

Final Report

Concerning

Replacing Engine #1 installed on the aircraft Boeing 737-800

Registered as UR-CLR

Belonging to Khartiv Airlines, Ukraine

After emergency landing at Cairo Airport

Flight Number KHK 3204, Porcibel/ Hurghada

On 26 October, 2013

Issued by

Aircraft Accident Investigation Central Directorate

Egyptian Ministry of Civil Aviation

Cairo

September, 2014

Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation and with European Regulation n°996/2010, the investigation has not been not conducted so as to apportion blame, nor to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents.

Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

Table of Contents

TITLE

FOREWORD

TABLE OF CONTENTS

SYNOPSIS

1 - FACTUAL INFORMATION

1.1 History of Flight

1.2 Injuries to persons:

1.3 Damage to aircraft:

1.4 Other Damages

1.5 Personnel Information

1.5.1 Captain

1.5.2 F/O

1.6 Aircraft Information

1.7 Meteorological Information

1.8 Aids to Navigation

1.9 Communications:

1.10 Aerodrome Information:

1.11 Flight Recorders

1.12 Wreckage and impact information

1.13 Medical Pathological Information

1.14 Fire

1.15 Survival Aspects

1.16 Tests and Researches

1.17 Organizational and Management

1.18 Additional Information

1.18.1 Pilot Report.

1.18.2 FCOM Instructions

1.18.3 Maintenance report

1.18.4 Maintenance actions carried out on the aircraft.

1.18.5 Information received from the National Bureau of Air Accident and Incident Investigation of Civil Aircraft of Ukraine, regarding examination of the engine after the event

2. ANALYSIS & CONCLUSION

2.1 The Aircraft:

2.2 The Aircraft captain

2.3 The aircraft F/O.

2.4 The FDR downloaded information:

2.5 The incident

2.6 FCOM

3. INCIDENT PROBABLE CAUSE

4. SAFETY RECOMMENDATIONS

Synopsis

Date of incident: 26 October, 2013.

Engine failure time: Almost 07:56 local time

Site of incident: Cairo, Egypt. (Emergency Landing),

Flight: Pericibel/ Hurghada.

Aircraft type: Boeing 737-800,

Aircraft registration: KHK 3204

Operator: Khartiv Airlines, Ukraine

1 - FACTUAL INFORMATION

1 - FACTUAL INFORMATION

1.1 History of Flight

- On 26 October 2013, at almost 07:56 local time, the said aircraft registered as UR-CLR, type Boeing 737-800, operated by Khartiv Airline (Ukraine) ,flight Porcibel/ Hurghada, and while cruising at 37000 ft altitude, the captain noticed a malfunction in engine #1 "Low oil pressure, low oil quantity, fail indication". As a result, the captain asked Cairo Air Traffic Control to perform an emergency landing at Cairo airport, He was cleared to do that.



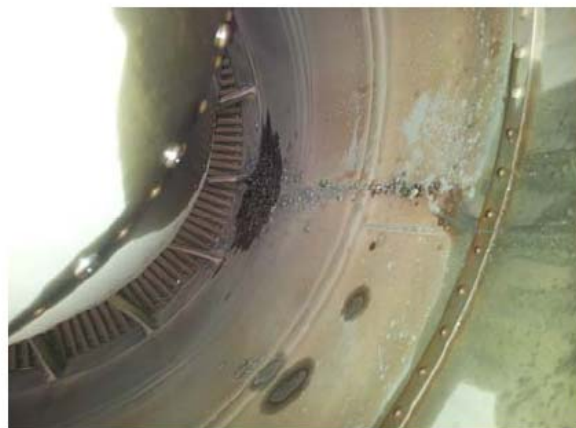
- The Aircraft landed at Cairo airport same day at almost 08:00 local time..
- The Maintenance engineer, belonging to "EgyptAir Company for Maintenance and technical Services" which is assigned to provide the maintenance service to the aircraft, inspected the aircraft. He found damage in engine #1 making the engine unserviceable. Consequently, he advised that engine #1 should be replaced. Engine #1 was replaced, tested. The aircraft became serviceable for flight.
- The aircraft took off from Cairo Airport on 10 December, 2013 to Poricebel airport.
- There were no injuries among personnel

1.2 Injuries to persons:

No injury.

1.3 Damage to aircraft:

The aircraft experienced damage in #1 engine



1.4 Other Damages

No other damages

1.5 Personnel Information

1.5.1 Captain:

A. Captain information:

- Name: [REDACTED]
- Age: 37 years
- Nationality: Ukrainian
- Granted an Air Transport Pilot License ATPL number 1629, issued from Ukrainian Civil Aviation, renewed and valid up to 15 August 2014
- Last medical check was made on him on 15-08-2013 and he was eligible to fly.
- Last proficiency check was made for him on 20-08-2013
- The following table shows his experience and his flying hours details:

Information	Hours	Minutes
Total number of flying hours	6347	54
Total number of flying hours on Boeing 737-800 type	1320	34
Total number of flying hours one month before the incident	32	55
Number of flying hours the day of the incident	03	05

B. First Officer Information:

- Name: [REDACTED]
- Age: 39 years
- Nationality: Ukrainian
- Granted an Air Transport Pilot License CPL number 010065, issued from Ukrainian Civil Aviation, renewed and valid up to 11 June 2014
- Last medical check was made on him on 11-06-2013 and he was eligible to fly.
- Last proficiency check was made for him on 18-05-2013
- The following table shows his experience and his flying hours details:

Information	Hours	Minutes
Total number of flying hours	1870	29
Total number of flying hours on Boeing 737-800 type	640	10
Total number of flying hours one week before the incident	07	30
Number of flying hours the day of the incident	03	05

1.6 Aircraft Information

1.6 Aircraft General Information

- The aircraft registration is UR-CLR, type Boeing 737-800.
- The aircraft is owned by : Khartiv Airlines, Ukraine
- It carries (is granted) a registration certificate number 3999, (Ukrainian Civil Aviation records)
- It carries (is granted) an Airworthiness registration certificate number 3999, issued from Ukrainian Civil Aviation on 31-07-2013 and valid up to 31-07-2014
- It carries an Operation Certificate to take off and land on the Egyptian territories, issued on 16-10-2013 from the Ministry of Civil Aviation, valid to 31-01-2014
- Aircraft total flying hours since new (TSN)= 25228 HRS, number of total cycles since new (CSN)= 8234 cycles.
- The aircraft is equipped with two engines. Engine #1 information is as follows:

-ENGINE TYPE	CFM56-7B27 ESN892707
-CSN	7218 CYC
-TSN	13976 HRS

1.7 Meteorological Information

- Not Relevant.

1.8 Aids to Navigation

- Not relevant.

1.9 Communications:

- Not relevant.

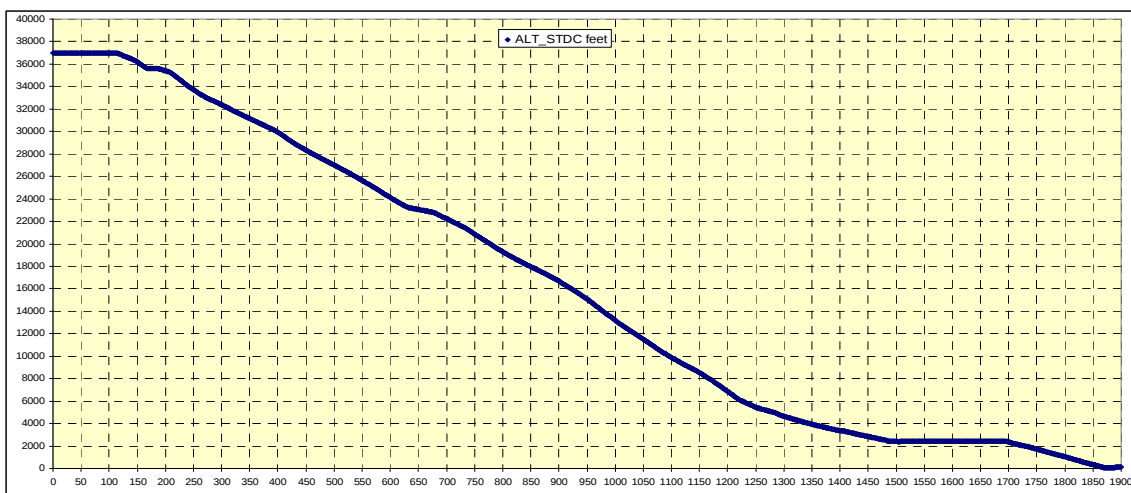
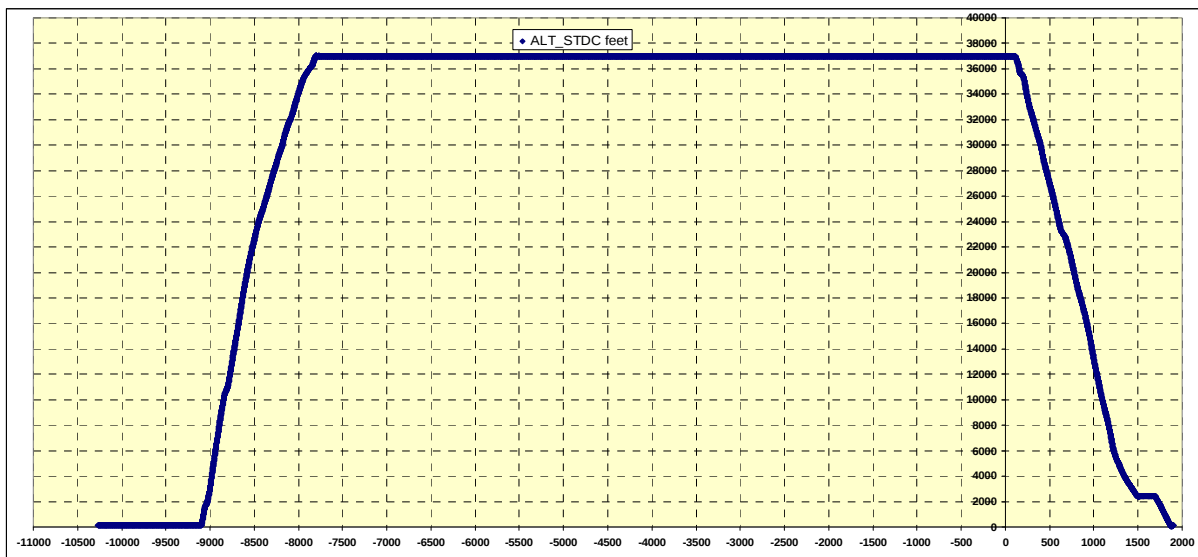
1.10 Aerodrome Information:

