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Fuel Contamination can still pose a Risk

Presented by
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Introduction

On 13 April 2010, the flight crew of an Airbus A330 aircraft from Juanda International Airport (WARR), Surabaya, Indonesia to Hong Kong International Airport (VHHH) declared "MAYDAY" when approaching VHHH. The aircraft experienced control problem on both engines. The aircraft landed at a groundspeed of 231 knots, with No.1 engine stuck at about 70% N1 and No.2 engine stuck at about 17% N1. Five main tyres were deflated after the aircraft came to a complete stop on the runway. After being advised by the rescue leader that there was fire and smoke on the wheels, the aircraft commander initiated an emergency evacuation of passengers. Some passengers and cabin crew were injured during the evacuation.

2. The Accident Investigation Division of HKCAD conducted an investigation into the accident in accordance with the Hong Kong Civil Aviation (Investigation of Accidents) Regulations and the Annex 13 to the Convention on International Civil Aviation. The investigation identified that the aircraft had uplifted 24,400kg of fuel at WARR. The fuel which was contaminated had initially caused stiction in the Fuel Metering Units (FMU) of both engines and eventually caused total seizure of those components, leading to the loss of thrust control of both engines during the aircraft's approach to VHHH. A series of events and contributing factors had in fact led to the uplift of such contaminated fuel to the aircraft.

3. With the collaborative efforts from all members, including experts from the aviation fuel industry, this rather complex investigation was successfully completed. The event has reminded us that fuel contamination remains a hazard that can pose serious risk in aviation. HKCAD is currently the President of the AsiaSASI and would like to share the valuable experiences gained from this investigation with the ISASI members.

