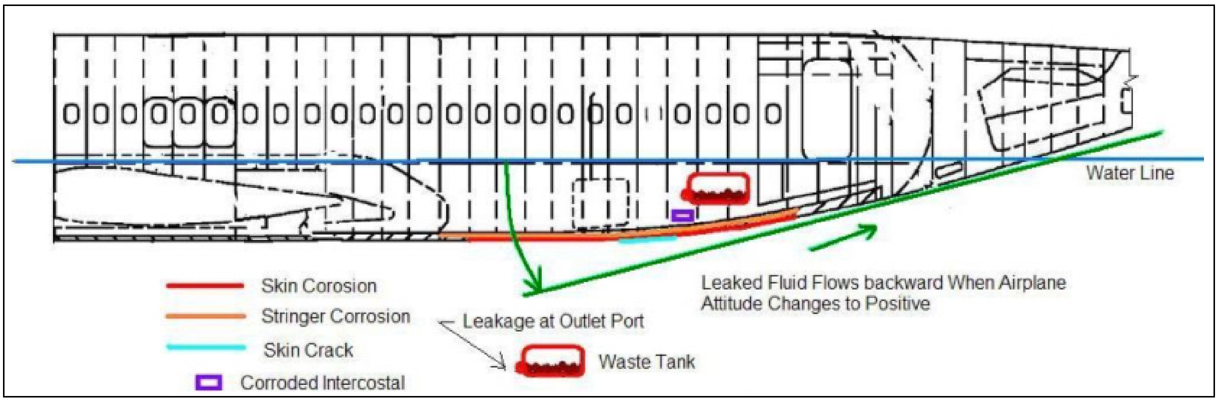


Figure 2.2-A The Leaked Fluid Moved to Aft Due to Airplane Pitch Change

7. The severity of corrosion can be compared from Chart 1.12-1 that those corrosion sites (K3 ~ K8) distributed in five frame spaces in front of K8 (BS847 ~ BS872) are relatively heavy in size and depth. This indicates at most of the time the leaked fluid stayed here, see figure 2.2-B[10]. The depth information of corrosion was provided by China Airline measured from corrosion blend out during temporary repair, as the crack skin with K8 area was not reworked by corrosion blend out, the residual skin thickness was alternately checked by the microscope observation to be 0.0037 inck thick as indicated in paragraph 1.16.2, compared to the original skin thickness 0.063 in, the corrosion had consumed 94% of the skin in the thickness.
8. During flight, air pressure inside the waste tank is kept lower than the ambient pressure inside of the pressurized cabin, this negative pressure difference keeps waste tank fluid retained in the tank and reduces the possibility or amount of leaking. While the airplane was on the ground with power turned off and the vacuum blower ceased operation, the air pressure returned to ambient air pressure, and allowed the waste tank fluid to leak due to the gravity force under a balanced air pressure through the compromised splice. Meanwhile with the attitude airplane on ground, the leaked fluid flowed forward away from the initial leaking point and accumulated in lower portions/corners of the belly structure, resulted in the major corrosion. While the airplane was flying, positive pitch angle

[10] The dimensions of corrosion areas were obtained via mesh method in according to the photograpgic projection areas refer to Table 1.12-1.

maked the leaked fluid moving rearward to areas was higher on ground but now relative lower during flight, resulted in minor corrosion sites such as K9, K10, K11, K12, and K13 respectively. In certain occasions with pitch down attitude of the airplane during flight, the fluid was moved further forward to cause the K1 and K2 area corrosion that relatively not as severe as those in the major corrosion sites.

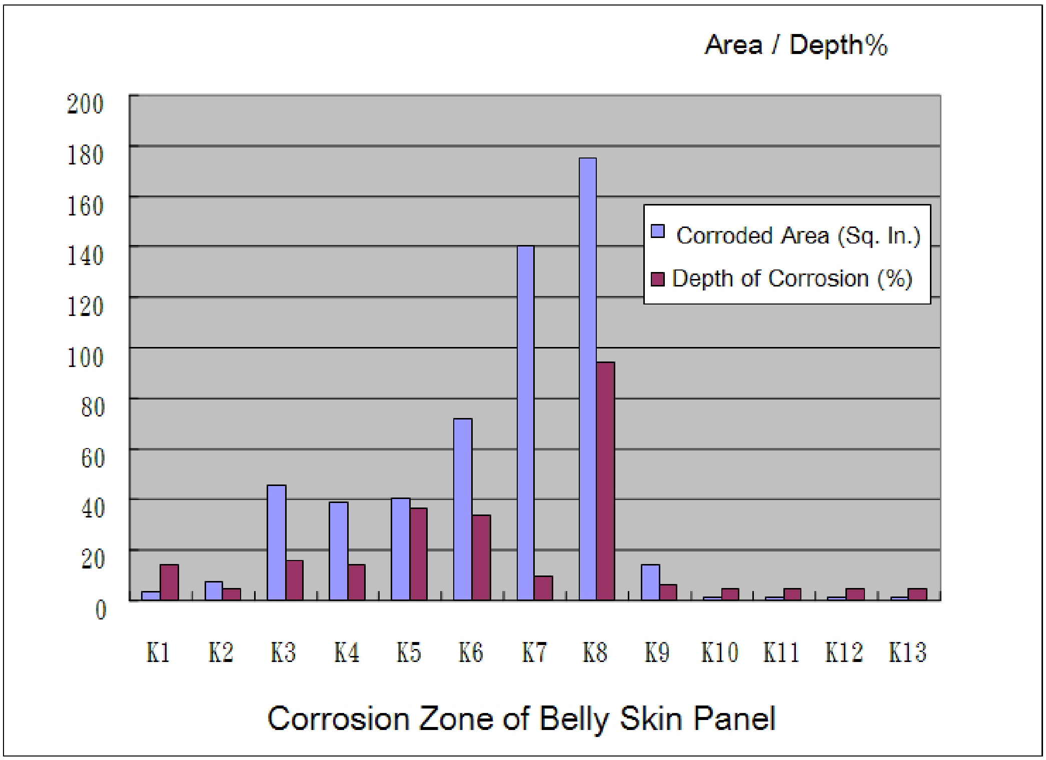


Figure 2.2-B Corrosion Servity and Distribution of the Skin

Appendix- 10：Revised engineering order to perform leakage test of waste tank at every RE check

工　程
執　行　單
ENGINEERING ORDER
ENGINEERING & MAINTENANCE DIVISION, CAL
中華航空公司　修護工廠

TYPE OF E.O.
☐ ALTERATION
■ INSPECTION
☐ MODIFICATION
☐ REPAIR
☐ OTHERS

E.O. NO. 738-38-32-0004
ATA SYSTEM 38

CLASSIFICATION
☐ MAJOR
■ MINOR

ISSUED DATE
INITIAL: Oct. 05, 2007
REVISION:
PAGE 1 OF 1

SUBJECT
Repetitive Leakage Test for 738 Waste Tank

AIRCRAFT MODEL OR REGISTRY NO. AFFECTED
737-809(B16802, B16803, B16805, B18601, B18605, B18606, B18607, B18608, B18609, B18610, B18612, B18615, B18617.)

ENG. MODEL OR ENG. S/N OR EBU NO. AFFECTED
N/A

ACTIVE: 1
PASSIVE: 0
TOTAL: 13

COMPONENTS AFFECTED:
N/A

P/N:
N/A

REFERENCE:
(TYPE NO, REV, DATE, ORIGINATOR)
738 AMM 38-32-07
738 AMM 12-17-01
738 IPC 38-32-51-04

REASON:
To prevent gray leakage from the waste tank and the related supply & drain lines.

AD NUMBER	REV.	EFFECTIVE DATE	AD FINAL DATE
N/A			

AFFECTED DOC:
N/A

EO FINAL DATE
At every RE Check.

ESTIMATION COST PER
■ AIRCRAFT
☐ ENGINE
☐ COMPONENT

RESPONSIBLE CONTROL UNIT	NAME	TELEPHONE
MN	H. M. Chen	7918

SPECIAL TOOLS REQUIRED
N/A

SHOP M/H: NONE
A/C M/H: 5
MATERIAL US$: FREE CHARGE
TOOLS US$: FREE CHARGE
SCRAP MATERIAL US$: FREE CHARGE
TOTAL US$: 250
TOTAL COST OF E.O. US$: 3250

WEIGHT & BALANCE
0 WEIGHT CHANGE (LBS)
0 MOMENT CHANGE (LBS-INCH)

ELECTRICAL LOADING CHANGE:
DC LOADS: 0 A.
0 BUS.
AC LOADS: 0 W.
0 BUS.

VALUE INCREASED ☐ YES ■ NO
WARRANTY ☐ YES ■ NO
INFORM FLIGHT CREW: ☐ YES ■ NO
SIMULATOR AFFECTED: ☐ YES ■ NO
FLIGHT OPERATION WILL ISSUE AD/SB BULLETIN FORM ☐ YES ■ NO

DESCRIPTION
1. Perform repetitive DVI on the waste tank and the associated components/plumbing (supply/drain lines from waste tank to service panel) to check if there is any sign of gray water leakage during flush the waste tank of the waste tank servicing.
2. Refer to job card for Accomplishment Instructions.

LIST OF EFFECTIVE PAGES OF EO.(ML=MATERIAL LIST, IFS=IMPLEMENTATION FEEDBACK SHE
REVISION CODE: D=DELETED, N=NEW, R=REVISED, U=UNCHANGED

DOC	PAGE	REV.	DATE
EO	1	0	Oct. 05, 2007
IFS	1	0	Oct. 05, 2007
ML	1	0	Oct. 05, 2007

DISTRIBUTION 分發單位
■ MN 工程計劃部　■ MS 補給部
■ ML 停機線修護部　☐ MV 裝備修護部
■ MB 場站修護部　☐ EZ 空服處
☐ MH 發修部　☐ OZ 航務處
☐ MD 專修部　☐ TZ 貨運處
■ ME 總工室　☐ ZG 機務訓練部
■ MI 品管室　☐ 構裝機料
☐ MA 會計部　☐ 安管處

PREPARI [redacted]
REVIEW [redacted]
APPROVED BY:
[redacted]
MS Confirmed (AD ONLY)

QP08ME099F1R9

Appendix- 11：CAL revised interval of execution of AMP 53-838-00

1 PROG NO : MG071 B737-800
RUN DATE : APR 15/08 ZONAL INSPECTION PROGRAM
BY ZONE SEQ

OF	ITEM NO	TSCODE	JOB TITLE	INTERVAL	SOURCE	EFFECTIVITY
0			ZONE: 142			
0			INTERVAL NOTE:			
			WHICHEVER COMES FIRST.			
09	53-838-00	E2	INTERNAL - ZONAL (GV): AFT CARGO	12 MO	MRB	ALL
			COMPARTMENT VACUUM WASTE		CHI	
			COMPARTMENT			
0			PERFORM AN INTERNAL ZONAL			
			INSPECTION (GV) OF THE AFT CARGO			
			COMPARTMENT VACUUM WASTE			
			COMPARTMENT.			
0			ZONE: 141, 143			
0			ACCESS NOTE:			
			VACUUM WASTE COMPARTMENT PANELS			
			REMOVAL REQUIRED. REMOVE			
			INSULATION BLANKETS AND SUPPORT			
			TRAYS IN ORDER TO LOOK FOR BILGE			
			STRCUTURAL DEGRADATION SUCH AS			
			DAMAGE, CHAFING, DEFORMATION,			
			CORROSION, LEAKS, CRACKS, AND			
			GENERAL CONDITION OF FASTENERS.			
09	53-840-00	E2	INTERNAL - ZONAL (GV): AREA BELOW	24 MO	MRB	ALL
			AFT CARGO COMPARTMENT		CHI	
0			PERFORM AN INTERNAL ZONAL			
			INSPECTION (GV) OF THE AREA BELOW			
			THE AFT CARGO COMPARTMENT -			
			SECTION 46 AND 47 (PART), STA 727			
			TO STA 947.5.			
0			ZONES: 143 144			
0			ACCESS NOTE:			
			REMOVE FLOOR PANELS, INSULATION			
			BLANKETS AND SUPPORT TRAYS IN			
			ORDER TO LOOK FOR BILGE			
			STRCUTURAL DEGRADATION SUCH AS			
			DAMAGE, CHAFING, DEFORMATION,			
			CORROSION, LEAKS, CRACKS, AND			
			GENERAL CONDITION OF FASTENERS.			
			CARGO LOADING SYSTEM			
			REMOVED/DISPLACED AS REQUIRED.			

Appendix- 12：Boeing and CAL communication letter about waste tank drain fitting inspection of 737 type airplane

FROM: THE BOEING COMPANY
TO: MOM [MESSAGE NUMBER:1-725906264-1] 02-Jan-2008 13:32:14 US PACIFIC TIME
Multi Operator Message

This message is sent to all 737-600/700/800/900 customers and to respective Boeing 737 Field Service bases, Regional Directors.