- Not relevant

1.11 Flight Recorders

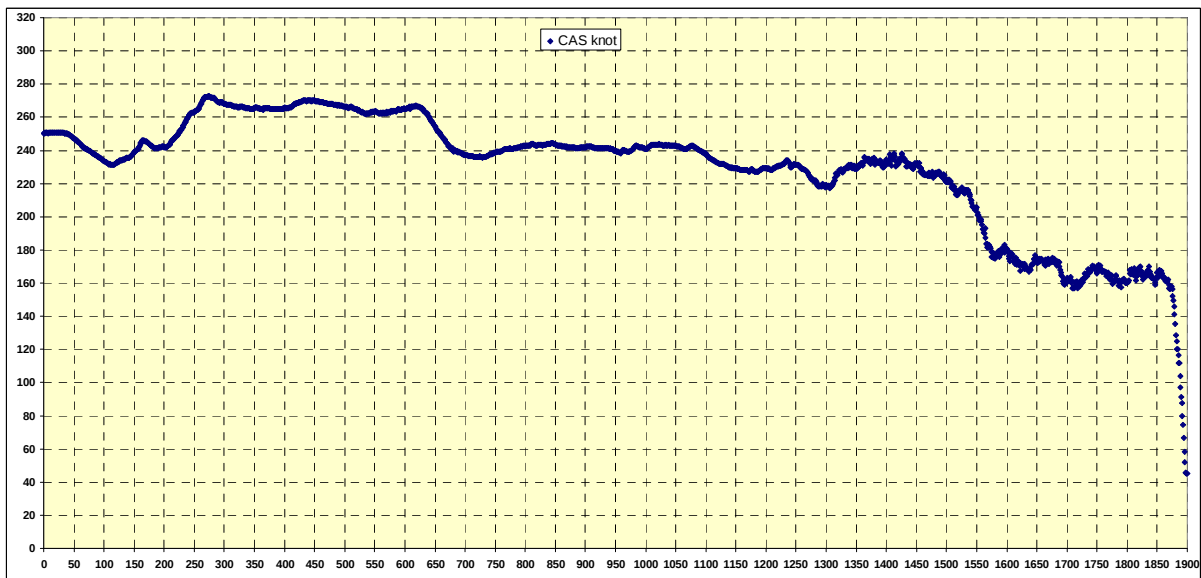
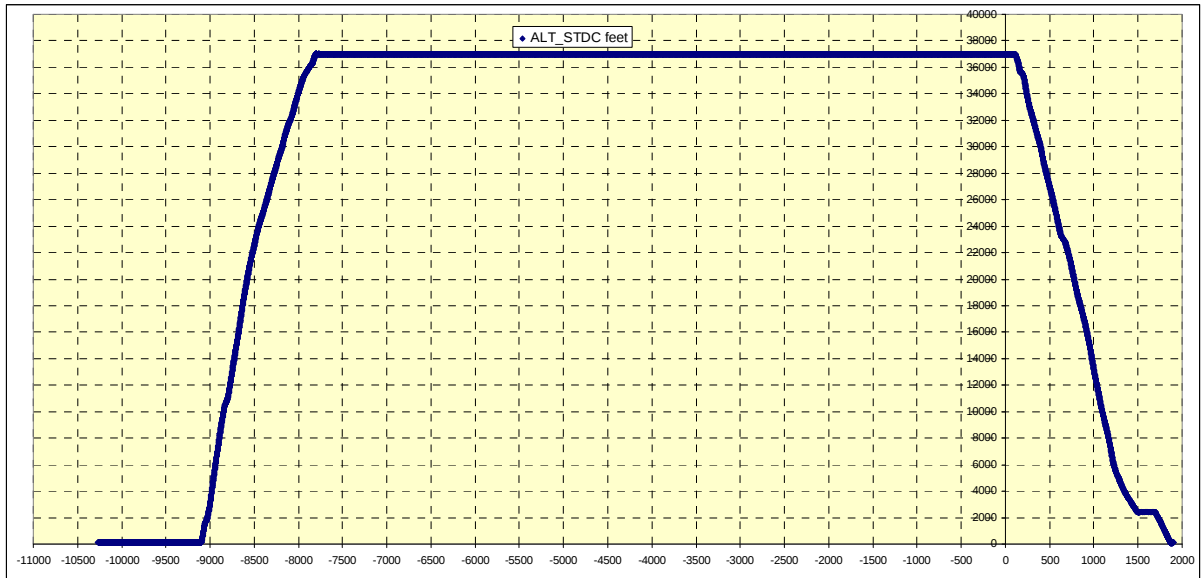
- The Flight Data Recorder FDR PN is 980-4700-042
- The incident aircraft FDR data was downloaded. The following graphs show the variation of the most relevant parameters with time. The time scale Zero second is referred to time 8:47:30 AM. Each parameter is plotted two times for more clarification. Once for the whole recorded time interval and the 2nd plot is for the last 1900 seconds,

1. Pressure Altitude:



- The Graph shows that the aircraft was cruising at an altitude of 37000 ft, the aircraft started its descent at the time 117 seconds, continued its descent up to 1900 seconds. (about 1790 second equivalent to about 29 min, 50 seconds)

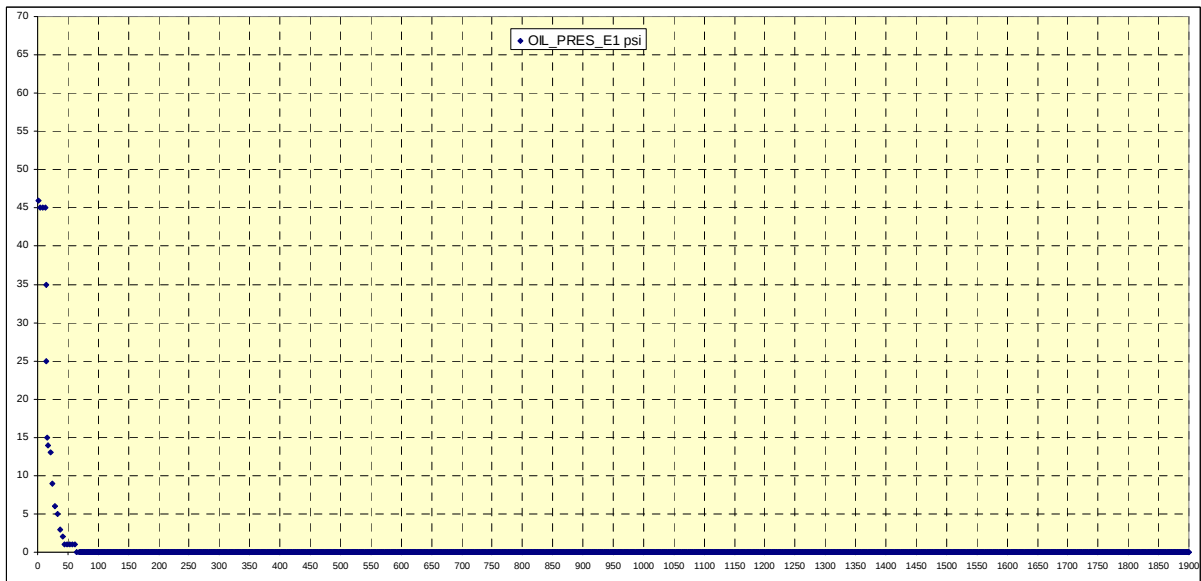
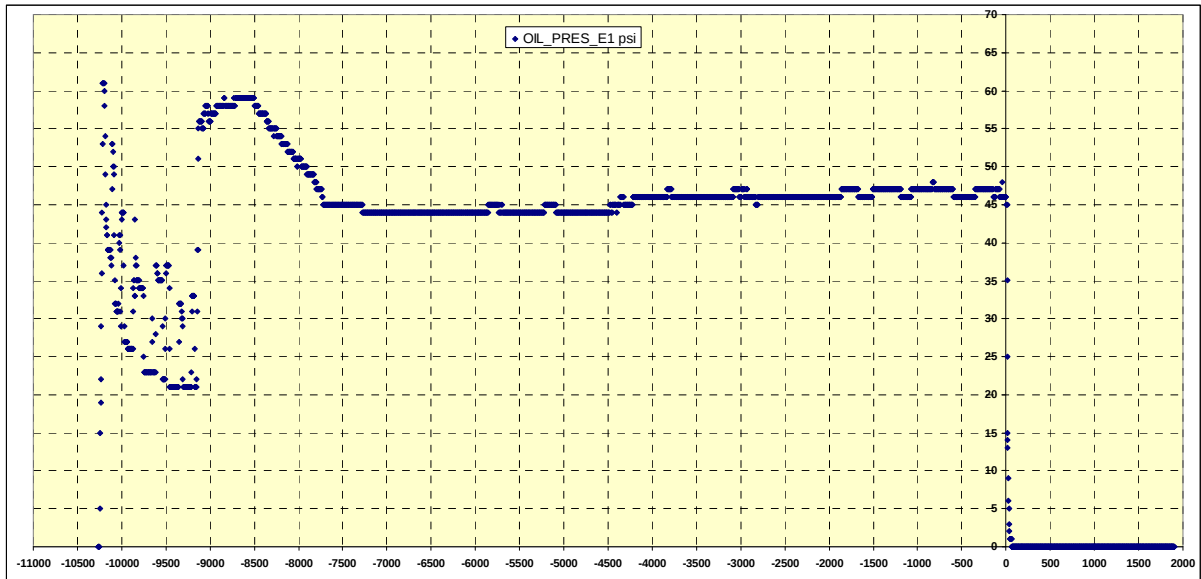
2. Calibrated Airspeed CAS:

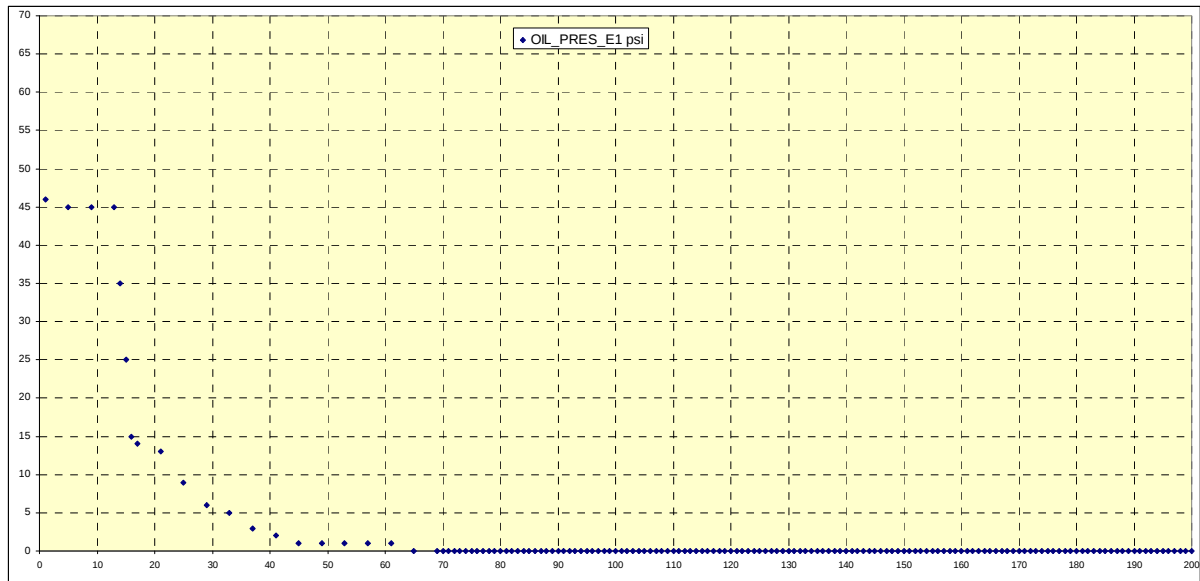


- The Graph shows that the aircraft was descending at varying speed. The following information can be concluded:

