Chief Inspector of Accidents
Accident Investigation Division
Civil Aviation Department
46th Floor
Queensway Government Offices
66 Queensway
Hong Kong

Accident Bulletin 1/2011

(An update Bulletin to Accident Bulletins 1/2010 and 3/2010)

Aircraft type:	Airbus A330-342
Registration:	B-HLL
Year of manufacture:	1998
Number and type of engines:	2 Rolls-Royce Trent 700 turbofans
Date and time of accident:	13 April 2010 at 1343 hours local time (0543 UTC)
Place of accident:	Hong Kong International Airport (VHHH)
Nature of Accident:	CPA 780 declared a Mayday when approaching VHHH with control problem on both engines. The aircraft landed on runway 07L at a groundspeed of 230 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 confirming from the rescue leader that there was fire and smoke on the wheels, the commander initiated an emergency evacuation of passengers.
Type of flight:	Scheduled Public Transport
Persons on board:	Crew : 13 Passenger : 309
Fatalities:	Nil
Serious Injuries:	Crew : Nil Passenger : One
Commander's licence:	Hong Kong Airline Transport Pilot's Licence (Aeroplanes)
Commander's age:	35
Commander's experience:	7,756 hours (of which 2,601 were on type)
Other crew	Flight Deck : One Co-pilot Cabin : 11 Cabin Crew
Source of information:	Inspector's Investigation

Update on Investigation of
Aircraft Accident on CPA 780 on 13 April 2010
(Airbus A330-342 Registration Mark B-HLL)

(All times are in UTC. Surabaya time is UTC+7 hours and Hong Kong time is UTC+8 hours)

The Hong Kong Civil Aviation Department (CAD) issued the Accident Bulletins 1/2010 and 3/2010 on 6 May 2010 and 11 August 2010 respectively regarding the investigation of the loss of thrust control encountered by CPA780 on 13 April 2010. This Update Bulletin provides further available information as the investigation progresses.

ECAM Messages Experienced During Flight

2. As previously reported, at 0158 hr, the aircraft was levelling off at Flight Level (FL) 390, the Electronic Centralised Aircraft Monitoring (ECAM) caution message "ENG 2 CTL SYS FAULT" was annunciated. The associated ECAM information "ENG 2 SLOW RESPONSE" was also shown for crew awareness. The analysis of the Flight Data Recorder (FDR) and Quick Access Recorder (QAR) data, Post Flight Report (PFR) and Aircraft Condition Monitoring System (ACMS) reports indicated that the ECAM message was associated with a higher than normal current demand to control the Main Metering Valve (MMV) in the No. 2 engine Fuel Metering Unit (FMU).

3. At 0316 hr, the ECAM caution message "ENG 2 CTL SYS FAULT" reappeared when the aircraft was levelling off at FL380. The associated ECAM information "AVOID RAPID THR CHANGES" was shown for crew awareness. On this occasion the ECAM message was associated with a higher than normal current demand in the Variable Stator Vane Controller (VSVC) controlling the airflow through the No. 2 engine compressor.

4. At 0519 hr, during the descent to FL230 for arrival to VHHH, the ECAM caution message "ENG 1 CTL SYS FAULT" was annunciated. This message was also associated with a higher than normal current demand to control the MMV but in this instance on the No. 1 engine FMU. An ECAM caution message "ENG 2 STALL" followed within a short period of time, indicating a surge within the No.2 engine. The commander moved the No. 2 thrust lever to idle position and advanced the No. 1 thrust lever to Maximum Continuous Thrust (MCT) position in accordance with the Airbus procedures.

5. At 0530 hr, the ECAM caution message "ENG 1 STALL" was annunciated. The commander moved the No. 1 thrust lever to idle position. He then tested the engines by gently advancing and retarding the thrust levers. However, only No. 1 engine responded

with stepped increase in N1 and did not reduce when the thrust lever was retarded. No. 2 engine remained at idle during the test. In an attempt to recover No. 2 engine control, the crew carried out a shutdown and restart on No. 2 engine in accordance with the Flight Crew Operating Manual (FCOM) procedures. However, the engine could only operate at sub-idle condition for the remainder of the flight. The No. 1 engine was stuck at approximately 74% N1 during the approach and reduced to about 70% N1 at touchdown. The No. 2 engine remained stuck at about 17% N1 throughout the approach and landing.