SERVICE REQUEST ID: 1-725906264
ACCOUNT: BOEING CORRESPONDENCE (MOM)
DUE DATE: 02-Jan-2008
PRODUCT TYPE: Airplane
PRODUCT LINE: 737
PRODUCT: 737-800
ATA: 3832-07

SUBJECT: Vacuum Waste Tank Drain Fitting Inspection

REFERENCES:
/A/ Vacuum Waste Tank P/N 01930-007
/B/ Attachment – File, ClamShell Typ.jpg
/C/ Attachment – File, Leak Example.pdf

\- -

SUMMARY:
This message is sent to advise operators of a severe corrosion condition found on a 737-800 airplane. The corrosion was extensive and resulted in a crack in the airplane skin at stringer (STR) 27L. The corrosion was traced to an undetected leak of material from the vacuum waste tank. The corrosion was extensive and resulted in a crack in the aircraft skin at stringer 27L. The leak occurred as a result of damage to the vacuum waste tank drain fitting. This message requests operators perform a visual inspection for leaks at the waste tank drain fitting, to inspect for corrosion, and to repair any damage as a result of this corrosion. Also, a temporary installation of a protective cover on the waste tank drain fitting is recommended.

\- -

DESCRIPTION:
Boeing has received a report from a 737-800 operator of severe corrosion at STR 27L near the waste tank service panel. It was determined that the corrosion was caused by waste tank leakage. This leakage occurred because of damage to the waste tank drain fitting flange. Subsequent inspection revealed two (2) additional airplanes in this operator's 737-800 fleet that also had leakage at the waste tank drain fitting.

The waste tank drain fitting is made from a nylon material and is connected to a stainless steel drain tube. This connection has a clamshell style clamp, which seals the joint with a stainless steel sleeve that slips over the o-rings on the tank drain fitting flange and the drain tube fitting flange. The sleeve is then held in place with the clamshell clamp. The type of joint allows axial and angular movement between the tank and the drain tube to avoid stresses to the joint. The configuration of this joint is depicted in the attached file, ref /B/ (Clamshell Typ.jpg).

Boeing contacted another operator, which had reported similar damage to their waste tank drain fitting. This operator indicated that approximately ninety percent of the waste tanks that are removed during heavy maintenance have shown some form of damage to the waste tank drain fittings. However, none of these airplanes exhibited any leakage from the waste tank joint at this location. It should be noted that the joint design can tolerate a certain amount of damage to the flange on the waste tank drain fitting without having leakage occur. The seal at the joint is between the stainless steel sleeve that slips over the two o-rings. The damage to the flange would have to be significant enough to allow the o-ring to be displaced from its installed position before leakage would occur. Please see ref /B/. The damage to the waste tank drain fitting flange appears to consistently be on the outboard lower section of the drain fitting. Boeing believes the damage may be caused by a riding condition between the waste tank nylon drain fitting flange and the stainless steel drain tube flange. It is possible that over time, a riding condition would result in the flange on the tank wearing through or being fractured.

Boeing visited an operator to witness the waste tank removal during a heavy maintenance visit. The drawing specifies a nominal gap of 0.15 inch between the waste tank drain fitting flange and the drain tube flange. On this airplane, there was a 0.18+ inch gap between the flanges, and the waste tank fitting was not damaged. It was observed that removal of this clamshell clamp was very difficult. Furthermore, it is possible that the nylon waste tank drain fitting flange can be damaged during the clamp removal process.

Boeing believes that a change to the material for the waste tank drain fitting flange from nylon to stainless steel would greatly improve the resistance to damage for the flange. This material change would improve durability of the tank drain fitting flange from any impacts with the adjacent drain tube, and also provide a more durable fitting from when the clamp and sleeve at this joint are removed during maintenance. Boeing is working with EDO Fiber Science, the manufacturer of the ref /A/ vacuum waste tank, on a plan to modify the drain fitting to include a stainless steel flange insert to replace the current nylon flange. At this time, a schedule for any design improvements to the tank has not been established. EDO is also planning on releasing a component service bulletin to allow for the retrofit/repair of the existing drain fitting.

DESIRED ACTION
==============
At the next available maintenance opportunity, Boeing recommends all operators of 737-600/700/800/900 airplanes perform a visual inspection of the area around the vacuum waste tank to determine if there is any leakage from the waste tank drain fitting. The Maintenance Planning Document (MPD) Item 53-838-00 identifies an inspection of the waste tank compartment in the aft cargo compartment every 5500 flight cycles or 24 months, whichever comes first. This inspection requires removal of the vacuum waste compartment panels. Perform this inspection to determine if any leakage has occurred at this fitting. Leakage from the waste tank should be clearly evident on the insulation blankets directly beneath the waste tank drain fitting, as shown in the ref /C/ attachment to this message.

If no leakage is observed, repeat this inspection at the regular maintenance intervals specified in the MPD.

If leakage from the waste tank is evident, remove the insulation blankets to inspect for corrosion on the structure in this area. This would include removing the cargo compartment floor panels and insulation blankets, inboard of the waste tank installation. Inspect for corrosion and remove additional insulation blankets as required, to determine the extent of any corrosion damage.

If corrosion damage is found, repair per the SRM and contact Boeing with the results of the inspection and repair. If the damage is beyond the SRM limits, contact Boeing for repair recommendations.

If leakage is found but no corrosion damage has occurred, Boeing suggests cleaning up the waste water on the interior surfaces and reapplying CIC as necessary to the airplane structure. Replace insulation blankets, as necessary.

There is currently no Boeing-approved repair that can be performed on the waste tank drain fitting by the operators. Damaged tanks would need to be returned to EDO for repair. Removing the clamp and stainless steel sleeve at the waste tank drain is difficult, and could result in further damage to the tank flange. Boeing recommends operators do not attempt to remove the clamp unless the operator intends to replace the waste tank assembly.

Boeing suggests a temporary installation to help reduce the potential for future leakage. The waste tank drain fitting experiences either a negative delta pressure or very low positive delta pressure. While the airplane is on the ground, if the tank is full, head pressure at the waste tank drain fitting may be up to one psi. If the tank is empty, head pressure will be zero. In flight, the tank drain fitting sees a negative delta pressure.

Because this fitting sees minimal positive pressure, a leak can be contained by wrapping the fitting with tape. Boeing suggests the following products:

1) Self-Fusing Silicon tapes (Example: Arlon and MOX-Tape)
2) Cargo Floor Moisture Barrier Tape per BMS8-346

Boeing suggests these tape be installed per the following instructions. Clean the area around the clamshell clamp. Wrap multiple layers of tape around at least one inch of the tank drain fitting, the clamshell clamp, and at least one inch of the drain tube. Wider tapes are preferable because there will be fewer seams and leakage paths. Ensure the entire fitting is encased in tape, and that there are no leakage paths for fluids from the clamp. Boeing recommends reinspection for leakage of the area around the waste tank drain fitting at a 60-day interval. If leaks are found, perform the above inspection and cleanup. If no leaks are found, no further action is required. Any repairs must be approved by the local regulatory agency.

If you need further information regarding the subject or if copies of attachments (when referenced) are required, please contact your local Boeing Field Service Representative. If your local Field Service Representative is unavailable, you may contact the appropriate Airline Support Manager or call the BCA Operations Center at XXX-XXX-XXXX.

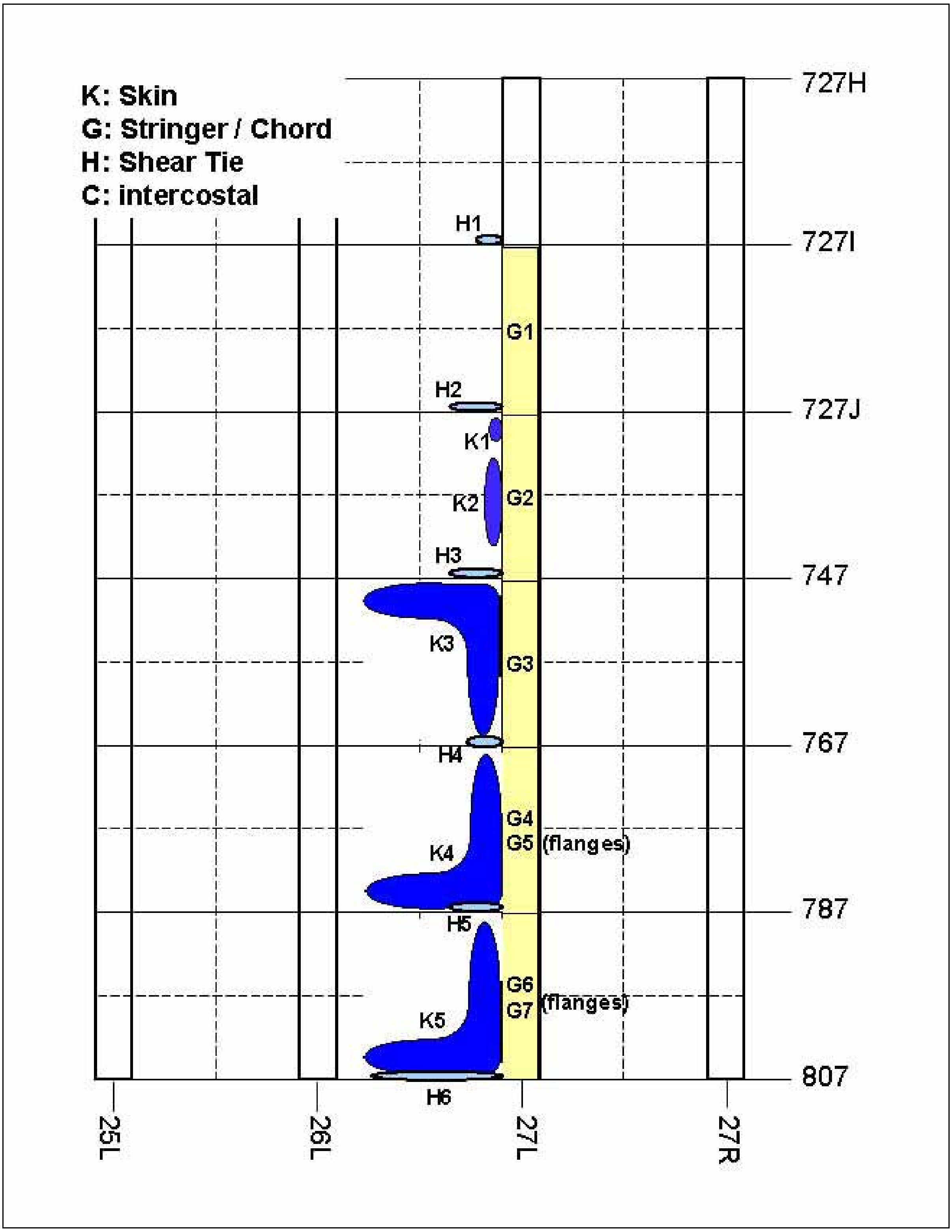
Fleet Support Engineering
Technical Customer Support
Commercial Aviation Services
The Boeing Company

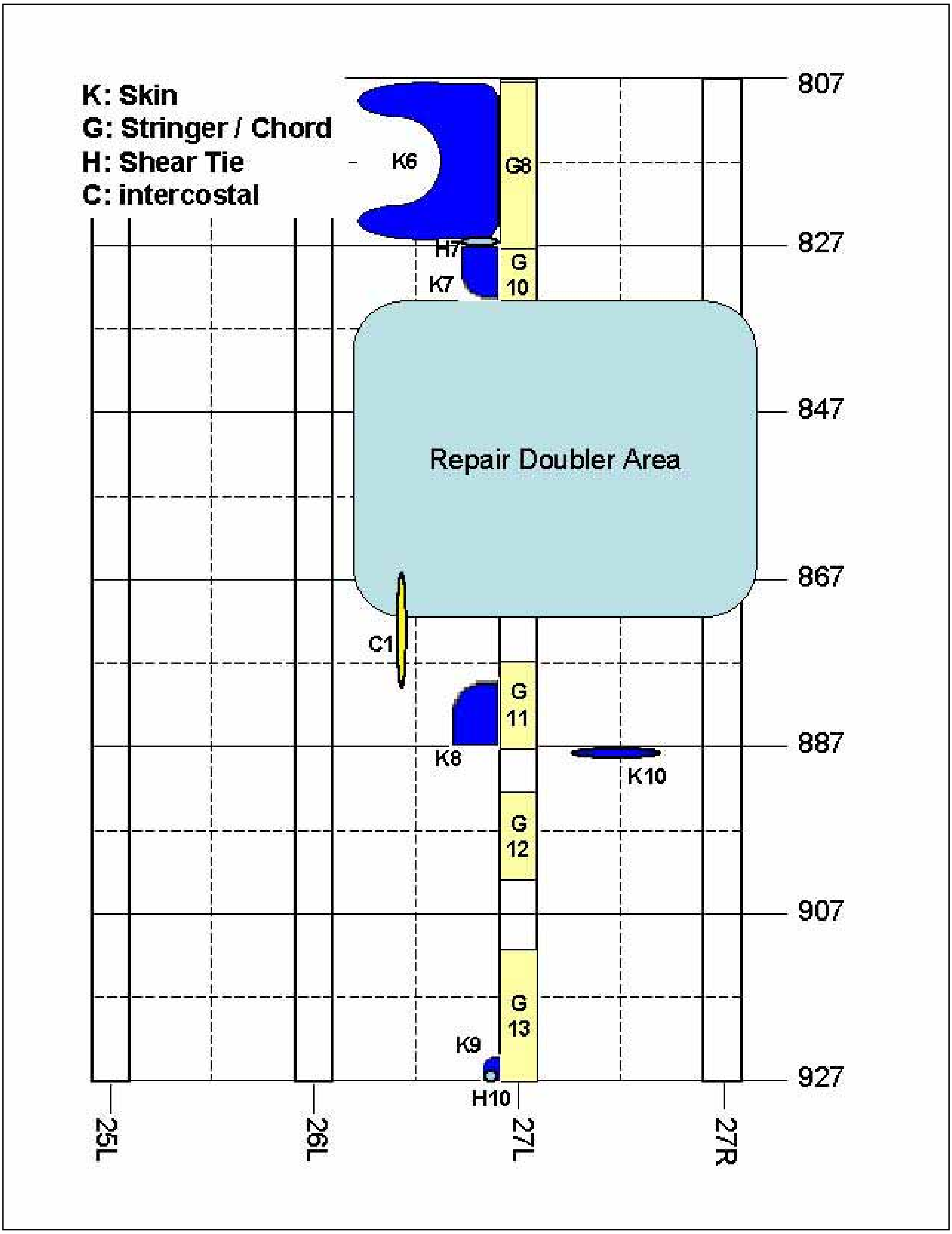
Appendix- 13：(A) Damage Report from the Operator