Time (seconds)	speed (knots)
26 (cruise)	251
143 (descent)	236
267 (descent)	272
1900	45 (min FDR reading)

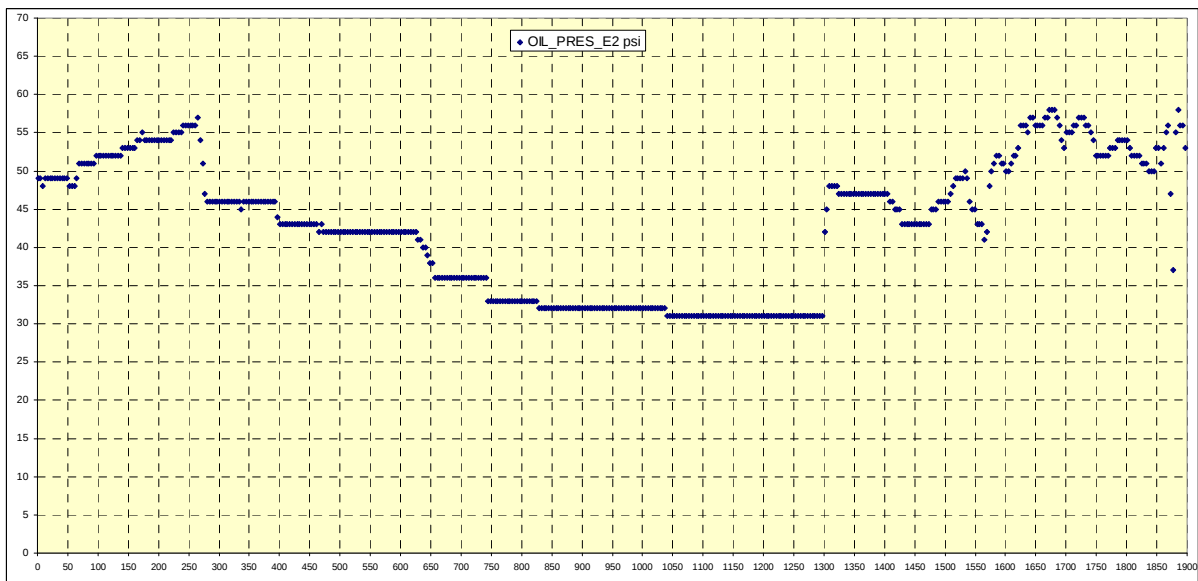
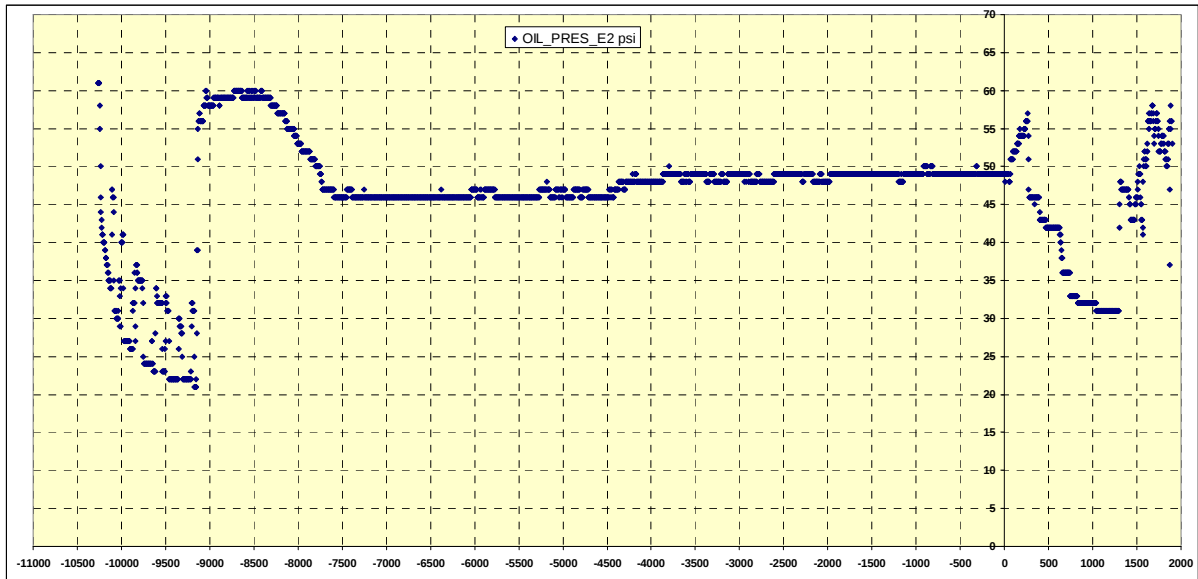
3. Oil press engine #1:





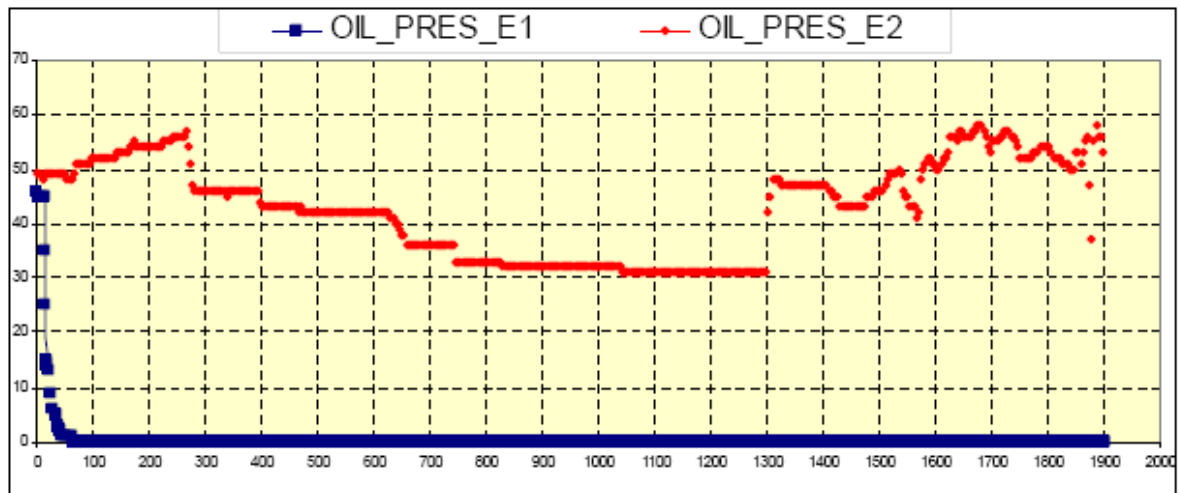
The oil pressure was showing about 45 psi during cruise. The pressure started dropping at almost 13 seconds. The oil pressure continued decreasing until it reached zero psi at about 65 seconds.

4. Oil press engine #2:

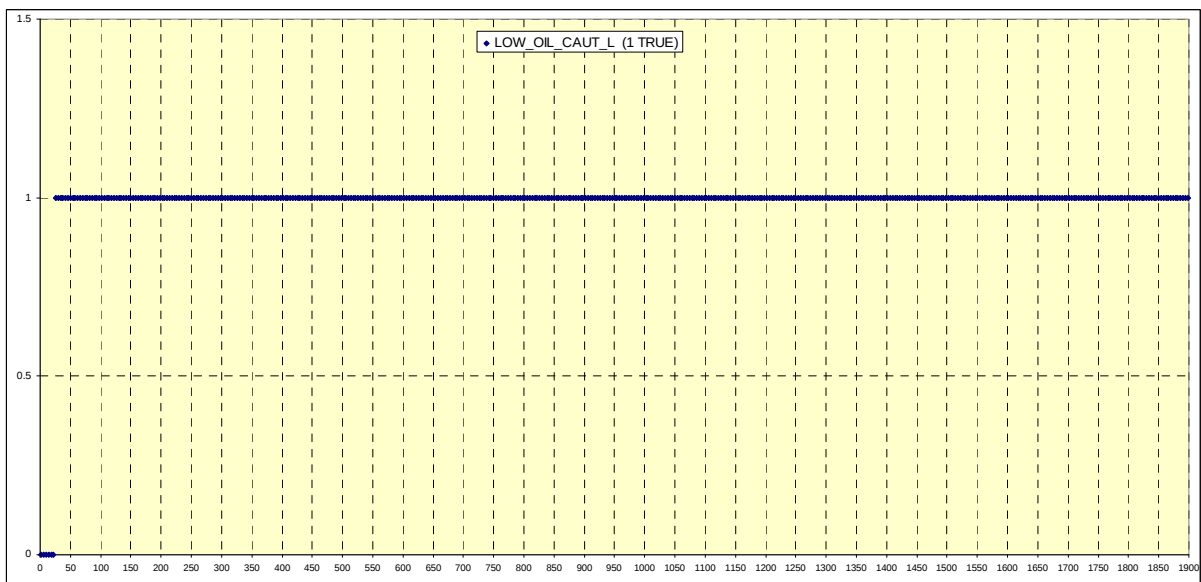
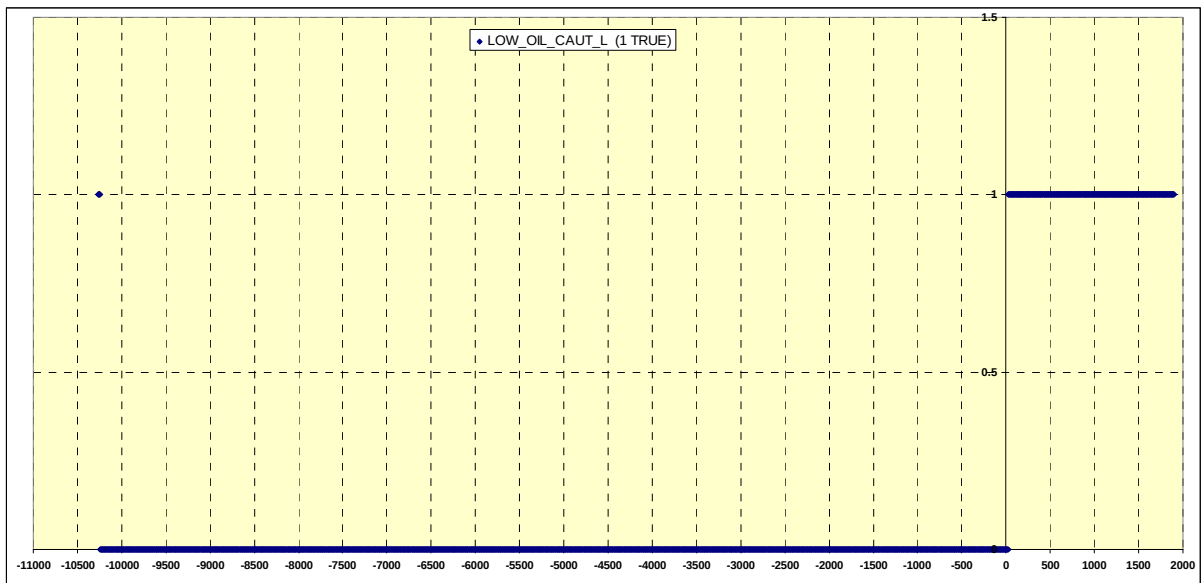


The oil pressure was showing about 49 psi at 0 seconds (cruise). The pressure showed variation during descent, with a maximum value of about 58 psi and a minimum value of about 31 psi.