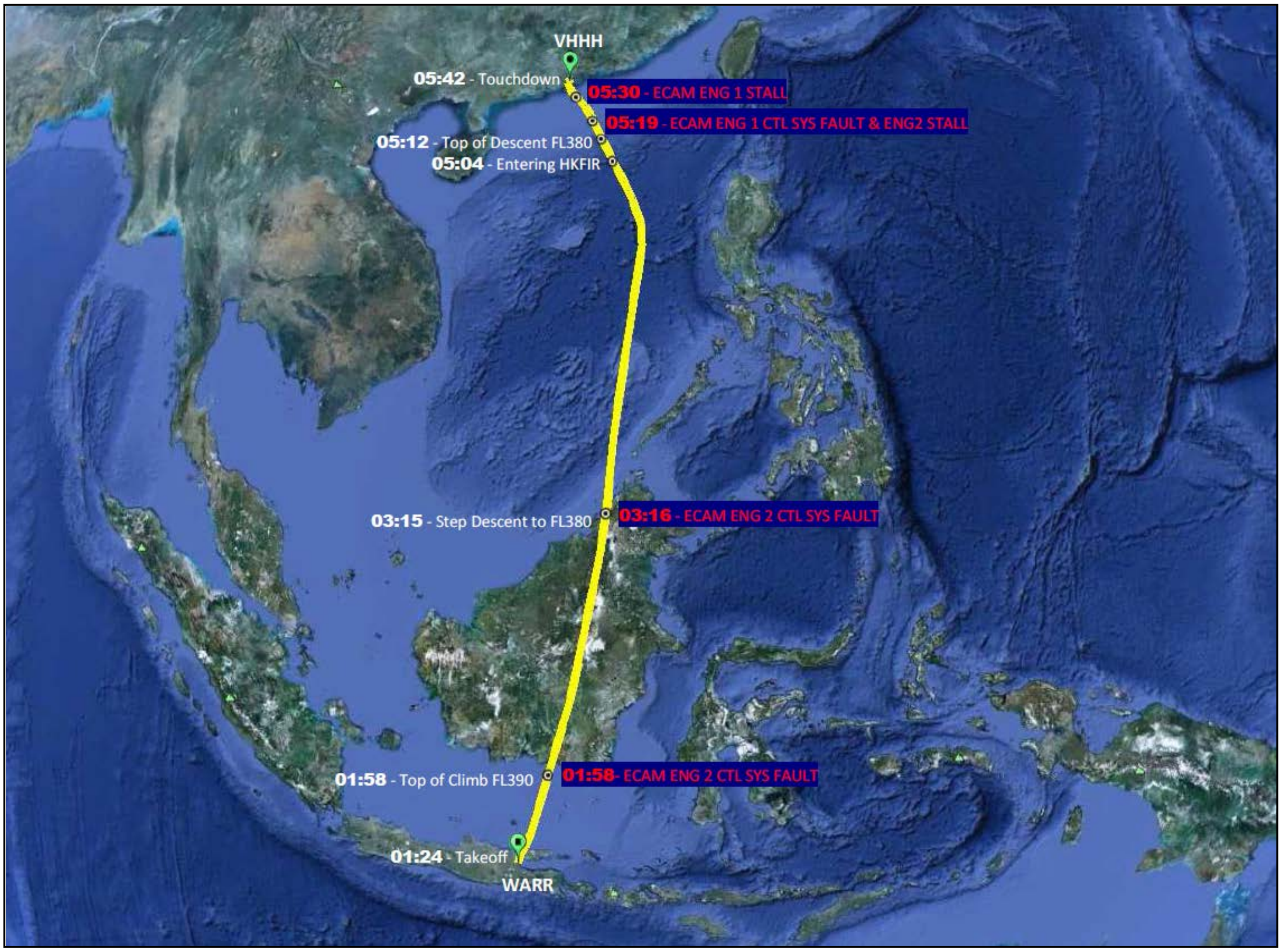

Figure 1 – Event Details of the flight from WARR to VHHH

The Contaminants

4. The contaminated fuel, which contained super absorbent polymer (SAP) spheres, caused the loss of thrust control on both engines of the aircraft. Laboratory analysis indicated that the SAP spheres contained elements that were consistent with the SAP material used in the filter monitors of the ground refuelling dispenser. Crystalline sodium chloride (i.e. salt) was also present on the surface of some SAP spheres. Most of the SAP spheres found had the size ranging from five to 30 µm with a majority in the order

of five to 15 µm. Further analysis showed that these SAP spheres contained elements of carbon, oxygen, sodium, chlorine, sulphur, and were mainly sodium polyacrylate, which is the SAP material used in a filter monitor of refuelling dispenser.

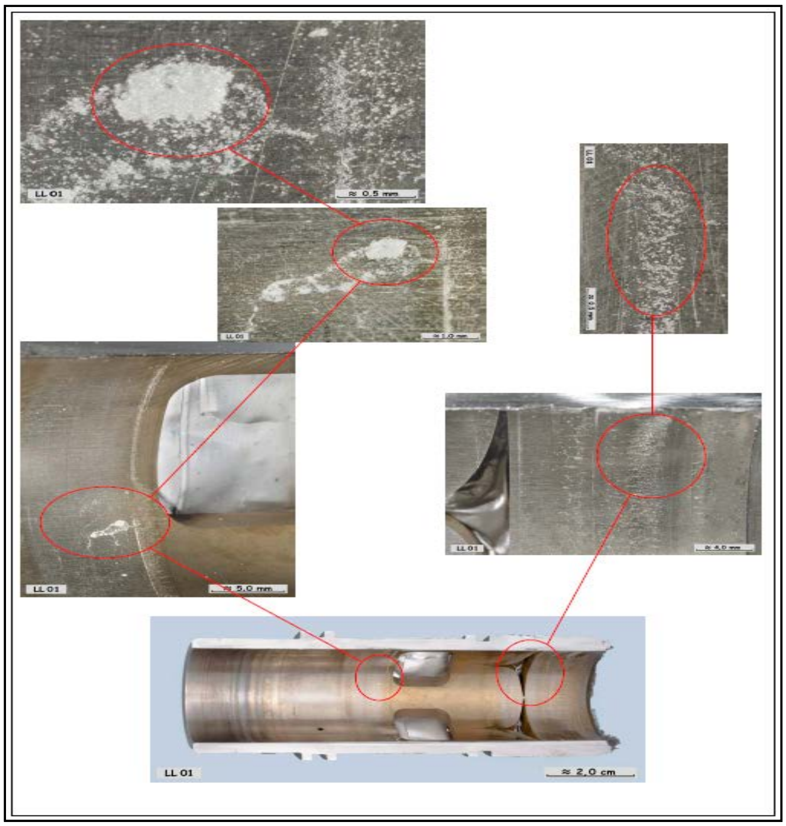

Figure 2 – The cutaway view of one of the main metering valve of the engine fuel component showing the presence of SAP spheres

5. While the exact mechanism of SAP spheres generation from the filter monitors during the refuelling could not be established, a mimicking test conducted at a laboratory during the investigation had generated SAP spheres. It demonstrated that the presence of salt water in the fuel and under an operating profile of low flow-rate refuelling, as practiced in WARR, could have generated SAP spheres.