YC589 (B-16805)
AFT CARGO COMPARTMENT
BELLEY STRUCTURES

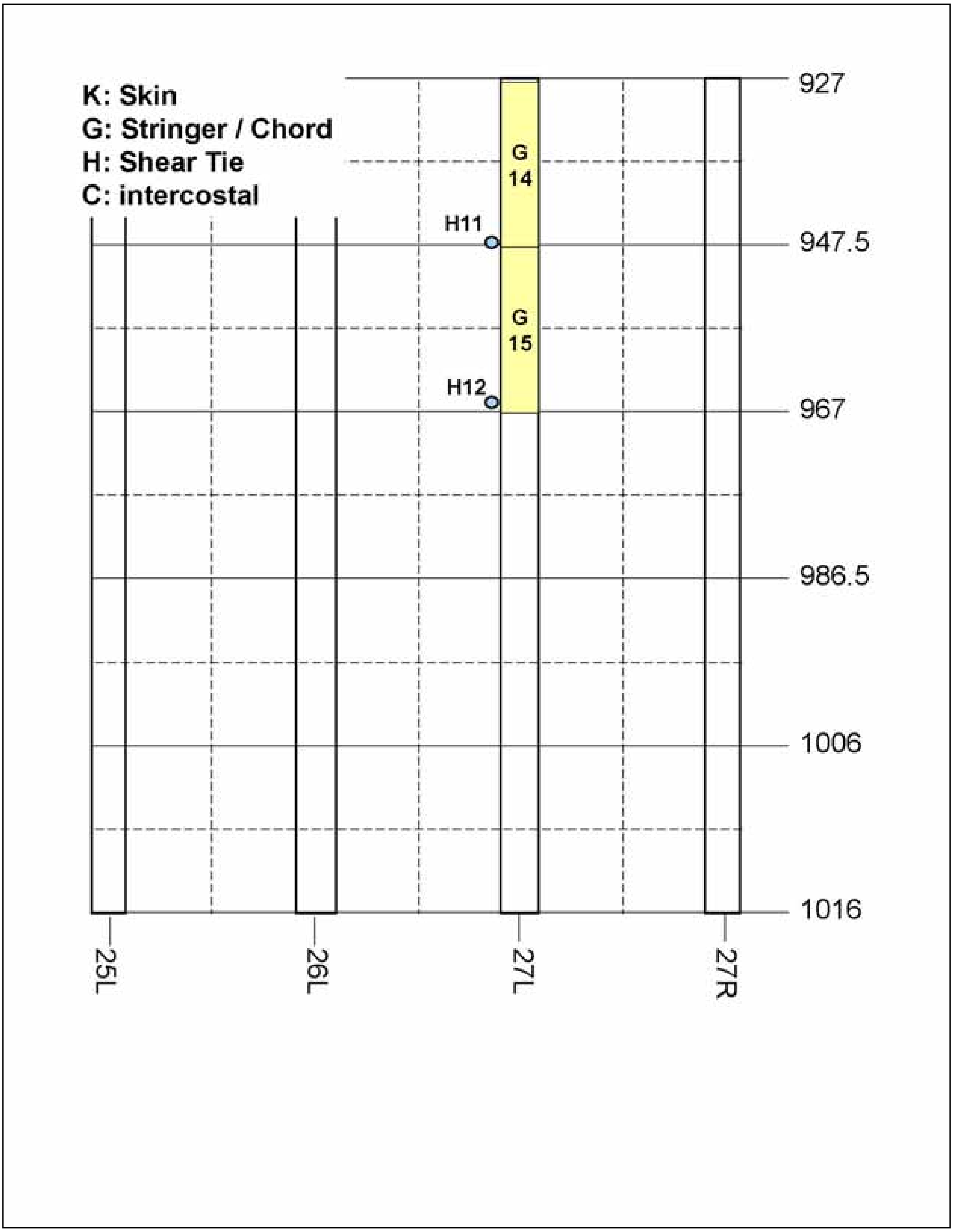
DAMAGE MAP

Oct-17-2007


K: Skin
G: Stringer / Chord
H: Shear Tie
C: intercostal
727H
727I
727J
747
767
787
807
H1
H2
H3
H4
H5
H6
K1
K2
K3
K4
K5
G1
G2
G3
G4
G5 (flanges)
G6
G7 (flanges)
25L
26L
27L
27R

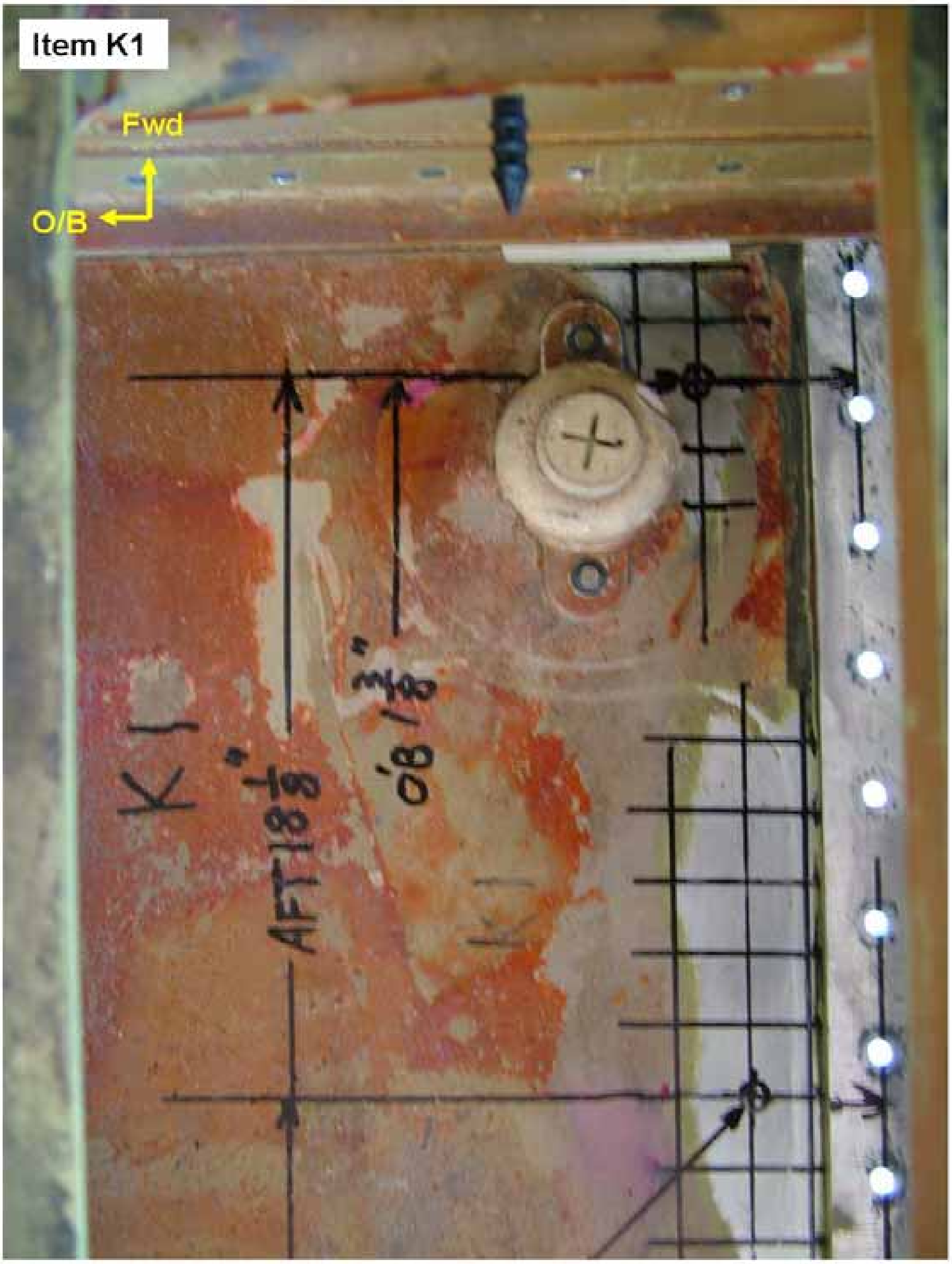


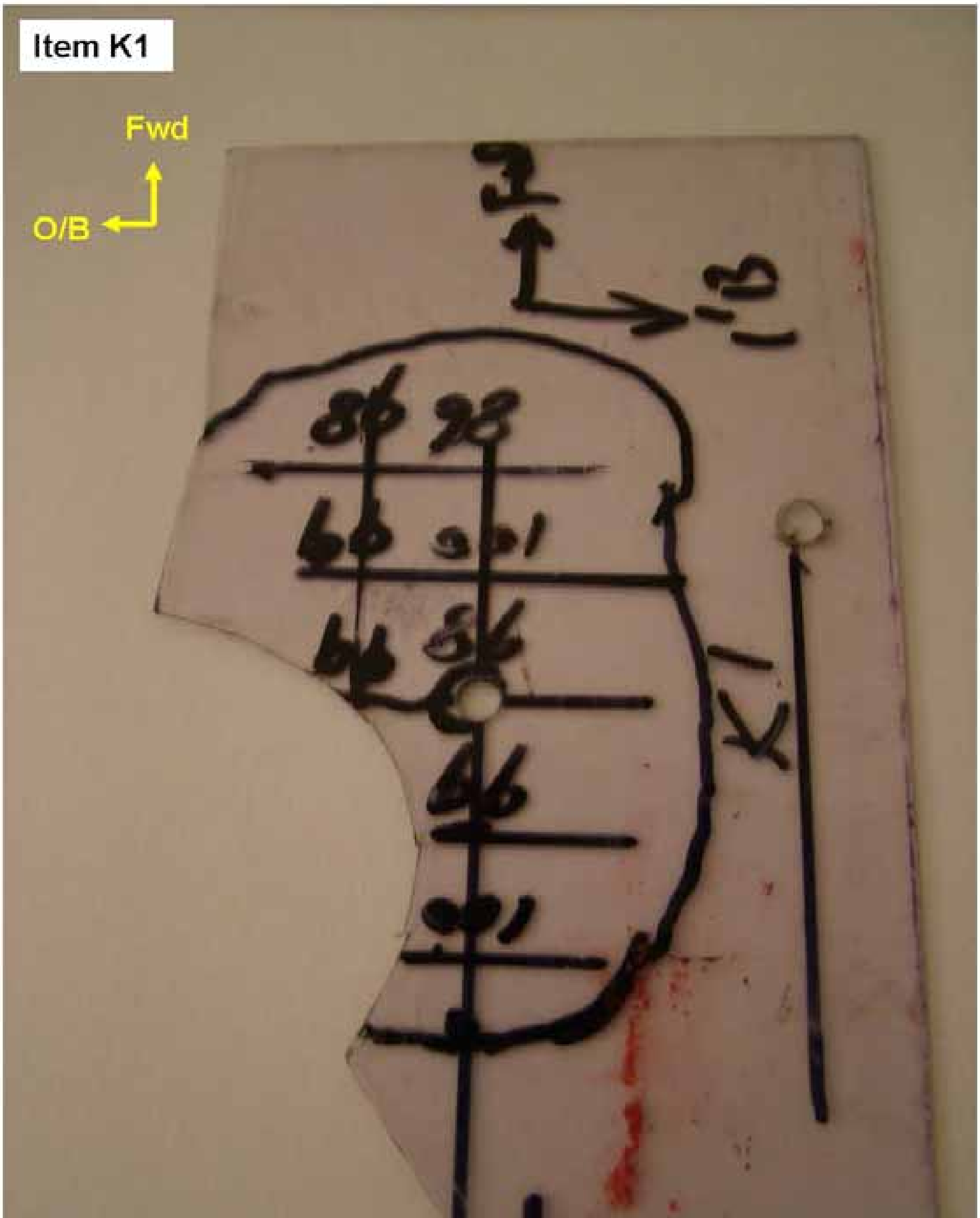
K: Skin
G: Stringer / Chord
H: Shear Tie
C: intercostal
K6
G8
H7
K7
G 10
Repair Doubler Area
C1
G 11
K8
K10
G 12
G 13
K9
H10
807
827
847
867
887
907
927
25L
26L
27L
27R