6. Taking into account the circumstances of the occurrence, Airbus continues to review the operational implications of this event to establish what additional information can be provided to flight crews.

Probable Cause of the Abnormal Engine Performances

7. All the FDR data, QAR data, the PFR and the ACMS reports were reviewed and analysed. There was no evidence of unusual command signal from the Electronic Engine Control (EEC), the manual thrust, and the auto thrust systems. The engine fuel system components were subject to detailed examination. This revealed that the MMV in the FMU of both engines were seized at positions consistent with the corresponding final engine power. The VSVC from No. 2 engine was also found seized. These seizures were caused by contaminant in the form of fine spherical particles (spheres), evidence of which was found throughout the engine fuel system and in fuel samples from the aircraft tanks. The abnormal engines performance during the flight was believed to have been caused by stiction and eventual seizure of the MMV.

The Contaminant

8. The spheres that seized the MMV of the FMU of both engines were in the order of 5 to 20 microns in size (see Figure 1). In other areas of the fuel system, spheres of 30 microns in size were also identified. Analysis showed that the spheres contained carbon, oxygen, sodium, chlorine, and sulphur (see Figure 2) and were mainly sodium polyacrylate, which was consistent with the super absorbent polymer (SAP) material used in the filter monitors on a fuelling dispenser. Further analysis revealed the presence of crystalline sodium chloride on the surface of some spheres (see Figure 3). [Note: Filter monitor removes small amount of particulate matter and dispersed free water from aviation fuel. On contact with water, the SAP absorbs the water and turns into gel that swells to fill the monitor, and in extreme situations, the gelling process may shut off the flow across the monitor completely.]

9. Such spheres were also present in the hose end strainer of the dispenser JUA06 used for refuelling the accident flight at Surabaya Juanda International Airport (WARR). Examination and analysis indicated that the spheres could not have been generated within the aircraft. Such contamination was believed to be related to the fuel uplifted at Stand No. 8 through dispenser JUA06. The investigation so far is not able to establish how the spheres were exactly created and how they could enter into the aircraft.

Hydrant Re-commissioning at WARR

10. The accident aircraft had uplifted 24,400 kg of fuel at WARR by using hydrant refuelling from Stand No. 8, which was part of the hydrant refuelling circuit serving Stands No. 1 to 10. Prior to the occurrence, there had been extension work performed to the hydrant refuelling circuit as part of the WARR apron extension project for Stands No. 1 to 4 undertaken by the Juanda Surabaya Development Task Force. Investigation revealed that the re-commissioning procedures of the hydrant extension work were not in line with the guidelines and practices commonly used by the aviation fuel industry, and the hydrant refuelling system for Stands No. 5 to 10 was used for refuelling before the completion of the re-commissioning procedures.

11. The re-commissioning process did not comply with the essential factors stipulated in the publication "EI 1585 2nd edition Nov 2007 - Guidance in the Cleaning of Aviation Fuel Hydrant Systems at Airports" which include but not limited to:

- Soaking of affected pipelines before flushing;
- Velocity of fuel flow inside the pipelines during flushing;
- Capacity of affected pipelines to calculate the flushing quantity;
- Monitoring of the clean-up efficiency;
- Assessment on completion of work before resuming the hydrant refuelling operation.

12. The dispensers' utilisation and maintenance records at WARR were reviewed. It was noticed that from 10 to 15 April 2010, four dispensers had unscheduled filter monitors replacement due to high differential pressure readings of the monitor vessel, which is an indication of clogging of the filter monitors. Various tests and examinations were also performed on the filter monitors removed from dispenser JUA06 after the occurrence. The test results indicated that these filter monitors had absorbed a significant amount of water.

13. Further tests were performed on the fuel sample collected from the hydrant refuelling circuit for Stands No. 5 to 10 after its isolation from refuelling operation. The

tests showed the presence of sodium chloride and water in this sample. However, the source of such contamination could not be determined.