Combined oil press graph (engine #1 and engine #2)



5. Oil low press caution (discrete) engine #1:

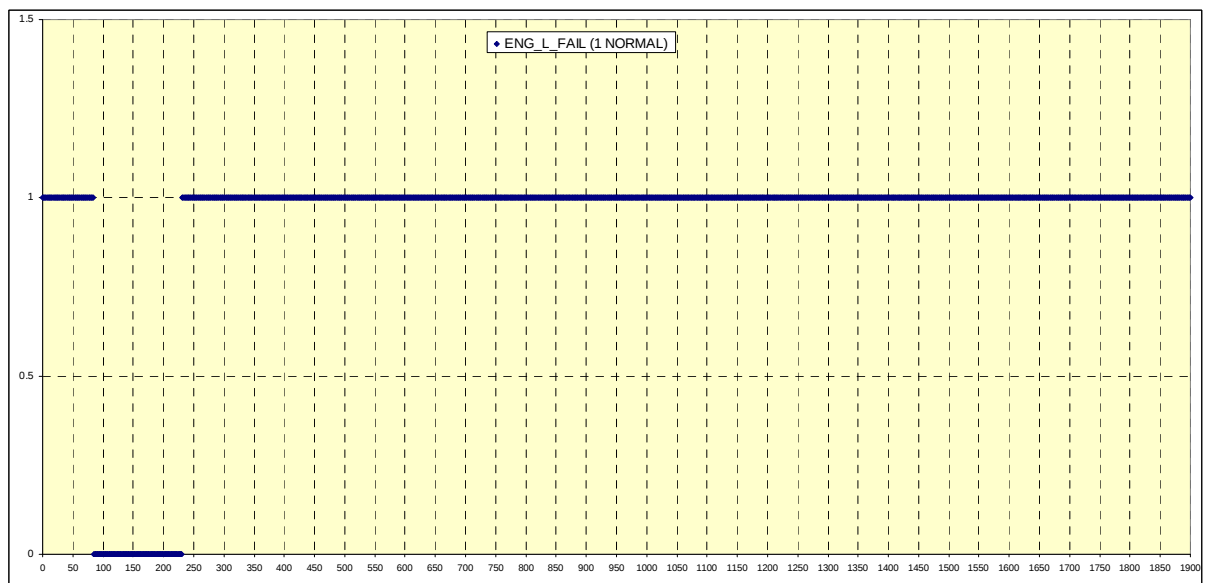
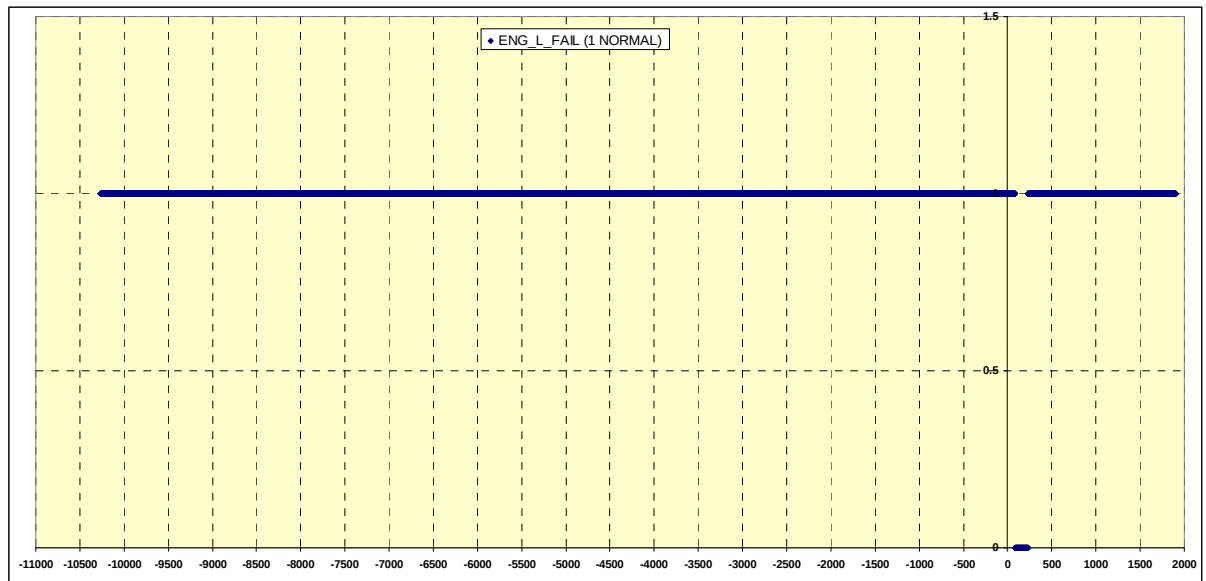


Oil Low Press caution came on at about 26 seconds and remained "On" the whole remaining time.

6. Oil low press caution (discrete) engine #2:

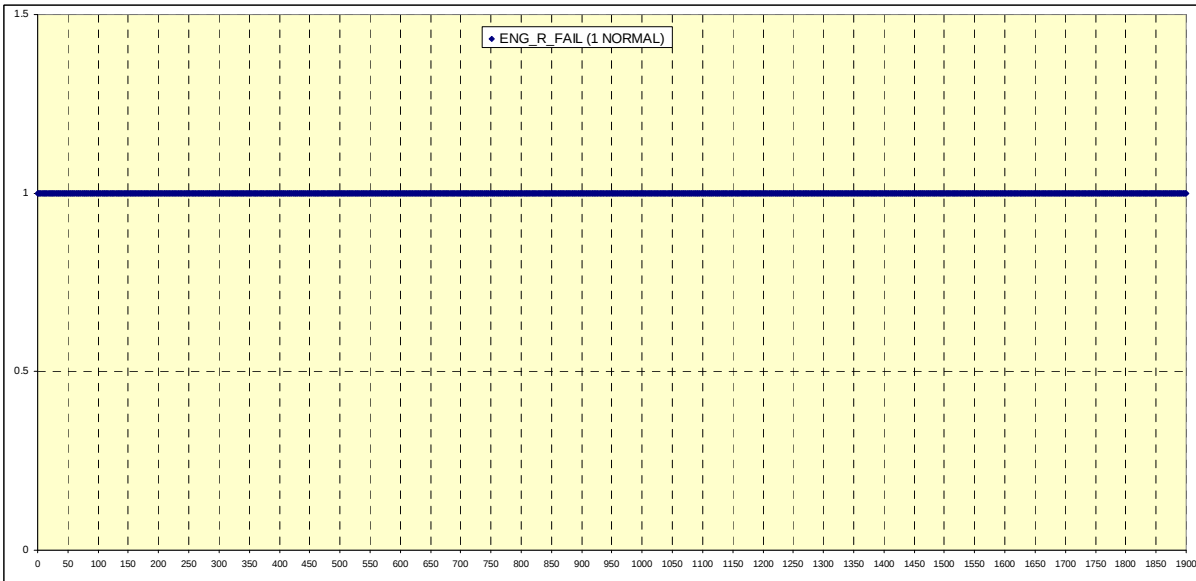
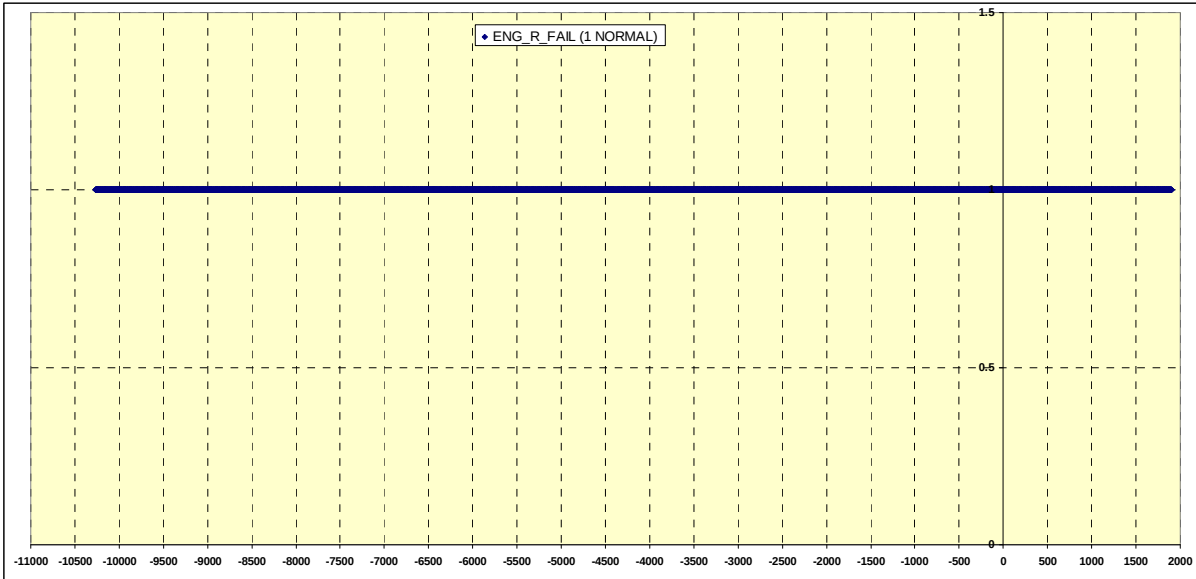
Not recorded