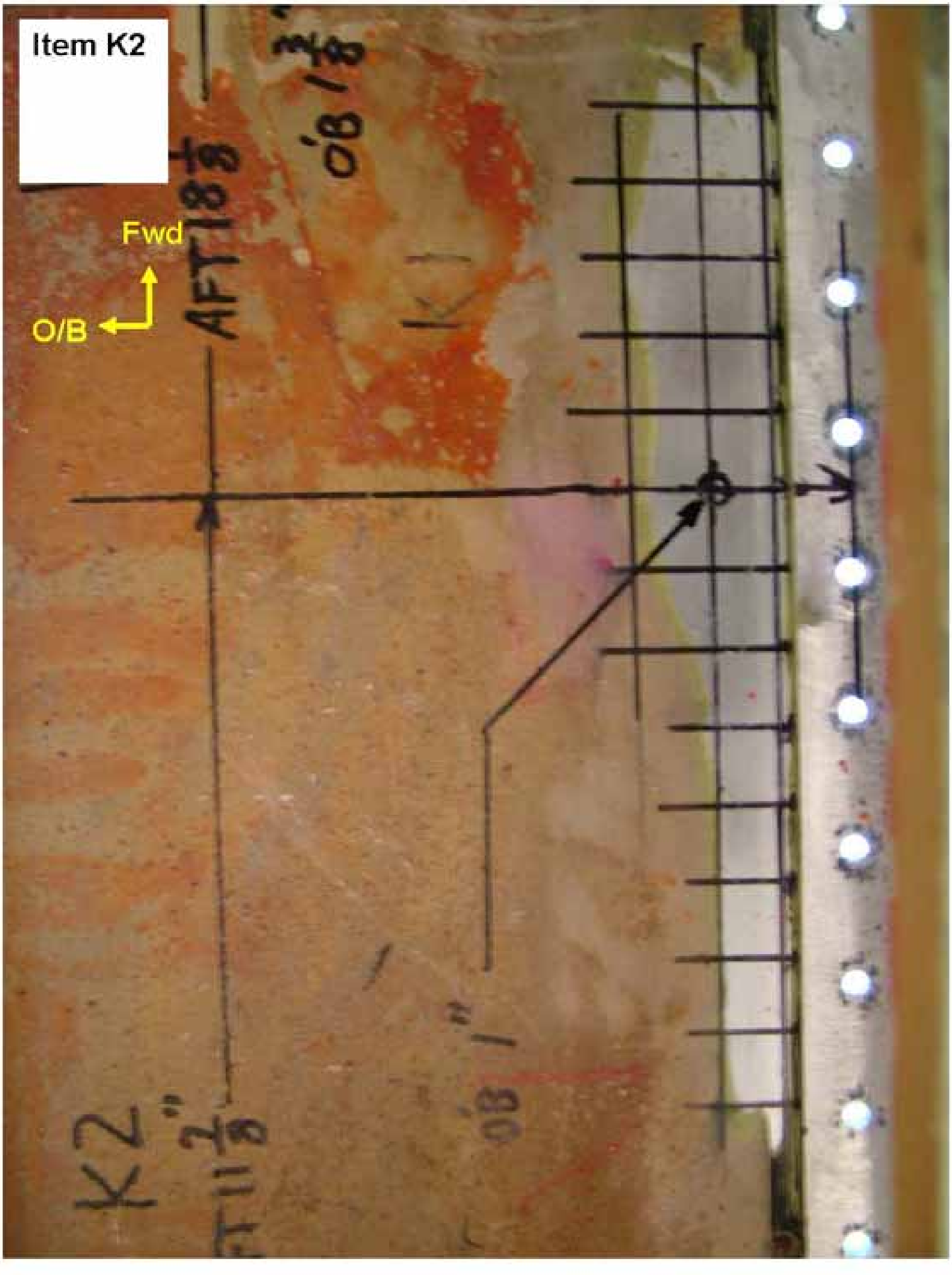

K: Skin
G: Stringer / Chord
H: Shear Tie
C: intercostal
G
14
G
15
H11
H12
927
947.5
967
986.5
1006
1016
25L
26L
27L
27R

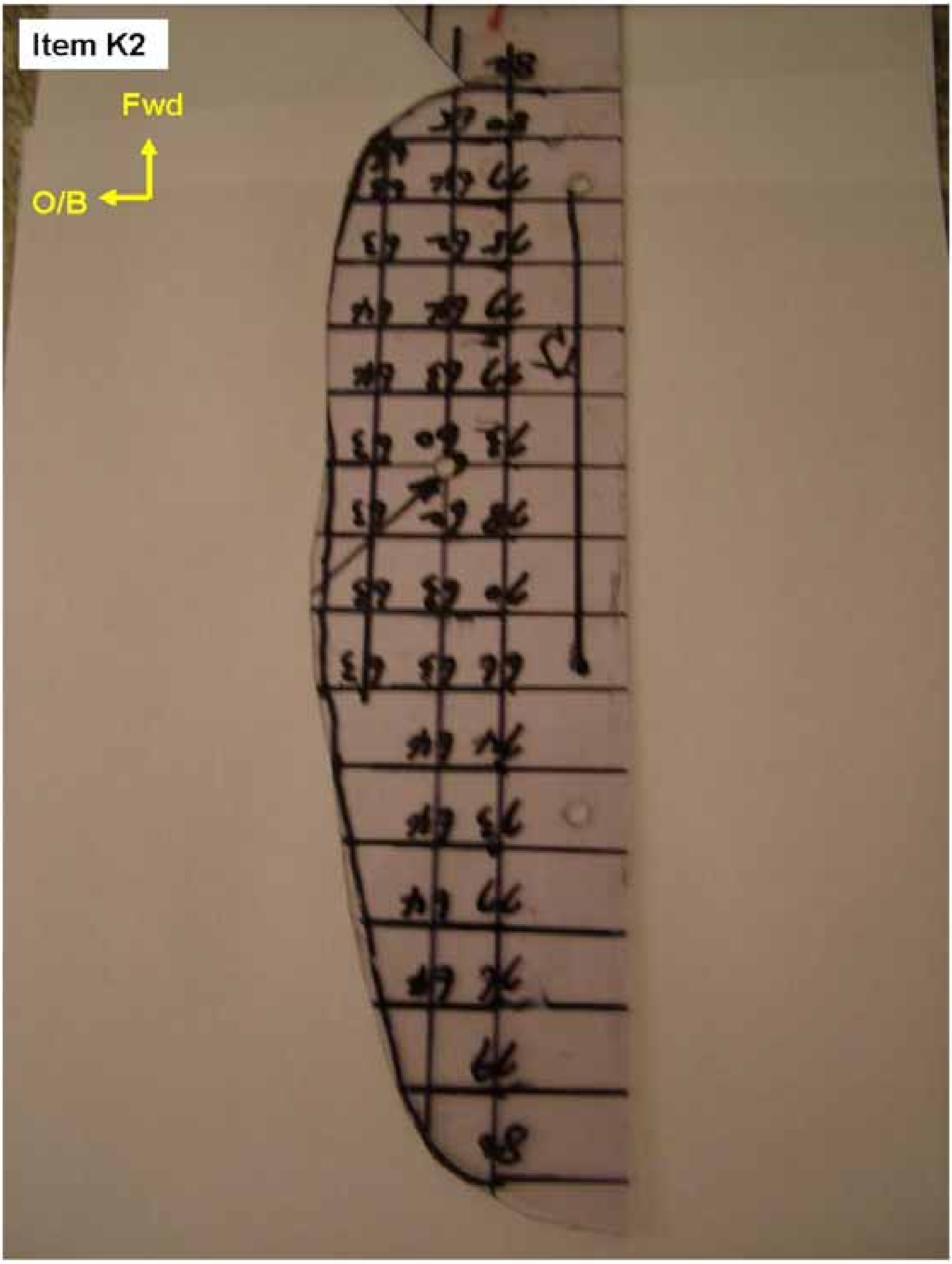
SKIN

ITEM NO.	LOCATION		DIMENSION (INCHES)		MIN. REMAINING THICKNESS (INCHES)
	STA	STRINGER	FWD-AFT DIRECTION	I/B-O/B DIRECTION	
K1	727J - 747	1.5 INCHES O/B OF S-27L	2	1	**0.086**
K2	727J - 747	1.5 INCHES O/B OF S-27L	9	1	**0.060**
K3	747 - 767	2 INCHES O/B OF S-27L	20	6	Fwd: **0.053** Aft: **0.055**
K4	767 - 787	1 INCHES O/B OF S-27L	20	6	Fwd: **0.054** Aft: **0.055**
K5	787 - 807	1 INCHES O/B OF S-27L	20	6	Fwd: **0.057** Aft: **0.040**
K6	807 - 827	2 INCHES O/B OF S-27L	20	5	Fwd: **0.051** Aft: **0.042**
K7	827 - 847	1.5 INCHES O/B OF S-27L	6	2	**0.057**
K8	867 - 887	1.5 INCHES O/B OF S-27L	6	2	**0.060**
K9	907 - 927	1.5 INCHES O/B OF S-27L	2	2	**0.057**
K10	AT AFT OF 887 FRAME		TBD (尚未開工無法打磨確認)		