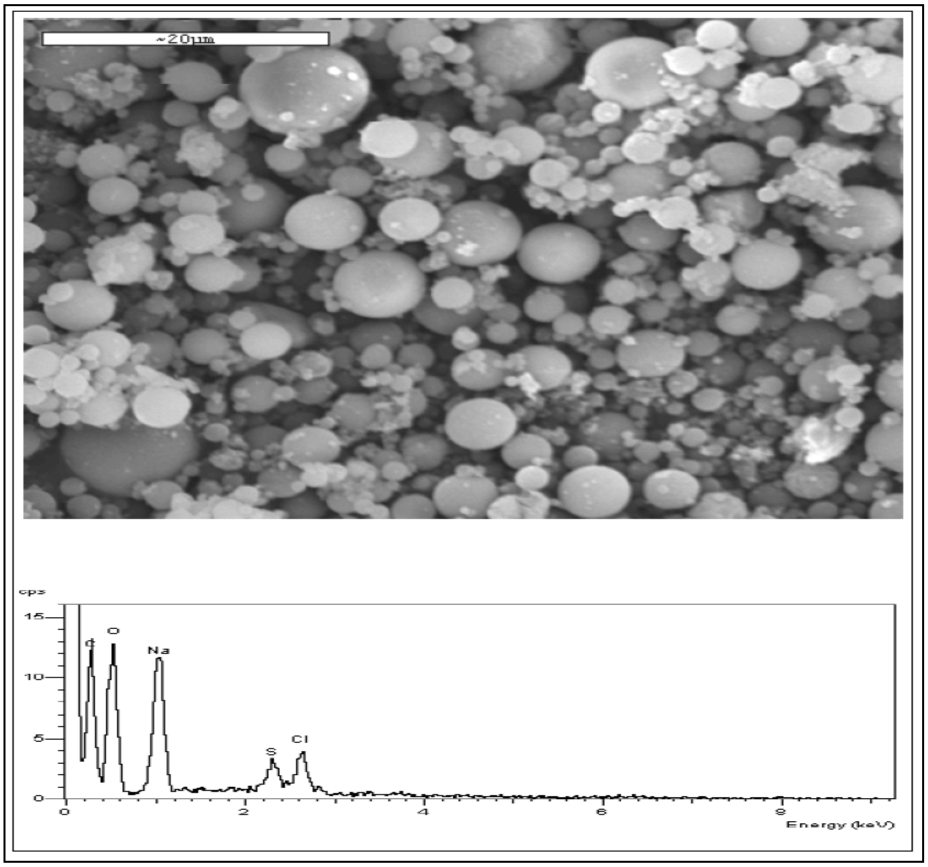

Figure 3 – Microscopic view of spheres and their composition under Scanning Electronic Microscope analysis.

A " Perfect Storm "

6. There were a series of events and contributing factors leading to penetration of all the safety layers and the formation of such a "perfect storm", i.e. the uplifting of contaminated fuel to the aircraft.