14. Regarding the two safety recommendations made in Accident Bulletin 3/2010 issued on 11 August 2010, the National Transportation Safety Committee of Indonesia (NTSC) has informed the CAD that the Juanda Surabaya Development Task Force had, with advice from an independent fuel expert, established a revised re-commissioning procedure which would be implemented when all necessary equipment and resources are ready. At the time of writing this Bulletin, the affected hydrant refuelling circuit is still being isolated from operation, pending for the implementation of the revised re-commissioning procedures.

Refuelling Operations at WARR

15. At WARR, into-plane refuelling services for domestic and international carriers are provided by PT Pertamina (Pertamina). Pertamina is also responsible for the maintenance of mobile equipment and certain refuelling facilities, excluding the hydrant refuelling circuit. Pertamina adopted the Joint Inspection Group (JIG) guidelines on aviation fuel quality control and operating procedures which are widely followed by aviation fuel operators. However, the following non-conformances were identified in accordance with JIG 1 "Guidelines for Aviation Fuel Quality Control & Operating Procedures for Joint Into-Plane Fuelling Services" Issue 10:

- The dispensers were mostly operated at flow rates well below the capacity defined by the dispenser manufacturer. Such low flow rate operation could reduce the effectiveness of the differential pressure monitoring (See Figure 4), which a high differential pressure would indicate clogging of the filter monitors in the dispenser, and therefore possible contamination of the fuel.

- The recording and monitoring of the weekly differential pressure of the dispensers was not performed properly. The differential pressure reading, which was taken under low flow rates during refuelling operation, may not have correctly indicated the condition of the filter monitors.

- During refuelling of the accident aircraft, the refuelling personnel noticed an event of refuelling hoses vibration and a higher than usual differential pressure on the dispenser. Although these were indications of possible clogging of the filter monitors, the refuelling personnel did not suspend the refuelling and investigate the unusual event.

16. After being advised of the occurrence and the probable ground fuel contamination at WARR, Pertamina had initiated a number of remedial actions including enhancing the monitoring of the dispenser differential pressure, and arranged an independent review by an aviation fuel expert on WARR's aviation fuel supply system and operation. At the time of writing this Bulletin, the NTSC has informed the CAD that Pertamina has taken additional measures to monitor the delivery of aviation fuel into aircraft at WARR, and developed an action plan for enhancement.

Collapsed Filter Monitor

17. It was noticed that one of the forty filter monitors (Model FG-230-4) was found collapsed when it was being removed from dispenser JUA06 for the investigation. Subsequent tests showed that the collapsed FG-230-4 did not allow flow across the monitor when installed in a test rig. Further test on similar FG-230-4 demonstrated that they could be collapsed in a bulk water "slug" test and a collapsed monitor could lose their structural rigidity and shorten in length by up to 20 mm (See Figure 5a and 5b). A study of the installation of FG-230-4 inside the filter vessel of the dispenser indicated that a collapsed FG-230-4 could be dislodged inside the vessel when there is sufficient back pressure, which could result in fuel bypassing the filtration system. Nevertheless, occurrence of filter bypass in previous refuelling could not be established.

18. The FG-230-4 support core is metallic and should withstand a differential pressure of 12 bars to meet the specification defined in document EI 1583 "Laboratory tests and minimum performance levels for aviation fuel filter monitors" 4th Edition. The manufacturer of this filter monitor, Facet International (Facet), indicated that their FG-230-4 passed annual quality testing which include the collapse pressure test. However, Facet conducted additional tests after this occurrence on FG-230-4 from the stock of various lots and the results showed a collapse pressure of 11 to 11.5 bar range which would fall below the 12 bar requirement. In a typical operating conditions, the refuelling system will seldom reach 11 bar pressure and a 12 bar requirement is in place to include a considerable margin above typical operation. At the time of writing this Bulletin, Facet was redesigning the FG-230-4 to provide additional strength.

Other Flights Received Fuel from Surabaya

19. On 12 April 2010, i.e. one day before the accident, the same scheduled flight CPA780 operated with an A330 aircraft powered by Trent 700 engines, registration B-HLM, received fuel from WARR by dispenser JUA06 at Stand No. 8 before departure, and reported No. 1 engine parameters fluctuation during the flight. There was no associated ECAM

message or any engine control problem. The No. 1 engine FMU was replaced as a result of the subsequent trouble shooting on ground. In light of this accident on 13 April, the investigation was extended to examine the B-HLM No. 1 engine, its associated fuel system and fuel components. Examination revealed the presence of spheres in the FMU and the low pressure fuel filter of B-HLM No. 1 engine. These spheres were similar to those found in the accident aircraft B-HLL.