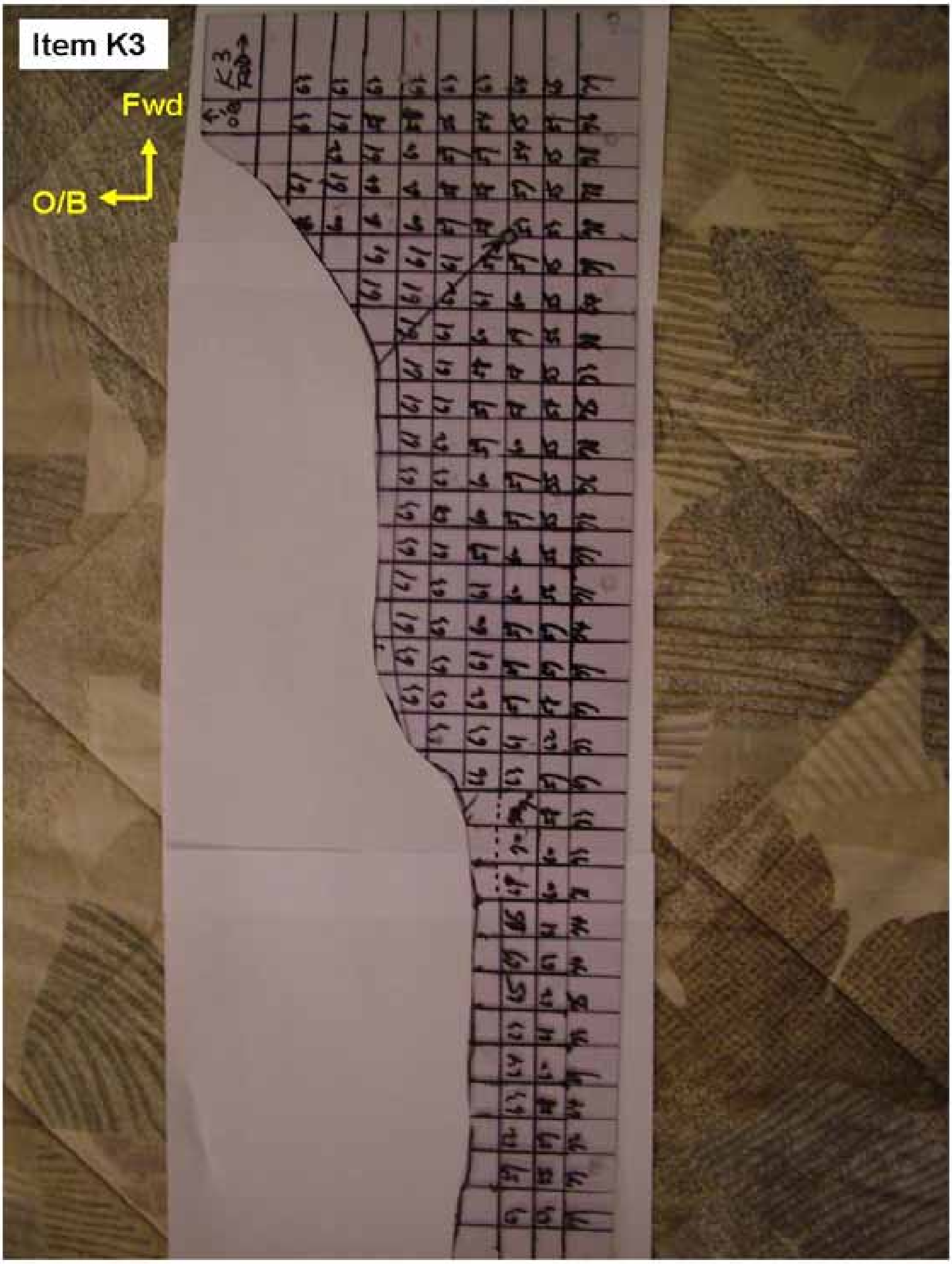

Item K1
Fwd
O/B
K1

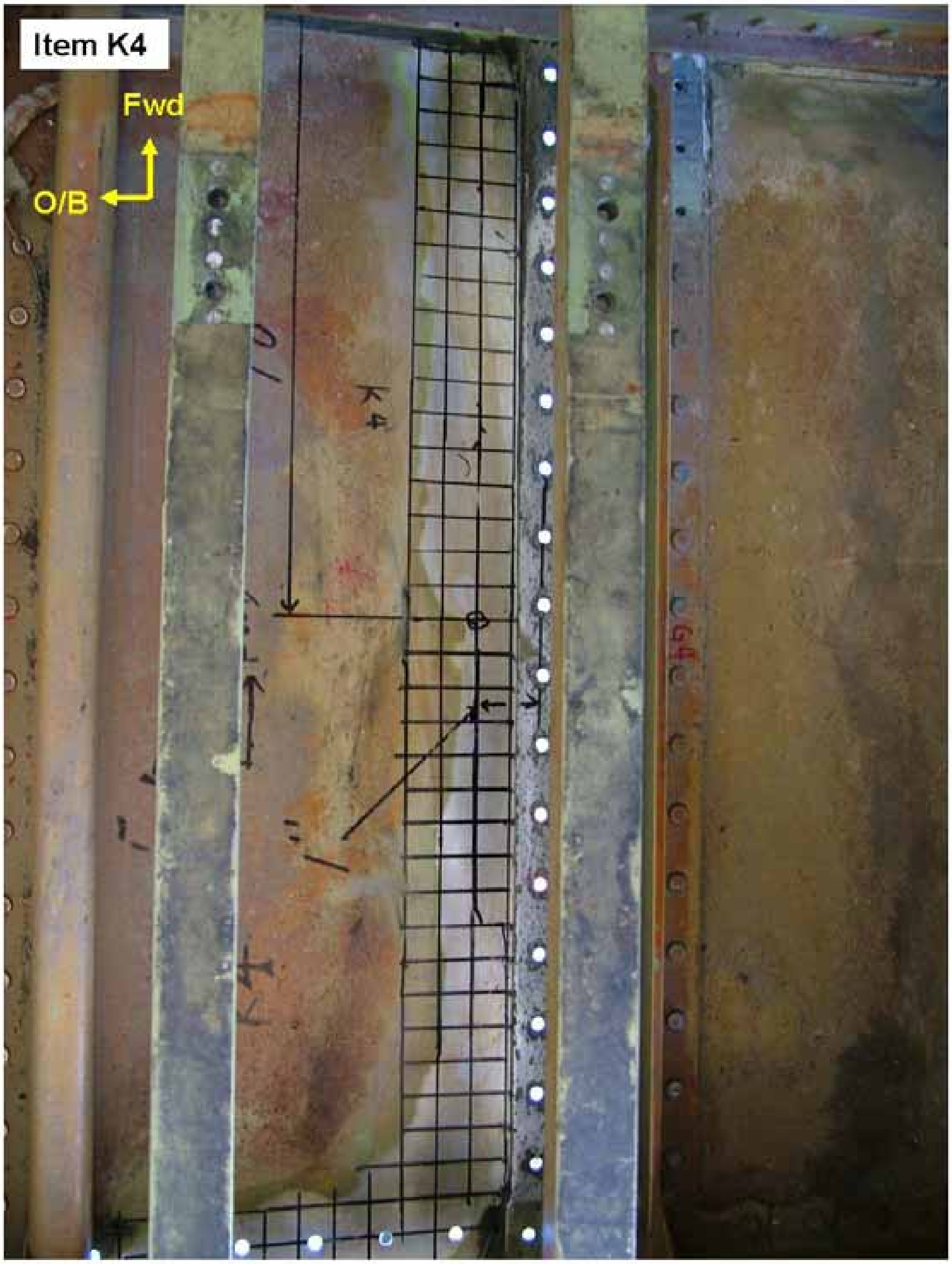

Item K1
Fwd
O/B

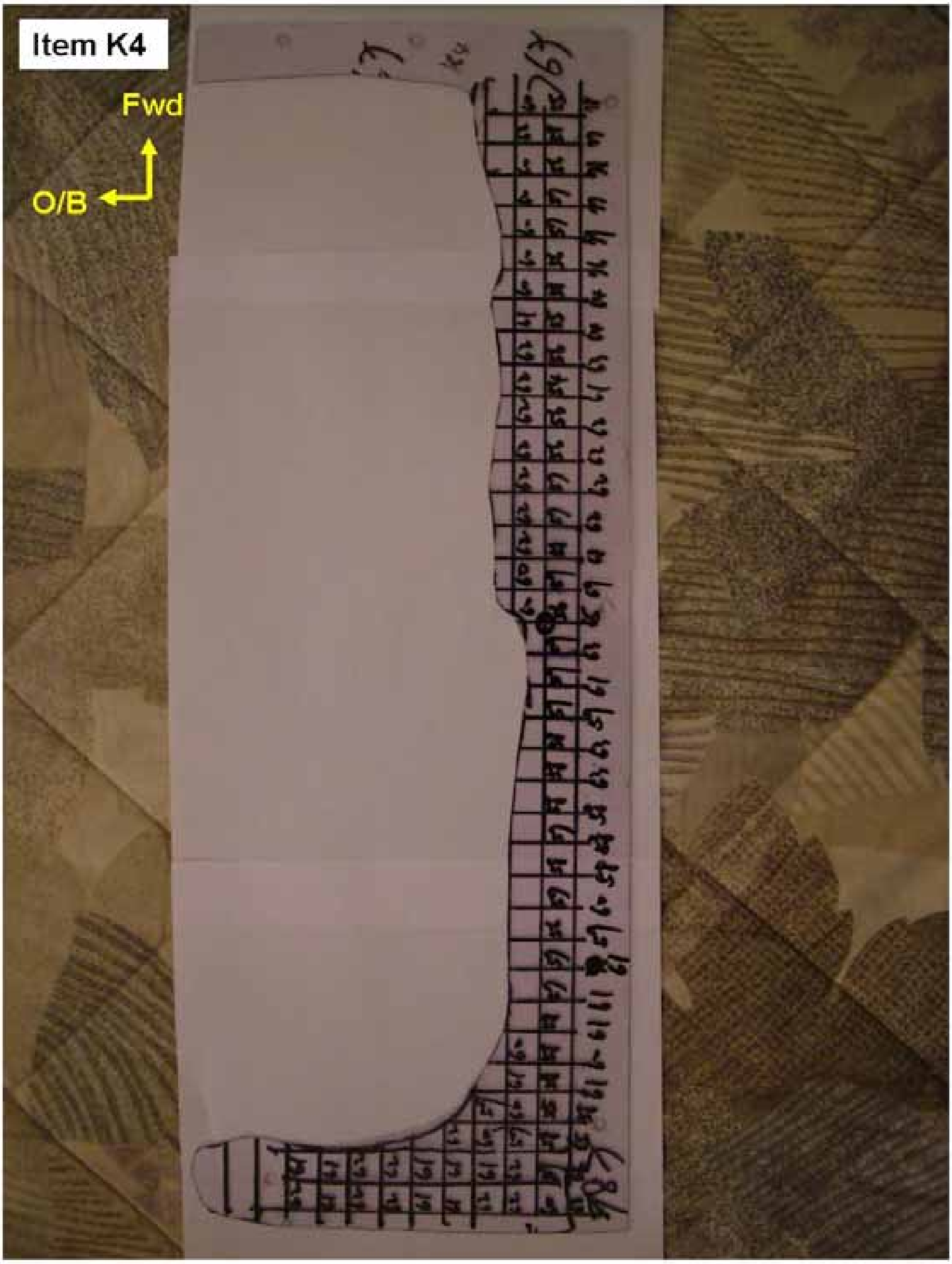

Item K2
Fwd
O/B


Item K2
Fwd
O/B

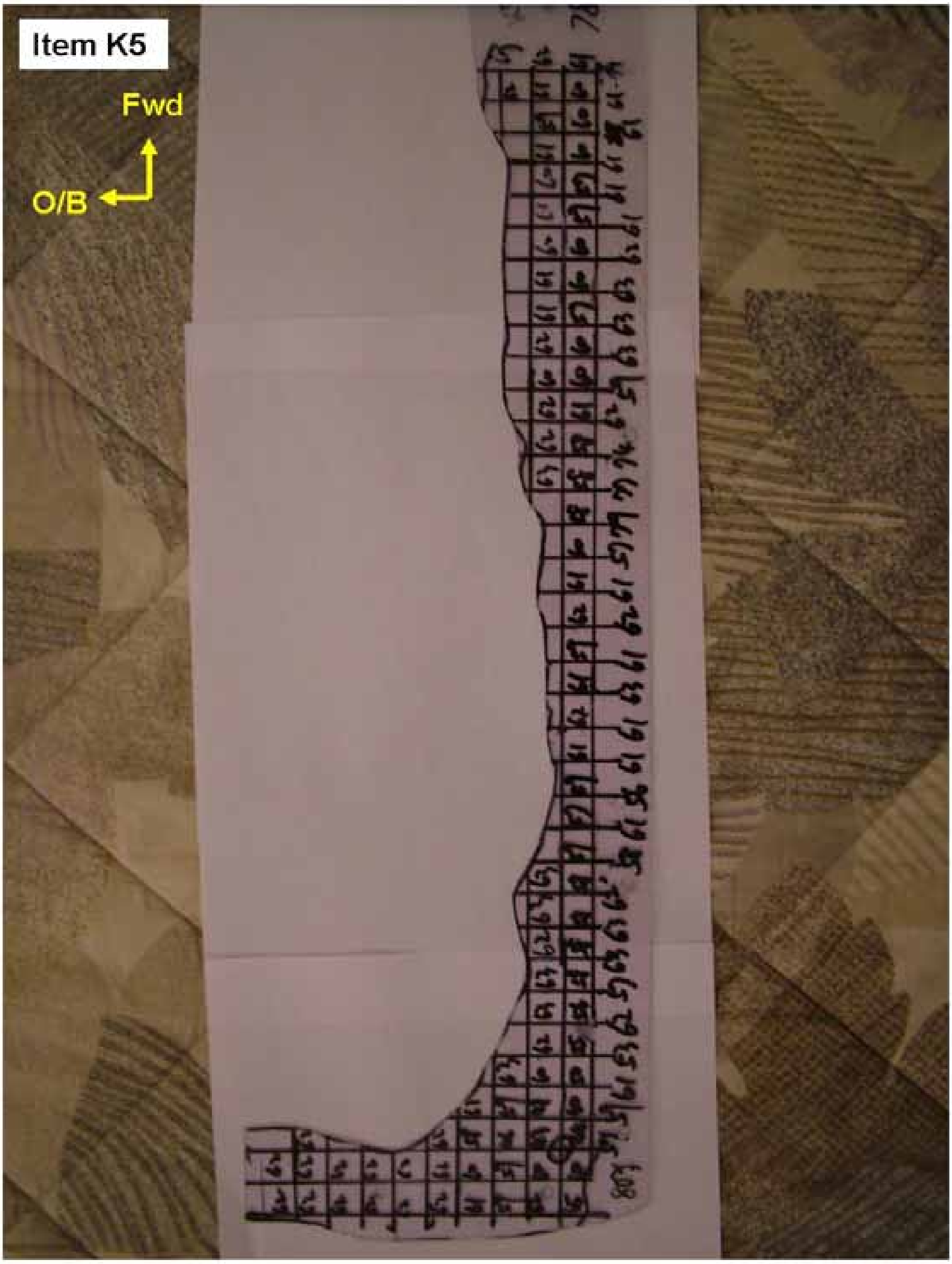
Item K3
Fwd
O/B
G3


Item K3
Fwd
O/B

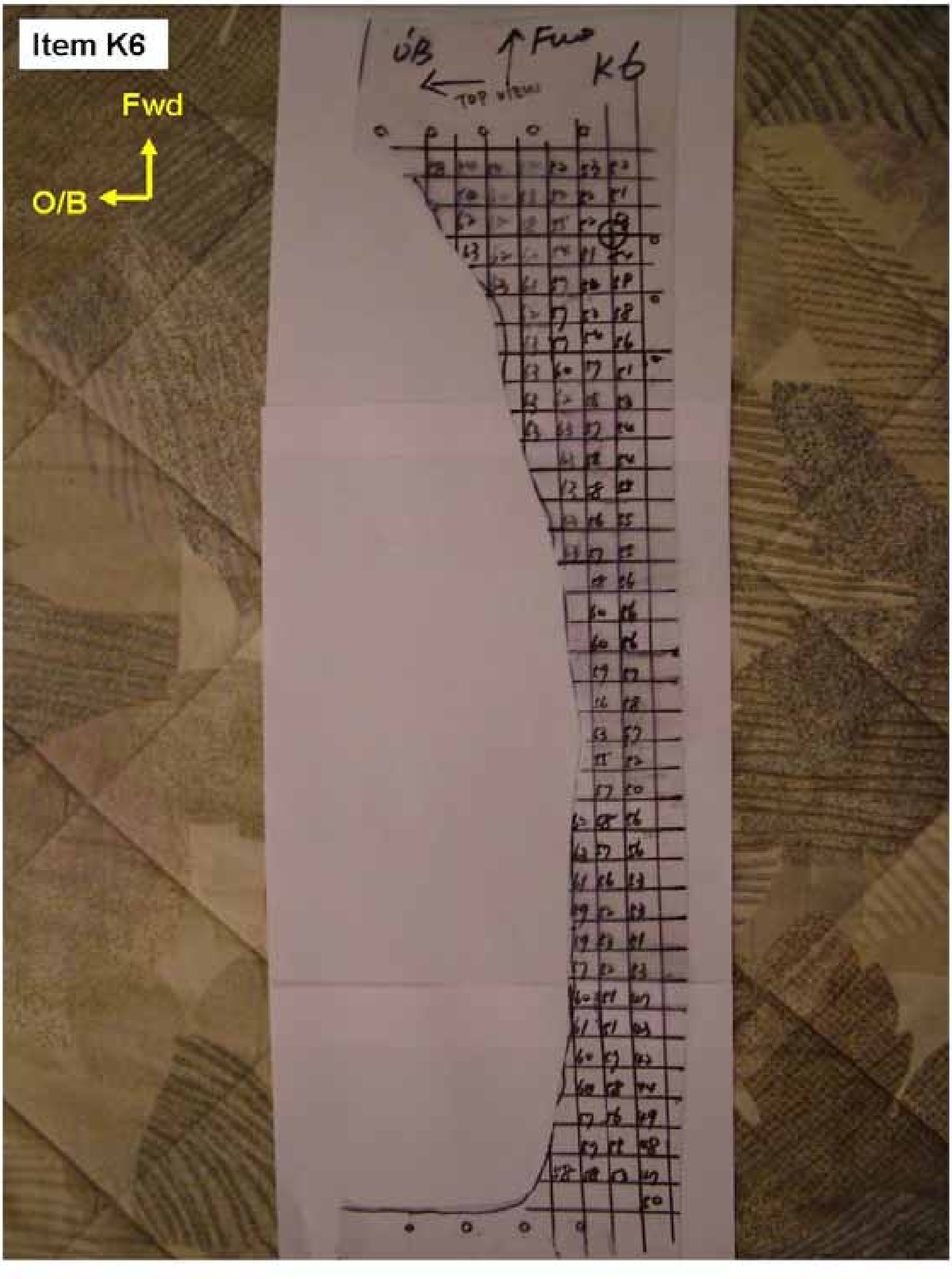

Item K4
Fwd
O/B


Item K4
Fwd
O/B

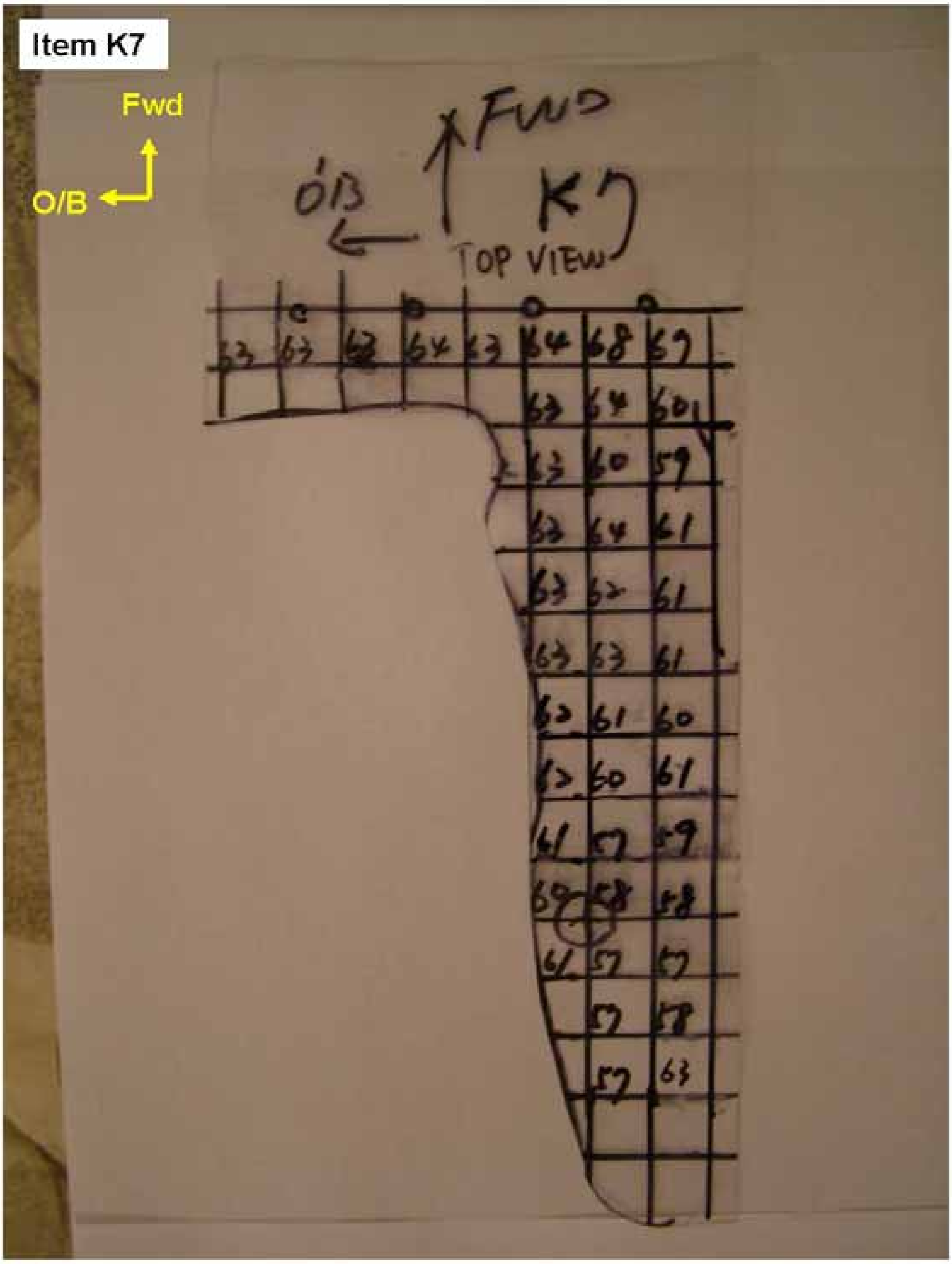

Item K5
Fwd
O/B

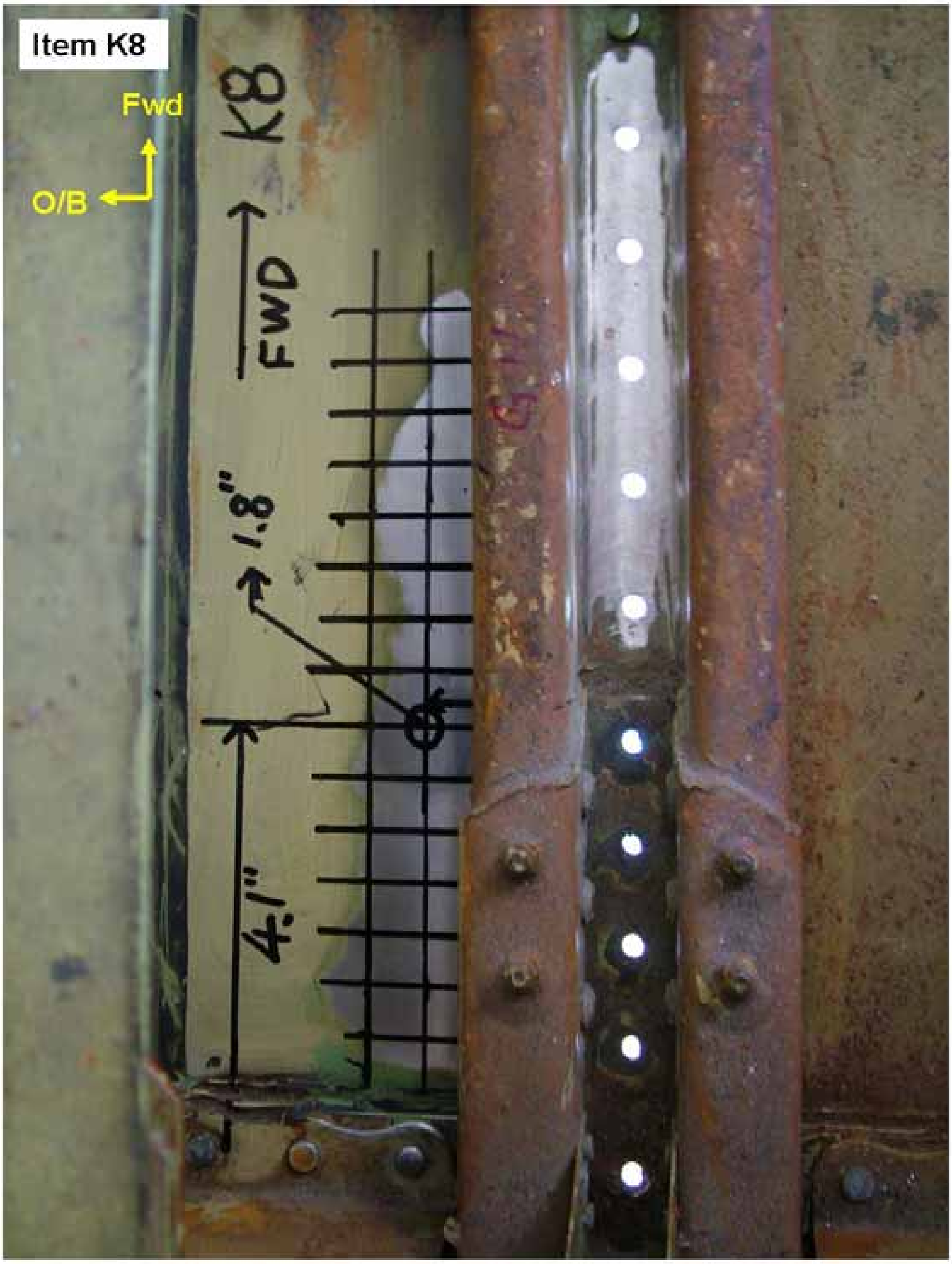

Item K5
Fwd
O/B

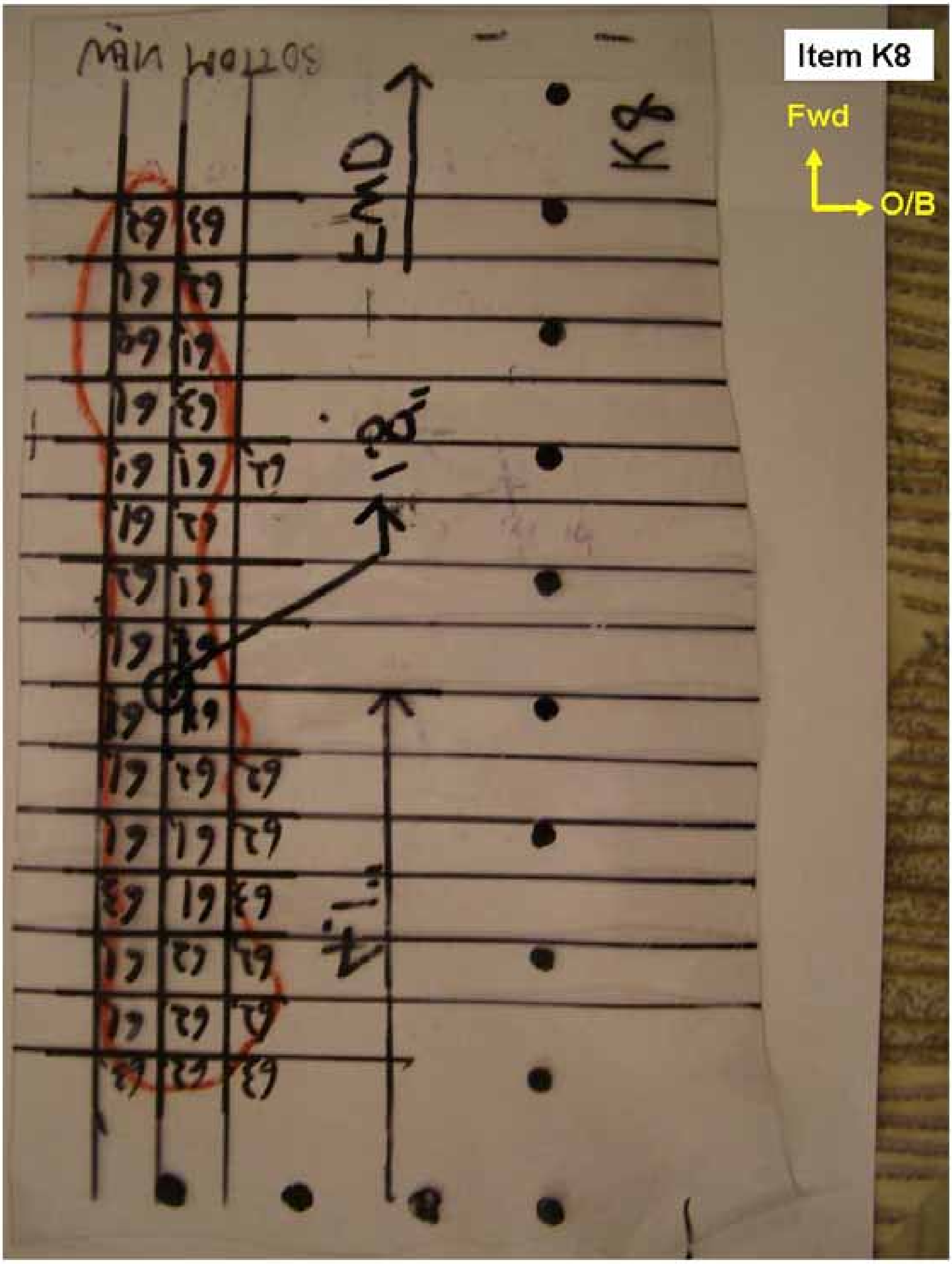

Item K6
Fwd
O/B
0.800"
18"
K6
K6

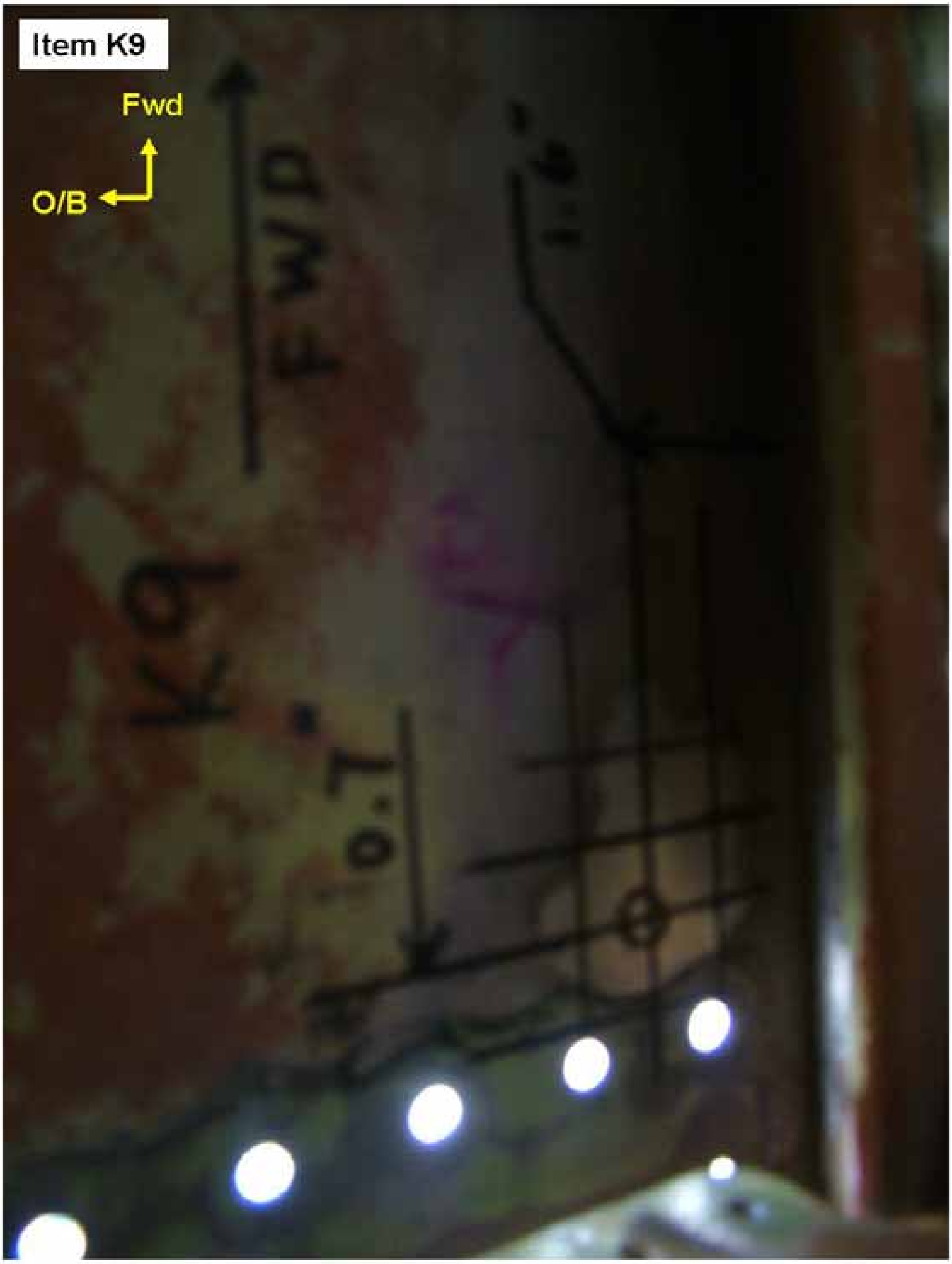

Item K6
Fwd
O/B

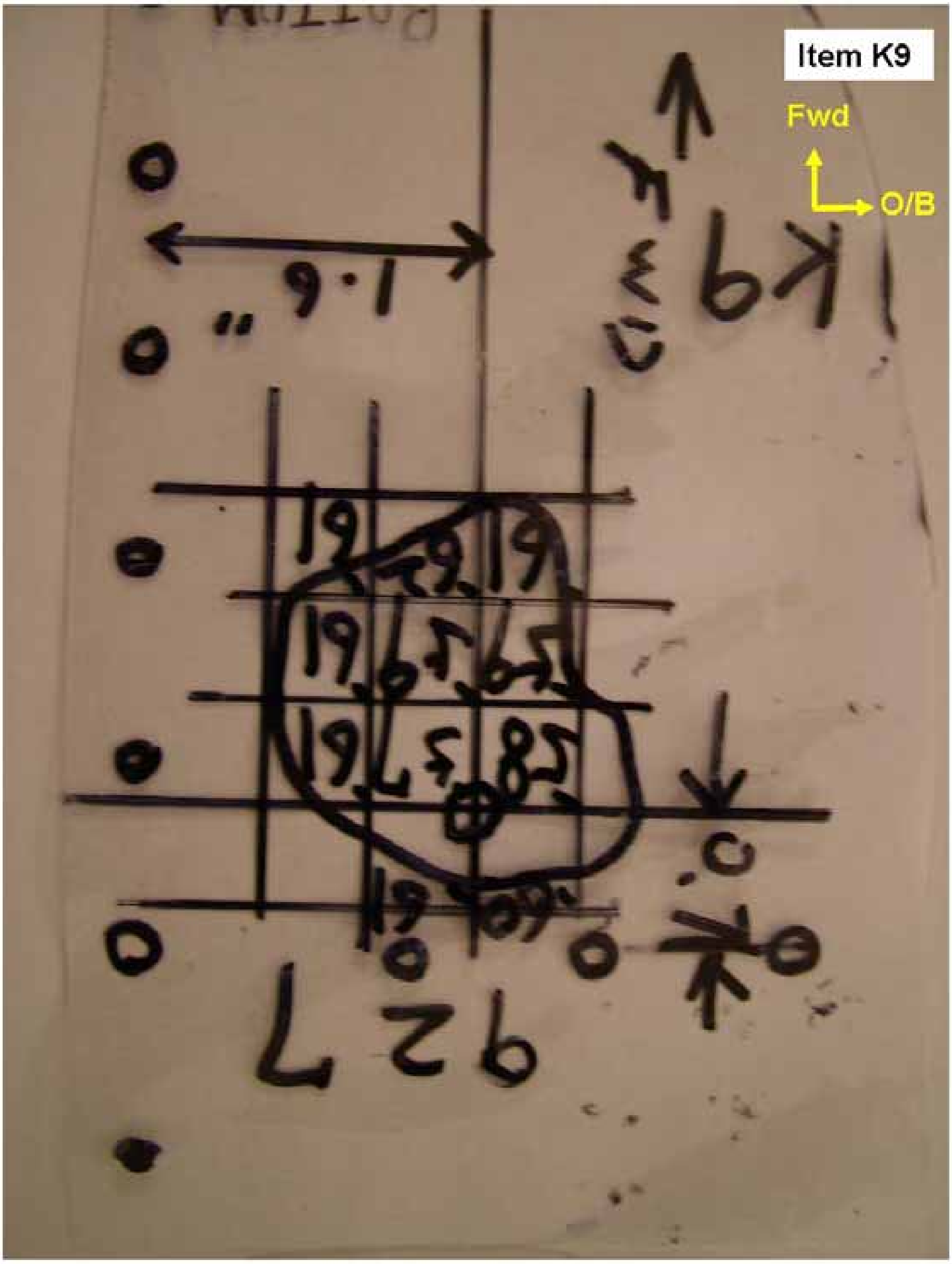

Item K7
Fwd
O/B
FWD
14.6
1.8"


Item K7
Fwd
O/B
FWD
O/B
K7
TOP VIEW


Item K8
Fwd
O/B
K8
FWD
1.8"
4.1"


Item K8
Fwd
O/B


Item K9
Fwd
O/B


Item K9
Fwd
O/B

STRINGER / CHORD

ITEM NO.	LOCATION		DIMENSION (INCHES)	
	BETWEEN STA	STRINGER / CHORD	FWD-AFT DIRECTION	I/B-O/B DIRECTION
G1	727I- 727J	S-27L	19	1.2
G2	727J - 747	S-27L	20	1.2
G3	747 - 767	S-27L	20	1.2
G4	767 - 787	S-27L	16	0.8
G5	767 - 787	S-27L	19	0.9
G6	787 - 807	S-27L	20	0.8
G7	787 - 807	S-27L	20	0.9