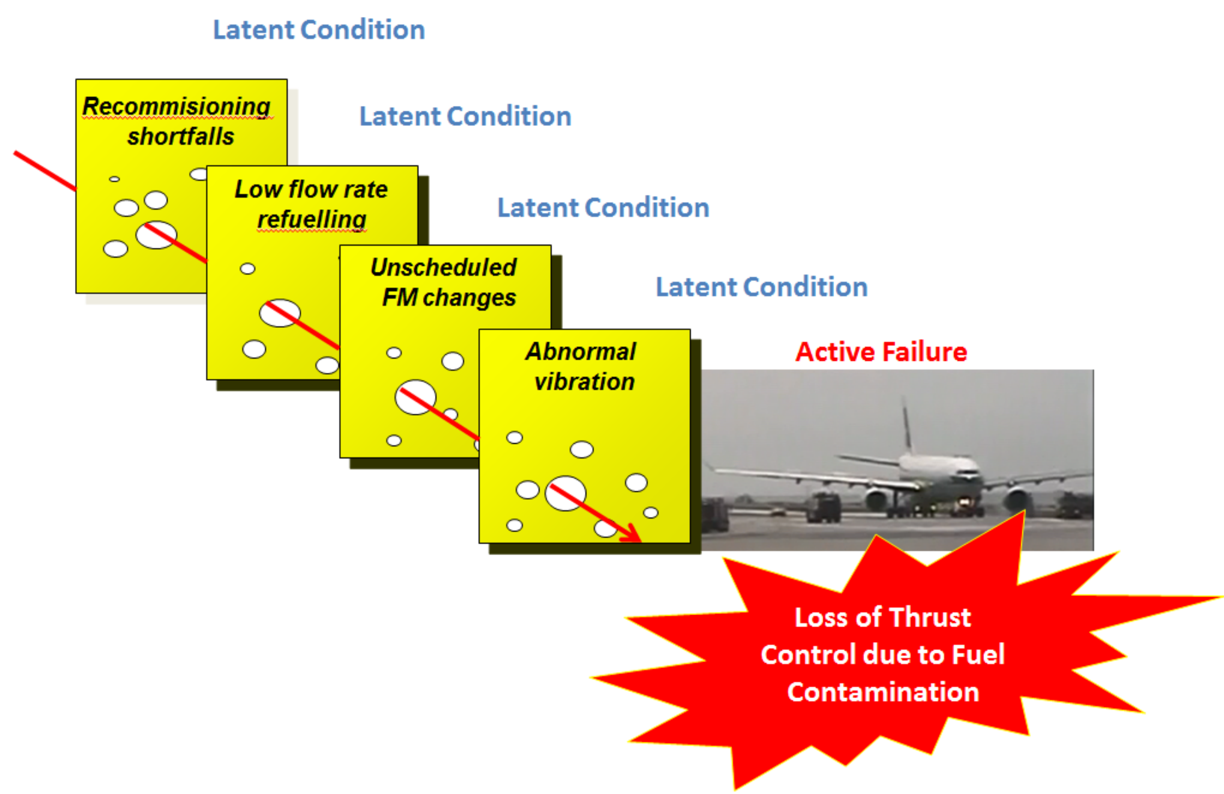

Figure 4 – The Swiss-*Cheese Model in Safety Management System*

7. WARR had an apron extension project started in year 2009 which involved an extension work of the hydrant refuelling circuit that supplied fuel to Stand No. 8 where the accident aircraft was parked and refuelled before departure. Fuel sample collected from the reworked hydrant after the accident contained salt. WARR is located close to the seashore and has three regulating ponds. The water of the regulating pond closest to the apron extension work site was found to contain salt. The tie-in process of the extended hydrant refuelling circuit required the open cutting of the existing underground piping. Records showed that during the tie-in processing period, there were heavy rainfalls and there were water puddles at the work site. It was likely that the water puddles at the work site contained salt. It was likely that the required tie-in procedures had not been strictly followed and salt water might have therefore entered the hydrant refuelling circuit during

the hydrant extension work.

Figure 5 – A photo taken during the tie-in process

8. The fuel industry has a set of robust requirements and procedures regarding aviation fuel supply, including the re-commissioning procedures required on any hydrant system. The re-commissioning process of the reworked hydrant refuelling circuit involved flushing the affected circuit. The flushing procedures after the hydrant rework had not adequately addressed all the essential elements stated in the Energy Institute (EI) 1585 document, which is a set of guidelines accepted as an international practice in cleaning of aviation fuel hydrant systems in airports. In this connection, it was likely that the flushing did not completely remove the salt water in the hydrant refuelling circuit.

9. In addition, the investigation noted that the re-commissioning process of the reworked hydrant circuit was not properly coordinated by the parties concerned and hence leading to the operation of the reworked hydrant system prematurely resumed while the hydrant system still contained salt.

10. After the pre-mature resumption of the hydrant operation, there were several unscheduled filter monitor replacements for the refuelling dispensers at WARR. These events indicated the possible fuel contamination in the hydrant system as the filter monitors had been activated by salt waters. However, such abnormal events were not investigated by the fuel supplier and hydrant operator. In addition, it was noted that the refuelling operation in WARR, in particular the low flow-rate refuelling, the dispenser differential pressure (DP) recording and monitoring, did not fully comply with the international fuel industry latest guidelines.