7. Engine Fail Warning (discrete) engine #1:



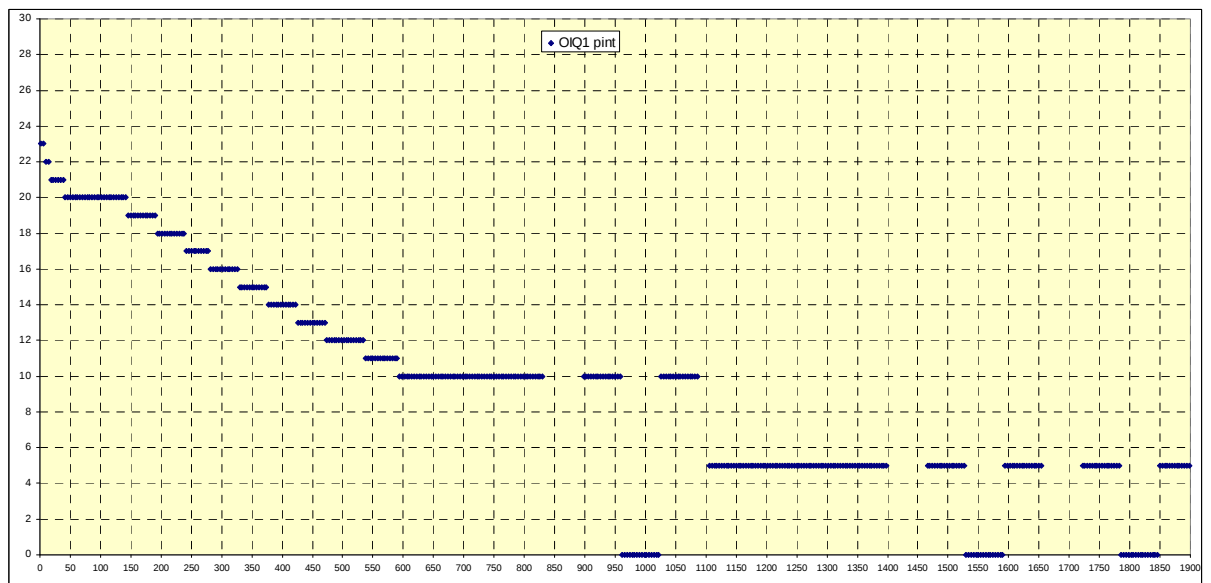
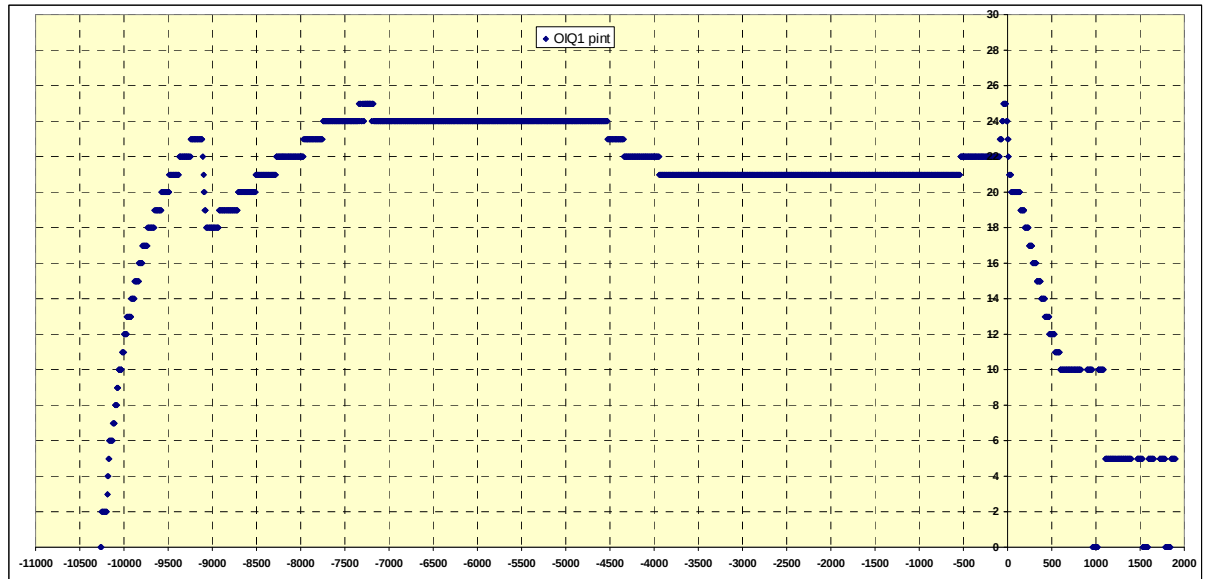
An Engine Fail warning appeared at almost 86 seconds and remained there until 230 seconds time, and then it vanished up to the end of recording (1900 seconds)

8. Engine Fail Warning (discrete) engine #2:



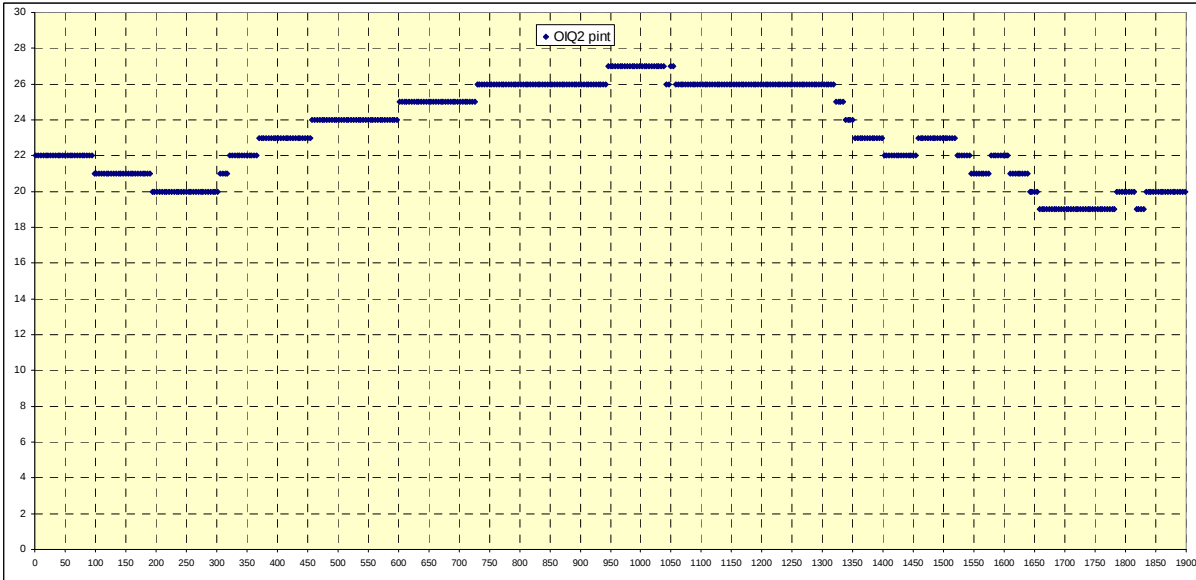
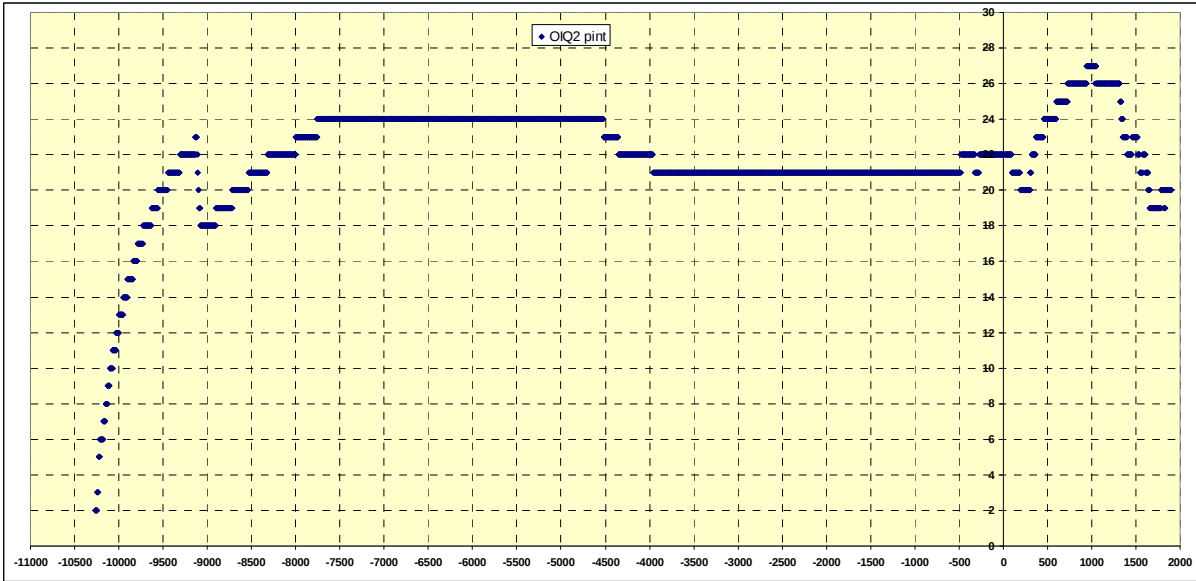
Engine Failure Warning did not show up

9. Oil Quantity Engine #1:



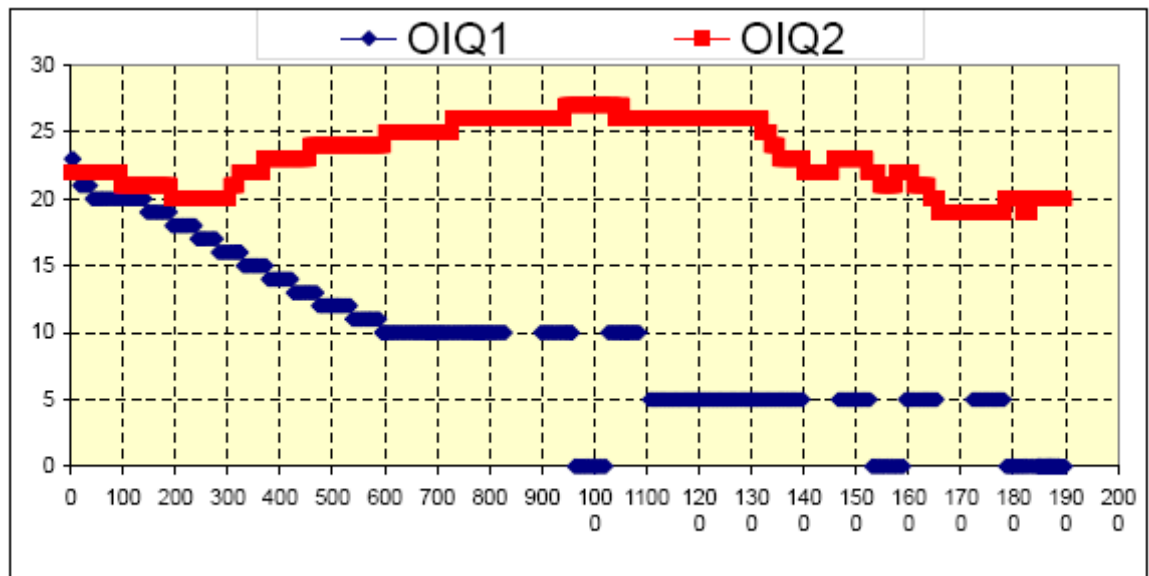
The oil quantity showed a value of about 23 US Quarts at 0 time. Immediately after that the oil quantity starts dropping continuously until it reached about only 10 US Quarts at almost 594 seconds. Starting from almost 962 seconds it started fluctuating between 0 and 5 US Quarts.