20. The CAD further reviewed the records of refuelling activities in WARR and enquired any abnormal engine performance experienced by those operators that had uplifted fuel from Stands No. 5 to 10 at WARR hydrant refuelling circuit from 11 to 19 April 2010. There was so far no other report of unusual engine performance or parameter fluctuation on flights which received fuel from WARR.

Oversight and Quality Control of Aviation Fuel at Airports

21. The fuel industry has established various specifications and guidelines for aviation fuel supply and quality control at airports. Although air operators are required to have a quality system to ensure the quality of fuel uplifted to aircraft, they however have to depend largely on aviation fuel suppliers at airports to provide quality fuel to aircraft. The oversight on quality control of aviation fuel and operations at airports is very much based on self-regulation of the aviation fuel supply industry and the airport operators. There are no international civil aviation requirements for oversight and quality control of aviation fuel supply, including refuel operations procedures and associated training requirements for the relevant personnel at airports.

Recommendation

22. While the investigation is on-going and without prejudicing its final conclusions, the investigation team issues the following recommendation:

> ***Recommendation 2011-1***
>
> *International Civil Aviation Organization to establish requirements for oversight and quality control on aviation fuel supply at airports. Such requirements should also cover the refuel operational procedures and associated training for relevant personnel.*

23. The CAD, in conjunction with the Air Accident Investigation Branch of United Kingdom (AAIB), the Bureau d’Enquêtes et d’Analyses pour la sécurité de l’aviation civile of France (BEA), the National Transportation Safety Committee of Indonesia (NTSC), and the National Transportation Safety Board of the United States of America (NTSB), continues to investigate into the circumstances of the accident with the support from Airbus, Rolls-Royce and Cathay Pacific Airways. During the course of the investigation, should safety recommendation be necessary, it will be promulgated immediately.

Issued on 20 January 2011

This update contains facts and information relating to the investigation up to the time of issue. The information is subject to alternation or correction if additional evidence becomes available.