Figure 6 – A typical filter monitor

11. The filter monitors of the dispenser used for refuelling the accident aircraft had in fact been activated by salt water. The SAP media in the filter monitors of the

dispenser when reacted with water containing salt turned into gel state and caused an increase in DP indication and vibration of the refuelling hose during the refuelling of the accident aircraft. However the unusual vibration observed was not immediately stopped and properly investigated. The continued refuelling had eventually led to the uplift of fuel contaminated with SAP spheres to the aircraft!

Lessons Learnt

12. The aviation industry and community have been promoting the safety management system (SMS), which is a system to assure the safe operation of aircraft through effective management of safety risk. The quality of aviation fuel is no doubt paramount to the safe operation of aircraft. Any risk related to fuel contamination occurrence, albeit very remote, could lead to very serious consequence.

13. The fuel industry has stringent specification, requirement and guidance material to ensure the quality of aviation fuel supplied to aircraft. The fuel industry follows the published specification, requirement, and guidance to establish operating procedures and performs audits to ensure compliance. While aircraft operators would develop audit program based on their operational experiences, they still had to rely on the fuel suppliers at airports to provide quality fuel to aircraft. Nevertheless, there was no overarching international civil aviation requirement on the control of aviation fuel quality, and the training of personnel who carry out fuel supply or those responsible for the oversight of fuel quality at airports. The manual monitoring of DP changes in a fuelling dispenser during refuelling is also considered not effective.

14. In this connection, apart from making recommendations to the relevant parties in WARR to ensure that the re-commissioning procedures of the hydrant system are

properly completed before resuming the hydrant refuel operation at the affected parking stands, the investigation team has also recommended ICAO to establish civil aviation requirements for oversight and quality control on aviation fuel supply at airports and to specify the requirement of installing a device in the equipment used in refuelling aircraft. This device should be able to automatically alert the equipment operator and stop the refuelling process when the DP across the equipment filtration system is outside the equipment designed value or range.

15. Under the leadership of ICAO and with the collaborative efforts of many parties, particularly the IATA Technical Fuel Group, the Manual on Civil Aviation Jet Fuel Supply was published. The document acts as a "signpost" document to the relevant industry practices, covering all matters related to aviation fuel quality control, operations and training across the entire supply and distribution system, from refinery to aircraft.

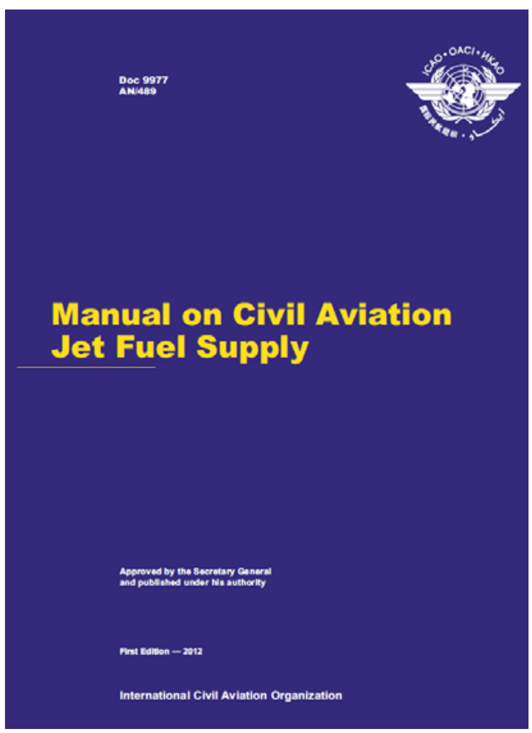

Figure 7 - ICAO Doc 9977

16. While the investigation has been completed, the fruitful investigation process has reminded us of the noble objective of accident investigation, i.e. the prevention of accident and incidents. Although the subject aircraft had landed safely on ground with the earnest efforts of the professional crew, members of the aviation community shall not forget the important lesson learnt. It also reminds us that whenever there is a change of circumstances, such as the re-commissioning of the reworked hydrant system in this case, all parties involved should be more vigilant in making a more robust assessment and audit.

17. Hopefully, the aviation community can make the best use of the ICAO document and all the useful information to further enhance safety by mitigating, if not eliminating, the risk of fuel contamination by stopping the penetration of the layers of protection.

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