10. Oil Quantity Engine #2:

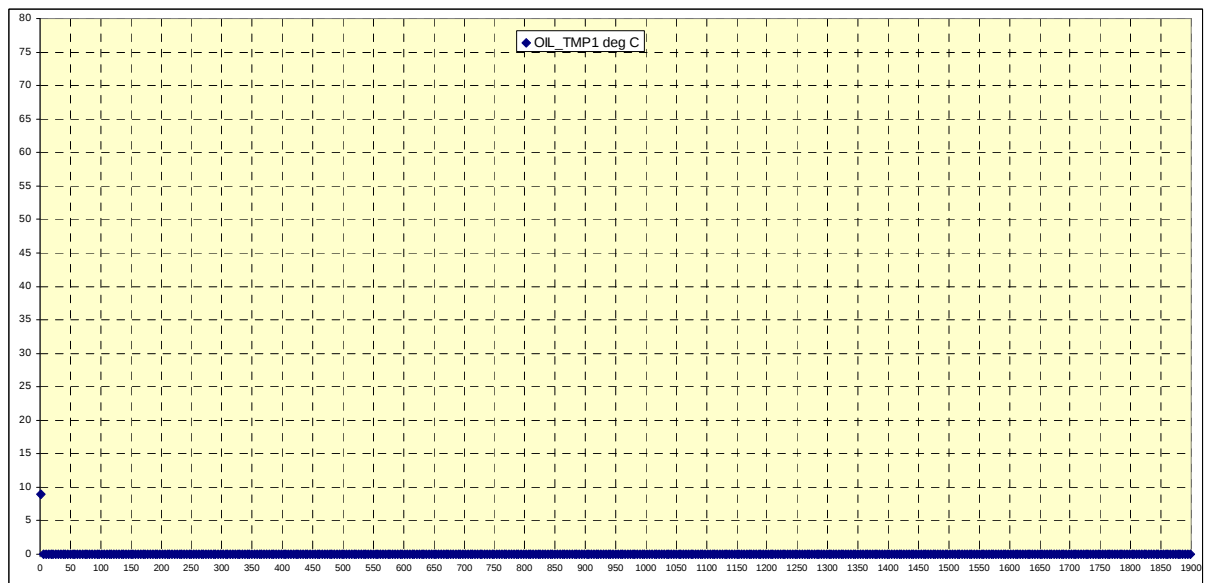
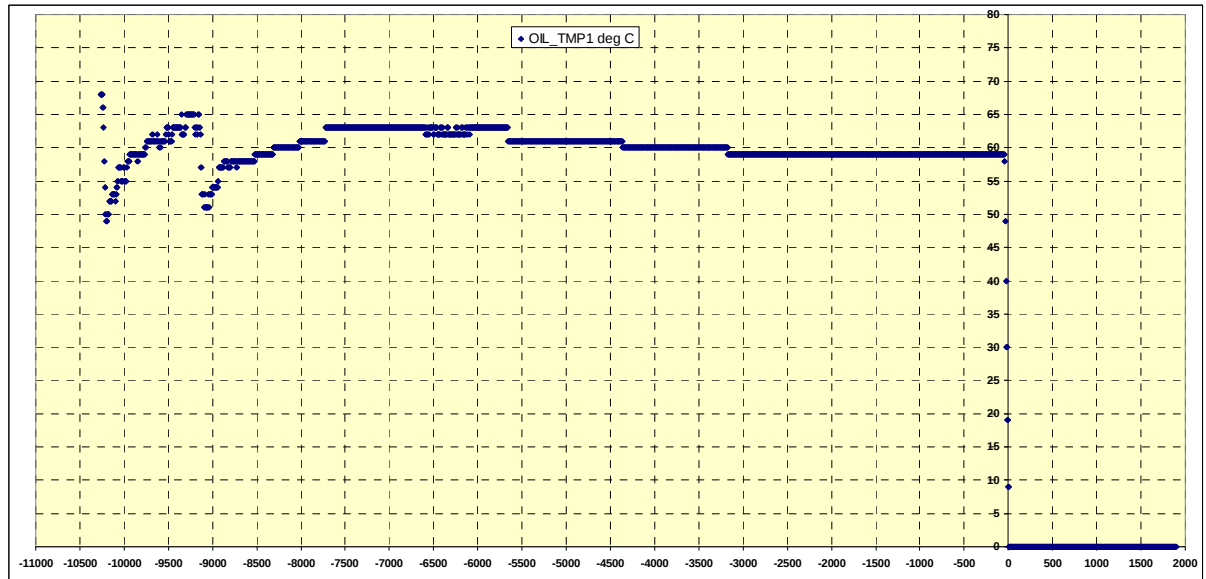


The oil quantity showed values between about 27 US Quarts and about 19 US Quarts.

Combined oil quantity graph (engine #1 and engine #2)

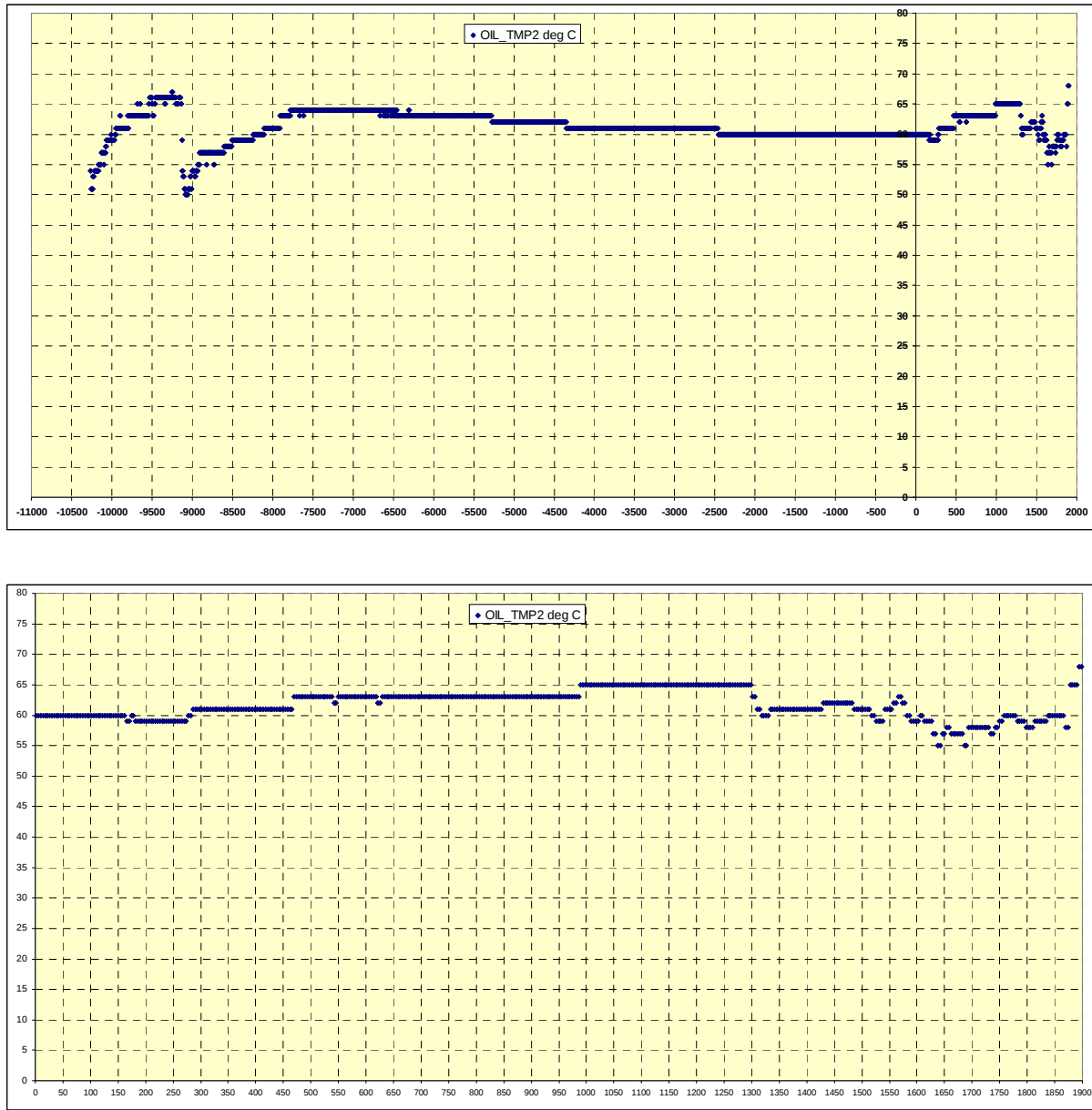


11. Oil temp Engine #1:



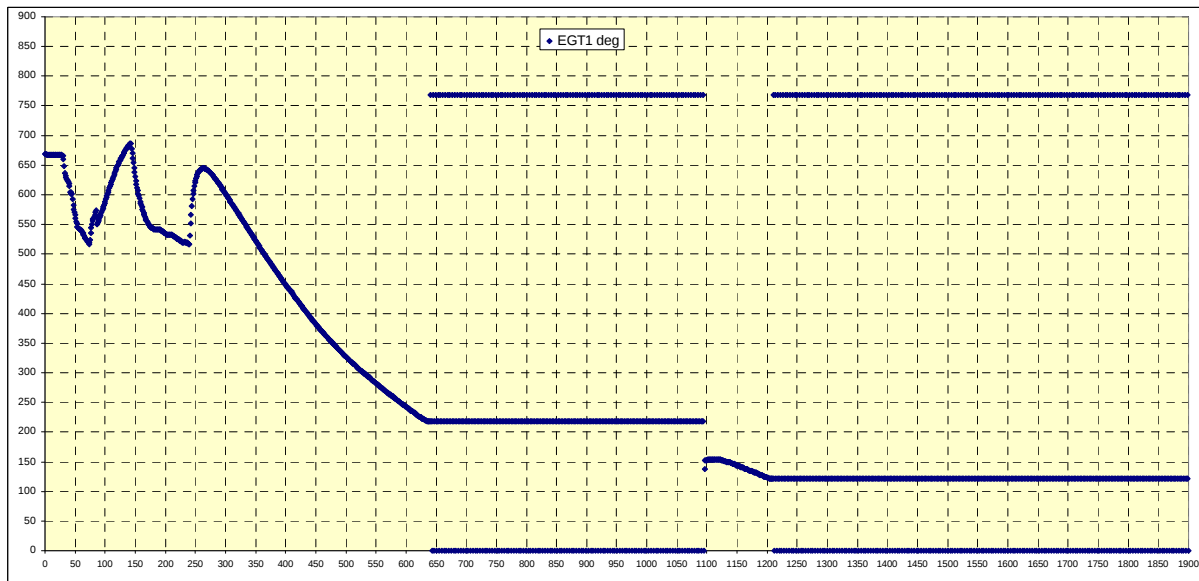
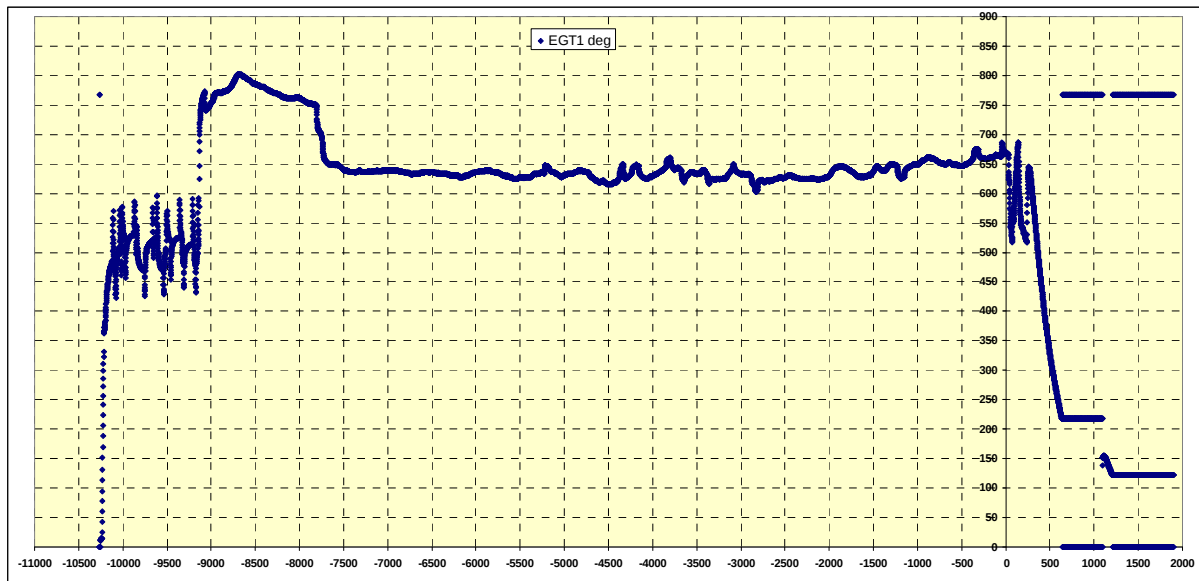
Oil temp was showing about 59 degree Celsius during cruise. Oil temp suddenly dropped to about 0 at almost -46 seconds