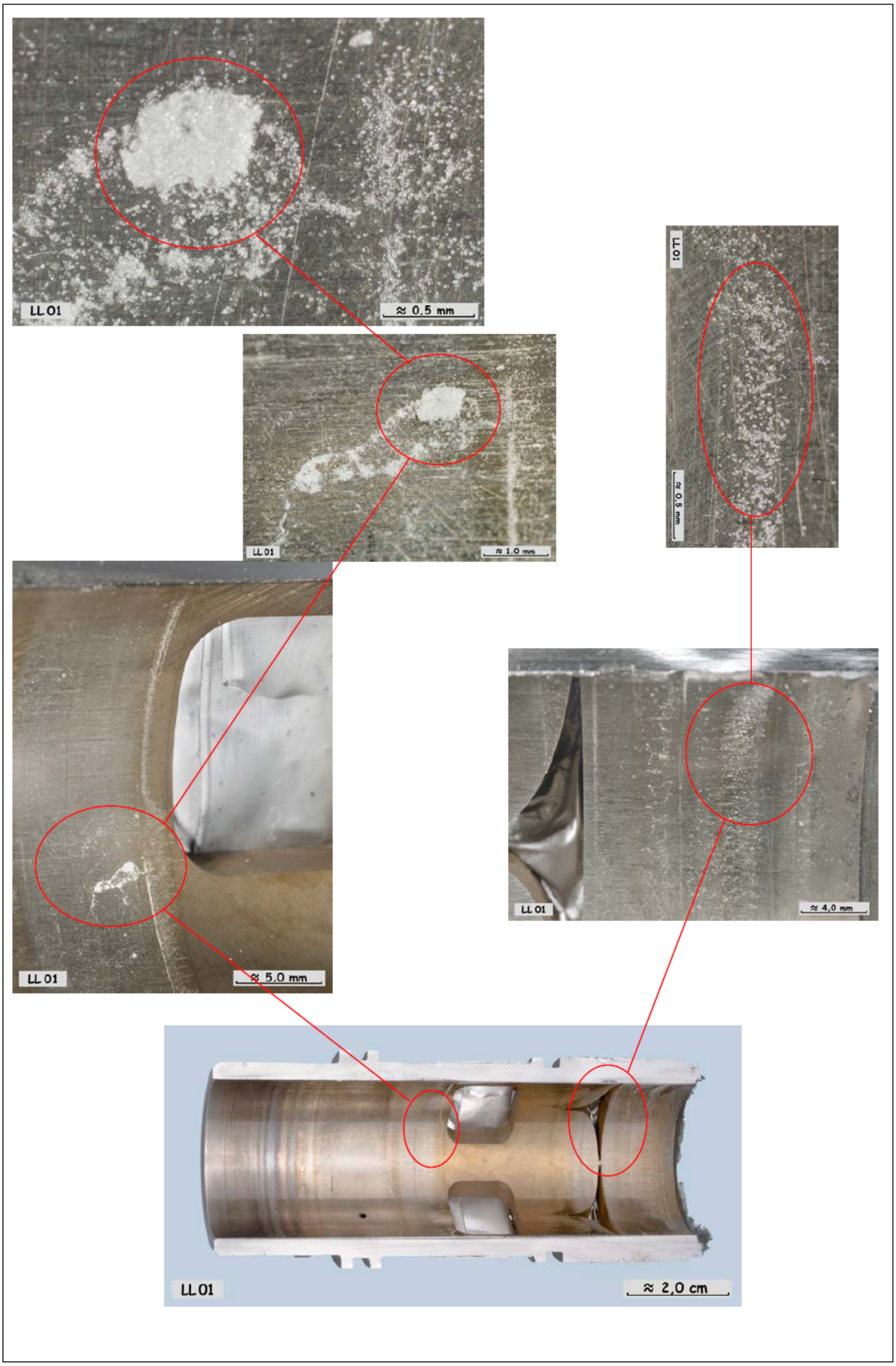


Figure 1: The cut-away view of No. 1 engine MMV sleeve showing the presence of spheres. Similar spheres were also present in No.2 engine MMV sleeve.