G8	807 - 827	S-27L	20	1.1
G9	807 - 827	S-27L	5	0.8
G10	827 - 847	S-27L	6	1.1
G11	867 - 887	S-27L	6	1.1
G12	887 - 907	S-27L	6	1
G13	907 - 927	S-27L	10	0.9
G14	927 - 947	S-27L	20	0.9
G15	947 - 967	S-27L	20	0.9

SHEAR TIE

ITEM NO.	LOCATION	
	STA	BETWEEN STRINGER
H1	727I	S-26L~S-27L
H2	727J	S-26L~S-27L
H3	747	S-26L~S-27L
H4	767	S-26L~S-27L
H5	787	S-26L~S-27L
H6	807	S-26L~S-27L
H7	827	S-26L~S-27L
H8	847	S-26L~S-27L
H9	867	S-26L~S-27L
H10	927	S-26L~S-27L
H11	947	S-26L~S-27L
H12	967	S-26L~S-27L

ITEM NO.	LOCATION	
	BETWEEN STA	BETWEEN STRINGER
C1	867~887	S-26L~S-27L

APPENDIX 13：(B)CAL to Boeing correspondence e-mail information

Email Message related to SR #: 1-624827258

Account: China Airlines

Activity #: 1-AERPFO

Timestamp: 14-Apr-2009 10:56:34 PM

Owner: [redacted]

Status: Done

Message Number: 1-624827258-17

Type: Email - Outbound

Sub Type: Boeing Response

From: BOECOM CAS BOC

Field Base: BFSTPE-CHI-Taipei-Taiwan

To: [redacted]

Cc:

Bcc: [redacted]

Subject: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

Body:

FROM: THE BOEING COMPANY
TO: CHI [MESSAGE NUMBER:1-624827258-17] 24-Sep-2007 21:04:07 US PACIFIC TIME
Boeing Response

This message is sent to the following:

[redacted]

SERVICE REQUEST ID: 1-624827258
PRIORITY: AOG
ACCOUNT: China Airlines (CHI)
DUE DATE: 24-Sep-2007
PROJECT: BFSTPE-CHI-Taipei-Taiwan
PRODUCT TYPE: Airplane
PRODUCT LINE: 737
PRODUCT: 737-800
ATA: 5361-10
PART NUMBER:

AIRPLANE (VARIABLE/SERIAL): YC589/30636 REGISTRY: B-16805
HOURS/CYCLES:15,890/6,385

SUBJECT: * Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

REFERENCES:
/A/ 1-624827258-16 CHI incoming dated 24-Sept-2007
/B/ 1-624827258-15 TBC response dated 24-Sept-2007

DESCRIPTION:
Ref /A/ reports receiving the ref /F/ Boeing response requesting that CHI perform a close visual inspection in aircraft belly to ensure no other corrosion pockets exist. CHI would like Boeing to provide some additional clarification on how far forward and aft they should be looking for corrosion. If Boeing could provide stringer locations or a distance beyond the end of corrosion found (i.e. 12 inches past the last corrosion location) it would be helpful. CHI specifically inquired if inspections in the aft cargo area was required.