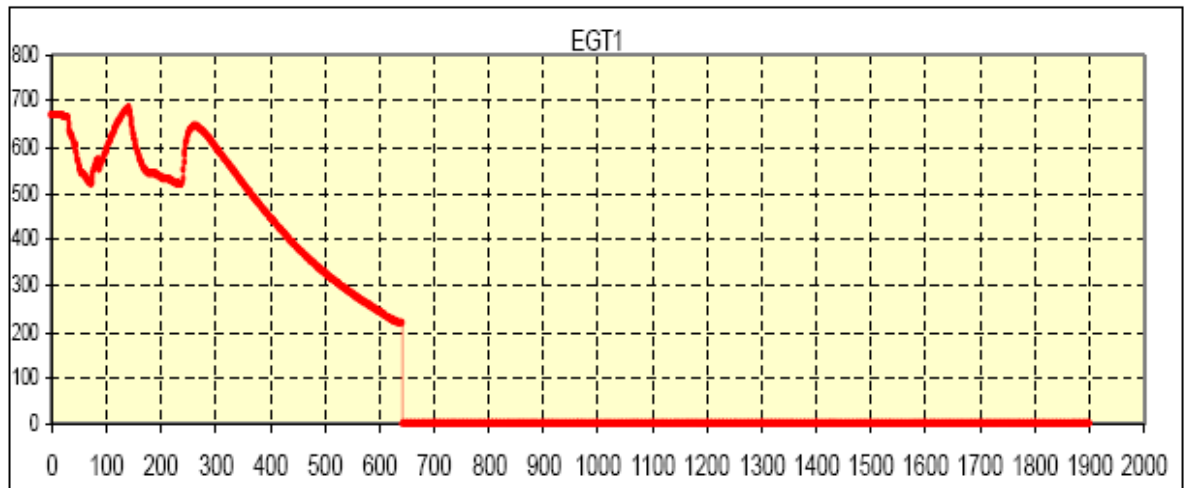
12. Oil temp Engine #2:



Oil temp did not show abnormal behavior.

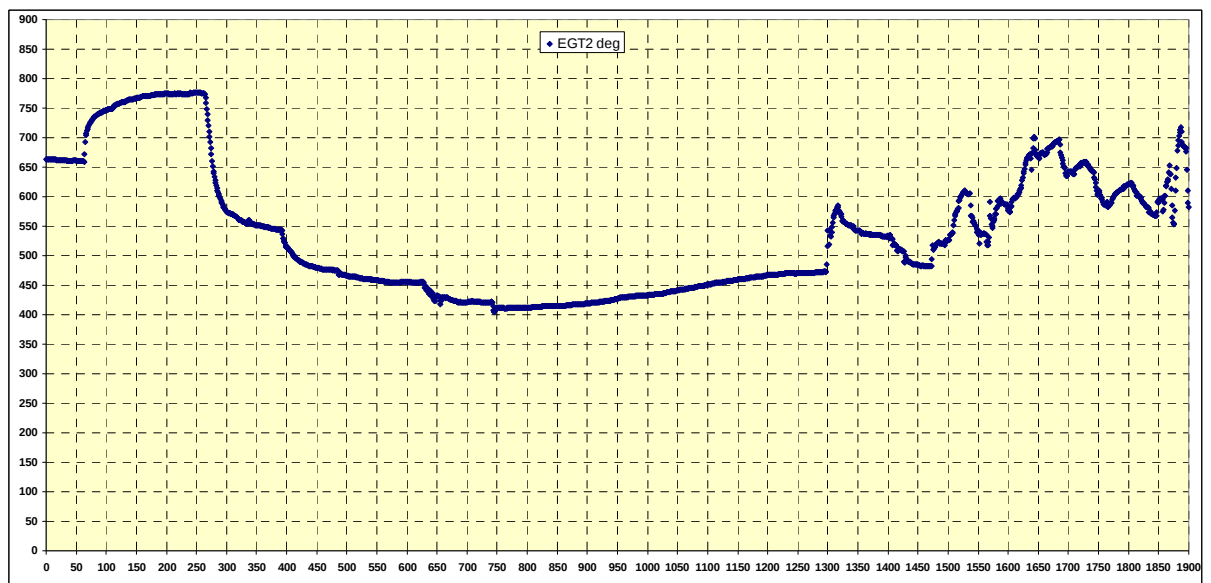
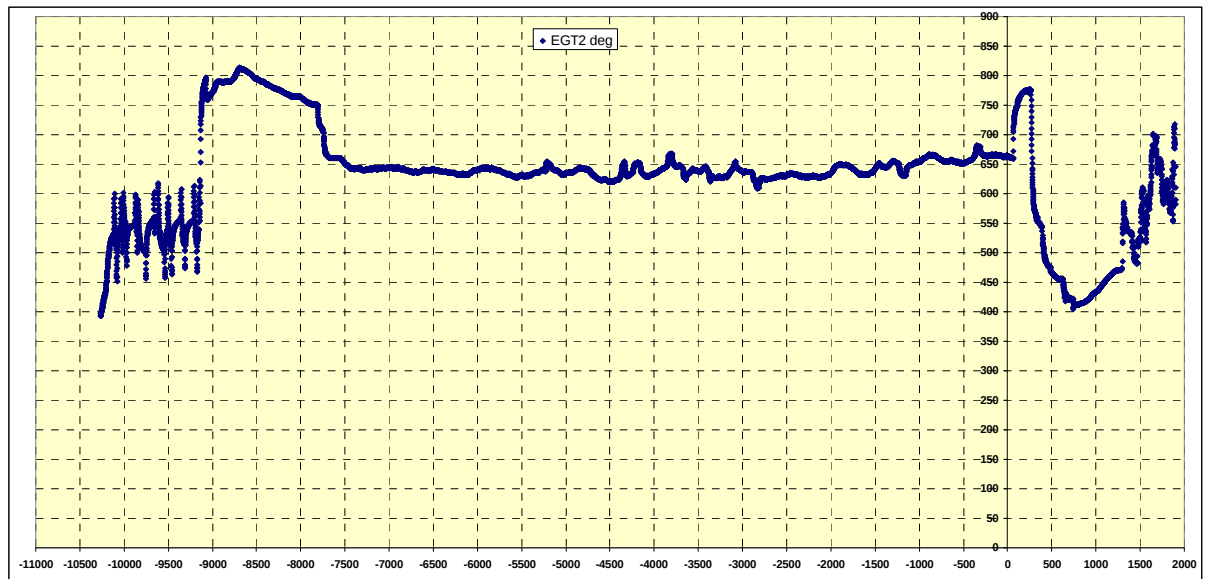
13. EGT Engine #1:





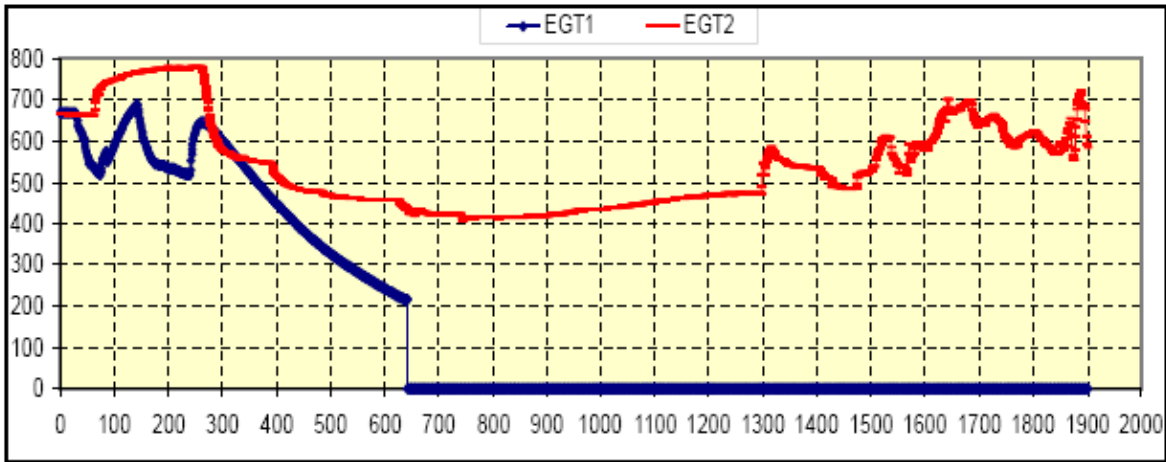
The EGT indication showed about 668 degree Celsius at 0 time (cruise). It dropped to almost 517 degree Celsius at about 74 seconds. It continues varying between almost 520 to 650 degree Celsius before dropping down to about 210 degree Celsius at about 630 seconds.