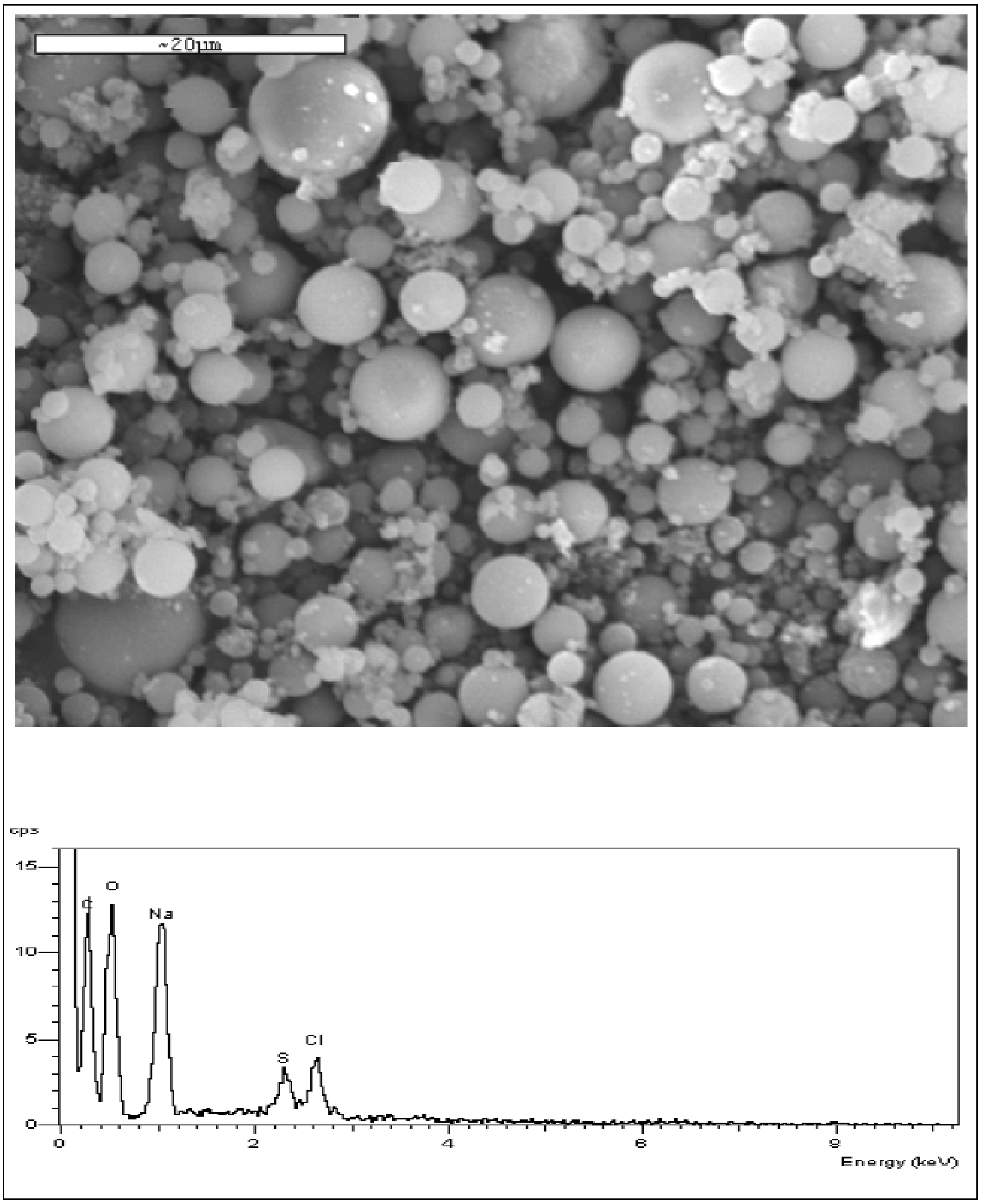