CHI has also inquired if Boeing would be willing to provide a NTO for a one-time non-pressurized ferry flight with the airplane in the current condition.

DESIRED ACTION
==============
1. Can Boeing provide an NTO for CHI to perform an unpressurized ferry flight from HSG to TPE with the

airplane in the current condition?

2. Can Boeing please provide some more definition regarding the inspection range for the corrosion. Please provide a stringer and body STA range or other parameters that would help CHI quantify the inspection area.

3. If removal of the stringer from the skin is required, does Boeing recommend that a cradle be installed? If yes, please specify locations for the cradle to be installed.

4. CHI is hoping Boeing can provide a plan that will provide the simplest and most efficient means of performing and required inspections and returning the airplane to TPE as soon as possible.

RESPONSE:
We have reviewed the Ref /A/ and offer the following repsonse to Items 1 through 4 above:

1) Boeing cannot provide approval to allow an unpressurized ferry flight without complete quantification of material lost and damage removal.

2) Visually inspect the corroded region and find where the corrosion ends. Then visually inspect an additional frame bay fore/aft and one stringer inbd/outbd. Also, report damage details of the intercostal refererenced in Ref /B/ to Boeing.

3) Cradling is not required. As an alternate to removing stringer see Item 4 below.

4) As a means of quantifying material lost and corrosion removal do the following:

-Clean up all debris inside the stringer and on the skin.
-Look for pillowing along stringer fastener row to identify corrosion areas under stringer.
-As an alternate to removing stringer CHI may confirm corrosion removal by removing a representative amout of fasteners along stringer and borescoping the holes to confirm there is no corrosion between skin and stringer.
-HFEC or UT along the skin side under the stringer AND inside the stringer to determine thickness along the fastener row. Compare to the dwg thicknesses to confirm no corrosion.
-Remove corrosion, as reqd. Report all blendouts to Boeing that exceed 10 percent of material thickness.
-Report any corrosion found that is inaccessible.

[redacted]
Fleet Support Engineering - Structures

[redacted]
Operations Center

Commercial Aviation Services
The Boeing Company

Email Message related to SR #: 1-624827258

Account: China Airlines

Activity #: 1-AHPXBZ

Timestamp: 14-Apr-2009 11:00:09 PM

Owner: [redacted]

Status: Done

Message Number: 1-624827258-26

Type: Email - Inbound

Sub Type:

From: [redacted]

Field Base:

To: [redacted]

Cc: [redacted]

Bcc:

Subject: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

Body:

Dear Boeing engineer,

This is a follow-up message of service request ID 1-624827258.
The priority is AOG.
Please kindly provide response on or before Sep-29-2007 14:00 Seattle Time.
Thank you very much.

REFERENCES:
/A/ Attachment: External Angle Repair Sketch and Intercostal Repair
/B/ 1-624827258-14
/C/ P/N 146A9403-142
/D/ Attachment: 20070928 Preliminary Damage Report

DESCRIPTION:

(I) CHI accomplished the ultrasonic inspection of skin from external side, and found there is no skin material lost under the stringer due to corrosion.

(II) Please refer to ref /D/ attachment for the skin remaining thickness after blend out. No visible corrosion after blend out. We propose to leave the skin as is.

(III) Please see ref /A/ attachment for the repaired ref /C/ intercostal. The corrosion has been blended out and the Repair Angle has been installed. Material: 7075-T6. Repair Angle Dimension: 13" x 2.5" x 0.050"(Thickness).

(IV) Because the material of the outboard flange of the stringer 27L between station BS 727I+3" and BS 820, and the flange attached to the skin between BS 812 and 904 is beyond repair due to corrosion damage, we are proposing to install repair angles on the exterior surface of the skin. See ref /A/ attachment and steps (1) to (5) below.

(1) Keep the existing stringer 27L as is.

(2) Prepare 1 EA External Repair Angle under the Stringer outboard flange from BS727I+3" to BS820. Thickness: 0.160". Material: 7075-T6.

(3) Prepare 1 EA External Repair Angle under the Stringer from BS812 to BS904. Thickness: 0.080". Material: 7075-T6.

(4) Install the above two External Angles by installing BACR15BB6D Rivets at existing stringer fastener holes. Install tapered filler at the step of the external doubler. Splice the 2EA External Angles by installing 6 EA BACR15BB6D Rivets. Refer to 737-800 SRM 51-40-02 for fastener installation.

(5) Apply alodine and one layer of BMS10-11 primer on all bare aluminum surfaces. Refer to 737-800 SRM 51-20-01.

(V) For the corroded shear ties that we reported before, we will reinstall 4 EA shear ties because only minor surface corrosion was found on those and corrosion has been blended out. The other 6 EA shear ties will be fabricated locally as replacements.

DESIRED ACTION:

(a) Please provide NTO on or before Sep-29-2007 14:00 Seattle Time if the proposed repair plan stated above is acceptable as a temporary repair to ferry flight the airplane back to Taiwan.

(b) If NTO is acceptable by boeing, please provide 8100-9 for the temporary repair by Sep-30-2007 17:00 Seattle Time.

best regards,

[redacted]
+886-932-941485 (cell at Japan)

Email Message related to SR #: 1-624827258

Account: China Airlines

Activity #: 1-AIN16B

Timestamp: 14-Apr-2009 11:31:42 PM

Owner: [redacted]

Status: Done

Message Number: 1-624827258-28

Type: Email - Inbound

Sub Type:

From: [redacted]

Field Base: BFSTPE-CHI-Taipei-Taiwan

To: [redacted]

Cc: [redacted]

Bcc:

Subject: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

Body:

Dear Boeing engineer,

This is a follow-up message of Service Request ID 1-624827258.
The priority is AOG.

CHI accomplished the repair without deviation.
On or before Sep-30-2007 23:00 Seattle Time, please kindly provide 8100-9 form for the temporary repair. (including the external repair doubler and external repair angles)

Note: CHI is not requesting the 8100-9 form for the ferry flight. CHI is requesting 8100-0 form for the temporary repair. CHI will request approval for ferry flight from both CAA and JCAB once we get the 8100-9 form for the temporary repair.

best regards,
[redacted]
+886-932-941485 (cell at Japan)

[redacted]

> FROM: THE BOEING COMPANY
> TO: CHI [MESSAGE NUMBER:1-624827258-27] 29-Sep-2007 18:25:14 US
> PACIFIC TIME
> Boeing Response
>
> This message is sent to the following:
>
> [redacted]
>
>
>
>
>
>
>
>
>
>
>
>
>
>
> SERVICE REQUEST ID: 1-624827258
> PRIORITY: AOG
> ACCOUNT: China Airlines (CHI)
> DUE DATE: 29-Sep-2007
> PROJECT: BFSTPE-CHI-Taipei-Taiwan
> PRODUCT TYPE: Airplane
> PRODUCT LINE: 737
> PRODUCT: 737-800
> ATA: 5361-10
> PART NUMBER:
>
> AIRPLANE (VARIABLE/SERIAL): YC589/30636 REGISTRY: B-16805
> HOURS/CYCLES:15,890/6,385
>
> SUBJECT: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of
> S-27L
>
> REFERENCES:
> /A/ 1-624827258-26

>
> DESCRIPTION:
> The Ref /A/ message documented inspection results completed to date and
> proposed a temporary repair to allow a one-time unpressurized ferry flight
> from from HSG to TPE.
>
> RESPONSE:
> Boeing has completed review of the Ref /A/ message and finds the proposed
> repair to be structurally acceptable with the following provisions:
>
> 1/ The repair angle from BS 812 to 904 is 0.160" thick.
>
> 2/ The repair angles are installed to the skin using BACB30MY6KX or Y hex
> drive bolts [or equivalent] in transition fit holes per BAC 5004-2.
>
> 3/ The repair angles are spliced between BS 812 and BS820 using BACB30MY6KX
> or Y hex drive bolts or their SRM equivalents installed in transition fit
> holes per BAC 5004-2.
>
> 4/ The remaining thickness of the stringer from BS 812 to 904 is 0.040
> inches minimum.
>
> 5/ The fasteners that install the repair angle from BS 727I + 3" to BS 820
> are also common to the outboard flange of S-27L.
>
> 6/ The repair angles extend past the damage by at least six fasteners.
>
> 7/ All the corrosion has been removed from the affected stringer.
>
> 8/ The skin common to the stringer is corrosion free, defect free and per
> the engineering drawing thickness.
>
> 9/ The shear ties that are being re-installed have a remaining thickness per
> the engineering drawing or are within the SRM allowable damage limits.
>
> The above repair approval assumes that there is no damage to underlying
> structure.
>
> Once the repair as noted above is accomplished without deviation, and based
> upon the information provided in the Ref /A/ message, we have no objection
> for the requested ferry flight from HSG to TPE under the following
> conditions:

>
> 1/ The requested ferry flight is to be accomplished unpressurized.
>
> 2/ Avoid known areas of turbulence and abrupt maneuvers, if possible.
>
> This evaluation for non-revenue ferry flight of the subject airplane was
> based upon the damage assessment stated in SR 1-624827258. Damage other than
> stated was not considered in the evaluation and Boeing cannot attest to the
> operational status of the subject airplane if any other damage, not reported,
> is present.
>
> The above detailed ferry flight has not been coordinated with the FAA, or any
> other regulatory agency. It is the responsibility of the operator to obtain
> any necessary permissions or permits from their local regulatory agency.
>
> NOTE: Per FAA guidance, Boeing AR delegated authority for FAA 8100-9 form
> signature in support of ferry flights does not extend to international
> carriers as they do not operate under CFR 21.197. Consequently, Boeing is
> no longer able to provide a FAA 8100-9 form granting ferry flight approval.
>
> If attachments are referred to, and are not present, please reply to this
> e-mail or contact your Boeing Field Service Representative.
>
>
> [redacted]
> Fleet Support Engineering - Structures
>
> [redacted]
> Operations Center
> Commercial Aviation Services
> The Boeing Company
>

Email Message related to SR #: 1-624827258

Account: China Airlines

Activity #: 1-AIN9JF

Timestamp: 14-Apr-2009 11:00:28 PM

Owner: [redacted]

Status: Done

Message Number: 1-624827258-29

Type: Email - Outbound

Sub Type: Boeing Response

From: [redacted]

Field Base: BFSTPE-CHI-Taipei-Taiwan

To: [redacted]

Cc:

Bcc: [redacted]

Subject: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

Body:

FROM: THE BOEING COMPANY
TO: CHI [MESSAGE NUMBER:1-624827258-29] 30-Sep-2007 17:25:43 US PACIFIC TIME
Boeing Response

This message is sent to the following:

[redacted]

[redacted]

SERVICE REQUEST ID: 1-624827258
PRIORITY: AOG
ACCOUNT: China Airlines (CHI)
DUE DATE: 01-Oct-2007
PROJECT: BFSTPE-CHI-Taipei-Taiwan
PRODUCT TYPE: Airplane
PRODUCT LINE: 737
PRODUCT: 737-800
ATA: 5361-10
PART NUMBER:

AIRPLANE (VARIABLE/SERIAL): YC589/30636 REGISTRY: B-16805
HOURS/CYCLES:15,890/6,385

SUBJECT: Fuselage skin damage from approx.STA839.5 to 868.5 at outboard of S-27L

REFERENCES:
/A/ 1-624827258-28 CHI incoming dated 30-Sept-2007
/B/ 1-624827258-27 TBC response dated 29-Wept-2007

DESCRIPTION:
Ref /A/ reported that CHI accomplished the repair without deviation.
On or before Sep-30-2007 23:00 Seattle Time, CHI requests that Boeing provide an 8100-9 form for the temporary repair (including the external repair doubler and external repair angles).

Note: CHI is not requesting the 8100-9 form for the ferry flight. CHI is requesting 8100 form for the temporary repair. CHI will request approval for ferry flight from both CAA and JCAB once they receive the 8100-9 form for the temporary repair.

RESPONSE:
We have reviewed the Ref /A/ request for 8100-9. The repair as accomplished per Ref /B/ is structurally acceptable for the ferry flight.

Please be advised we cannot provide an 8100-9 for this ferry flight.

[redacted]
Fleet Support Engineering - Structures

[redacted]
Operations Center
Commercial Aviation Services
The Boeing Company