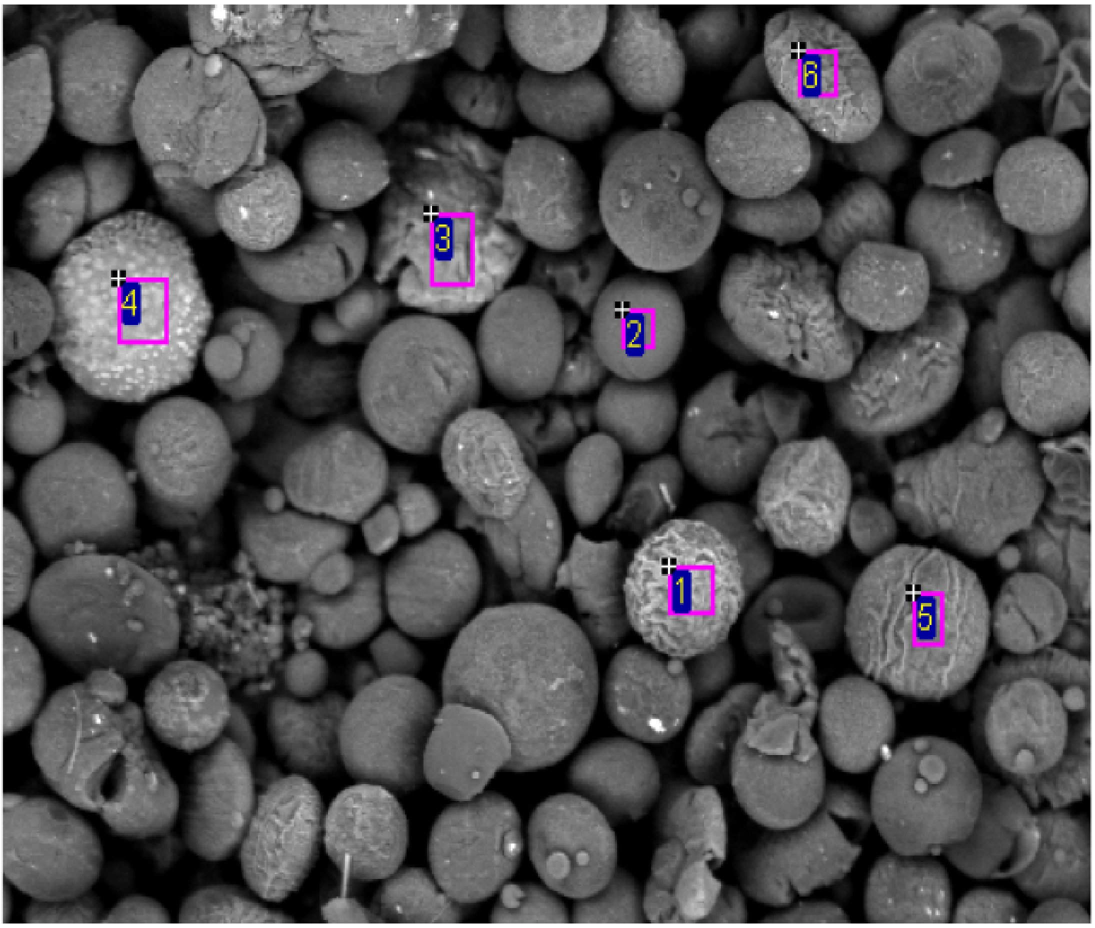


Figure 2: Microscopic view of spheres and their composition under Scanning Electronic Microscope (SEM) analysis.



Spectrum	C	O	Na	S	Cl	
1	51.71	30.98	13.40	0.58	3.33	More Cl (and presumably NaCl) on brighter spheres
2	71.52	20.42	7.39	0.25	0.42	
3	53.93	29.74	11.60	0.60	4.13	More Cl (and presumably NaCl) on brighter spheres
4	35.50	42.06	16.46	2.83	3.15	More Cl (and presumably NaCl) on brighter spheres
5	54.82	32.16	11.47	0.46	1.08	
6	54.87	31.48	10.69	0.66	2.30	

Figure 3: The presence of crystalline sodium chloride on the surface of some spheres.

Figure 4: The differential pressure gauge of a dispenser.

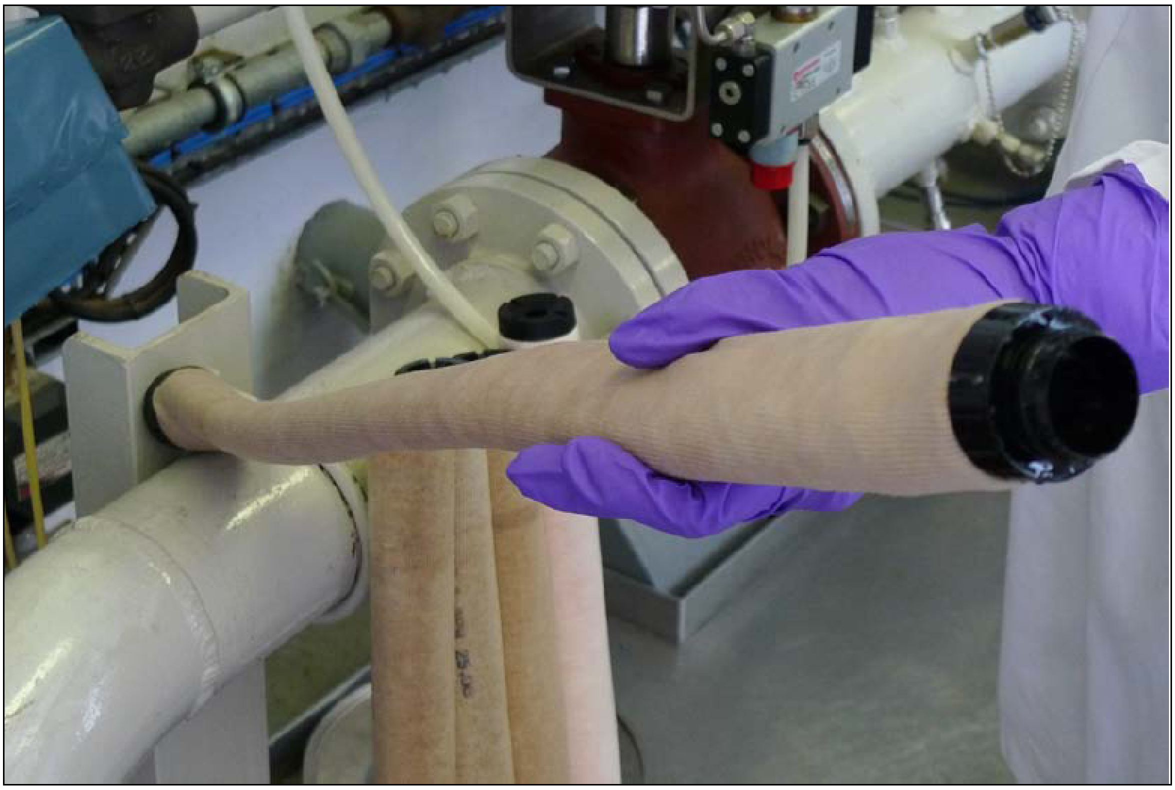


Figure 5a: A collapsed monitor losses the structural rigidity.

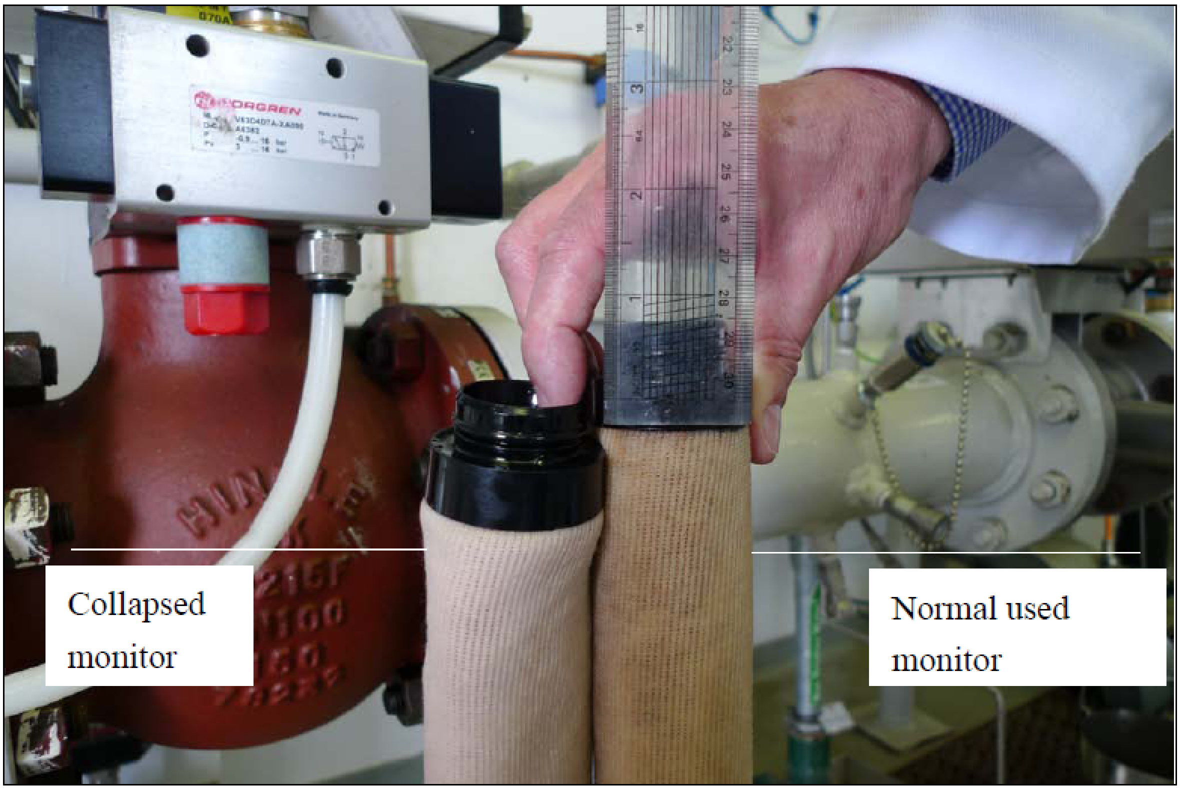


Figure 5b: A collapsed monitor is shorter than a normal monitor.