14. EGT Engine #2:

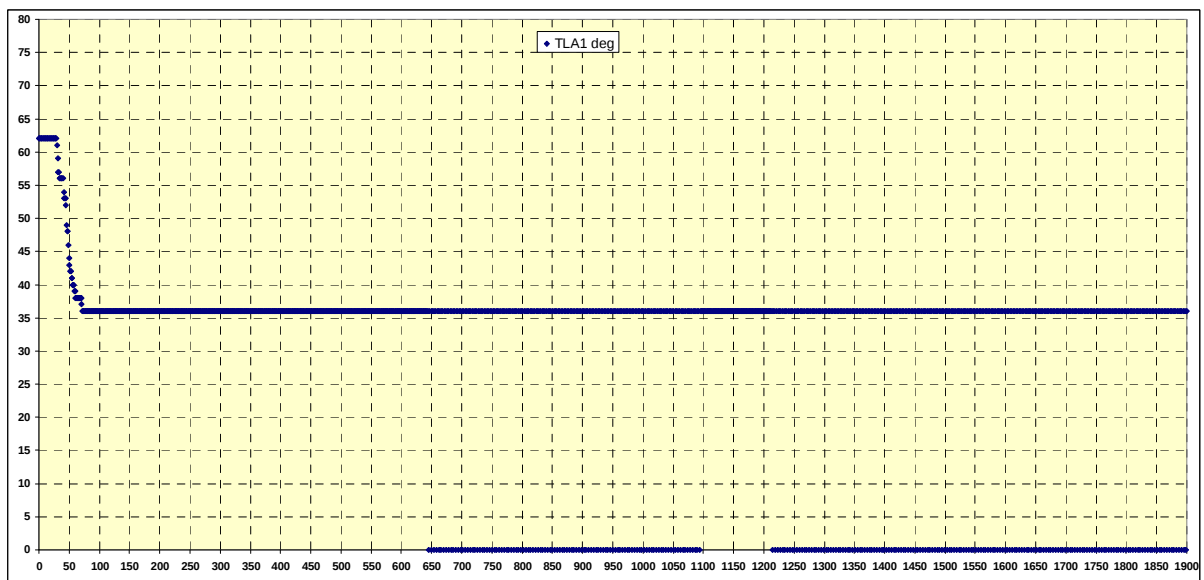
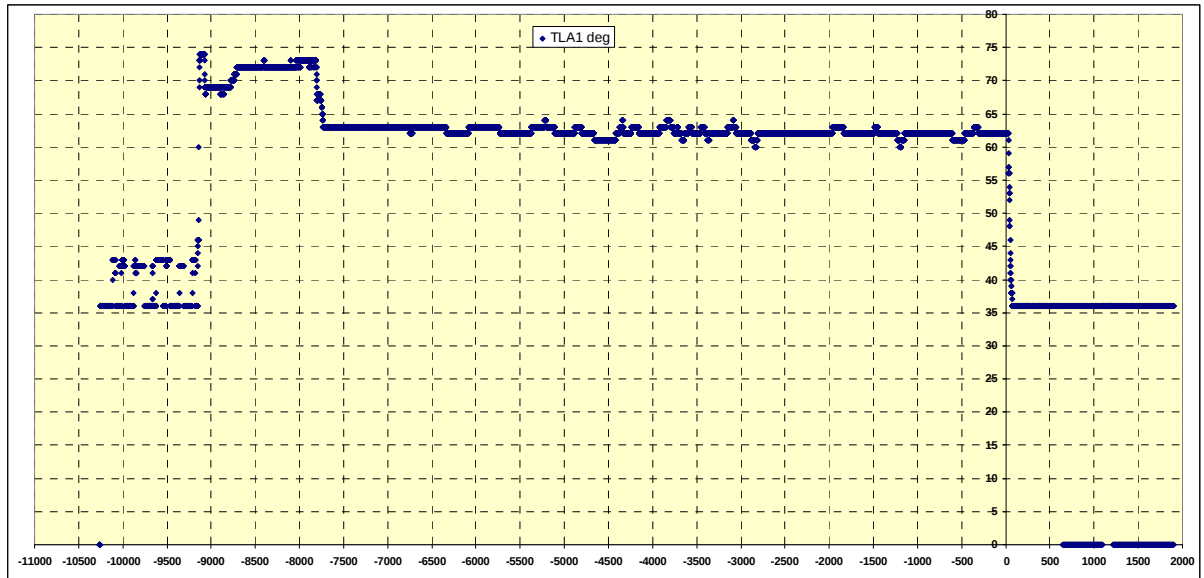


The EGT was varying during the descent. EGT did not show abnormal behaviour.

Combined EGT graph (engine #1 and engine #2)



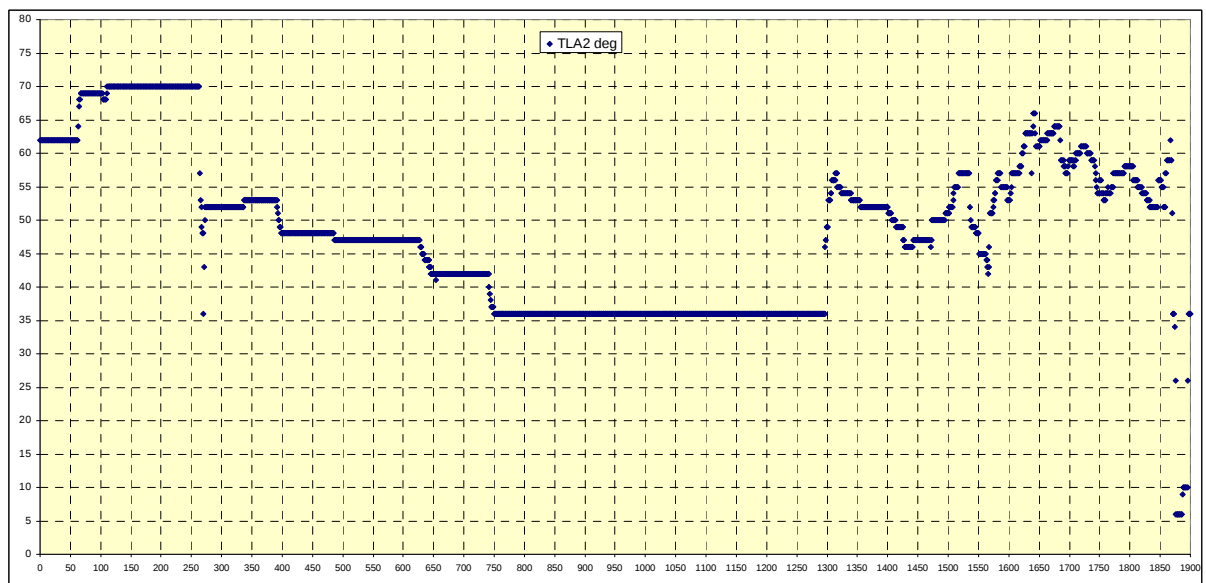
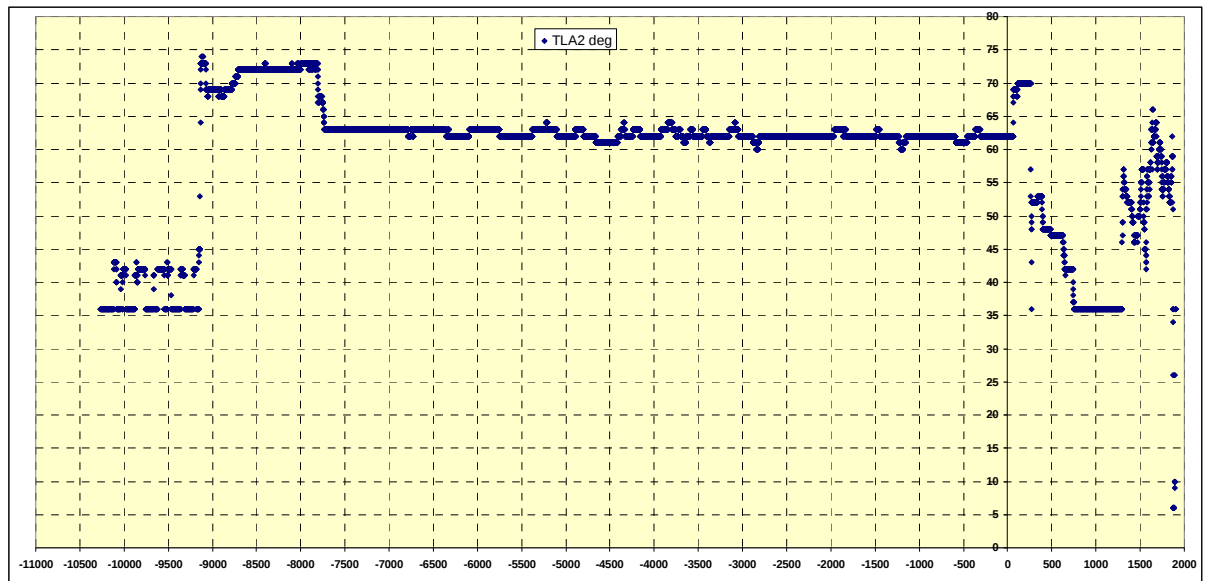
15. TLA Engine #1:



At 0 seconds (cruise), the TLA for engine #1 showed about 62 degree. At almost 29 seconds, the throttle lever started being retarded showing about 36 degrees (forward idle position) at about 72 seconds¹. The throttle lever remained at this position up to the end of recording.

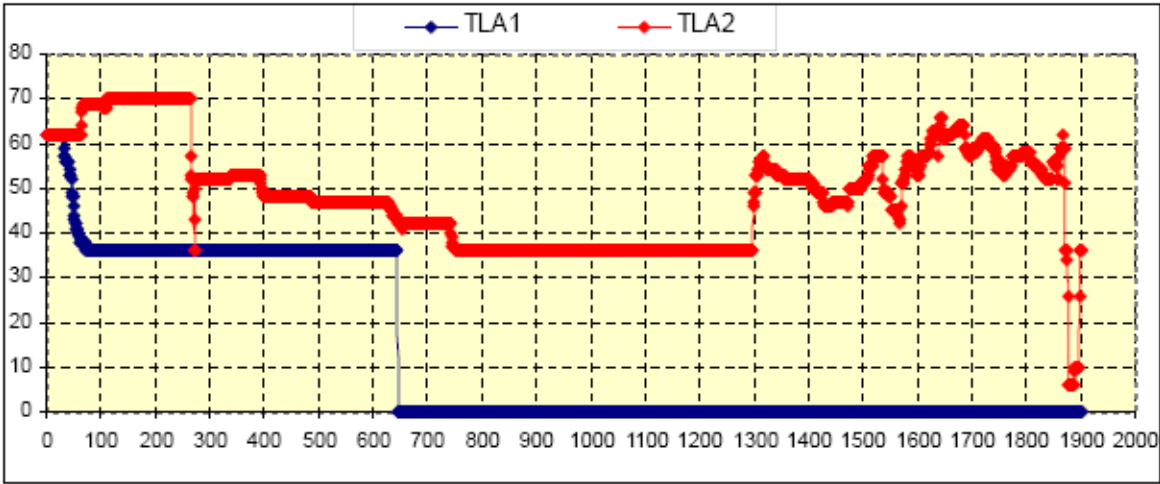
¹ The fwd idle reverse as shown in the B737-800 manual is 36-38 degrees at the EEC resolver.

16. TLA Engine #2:

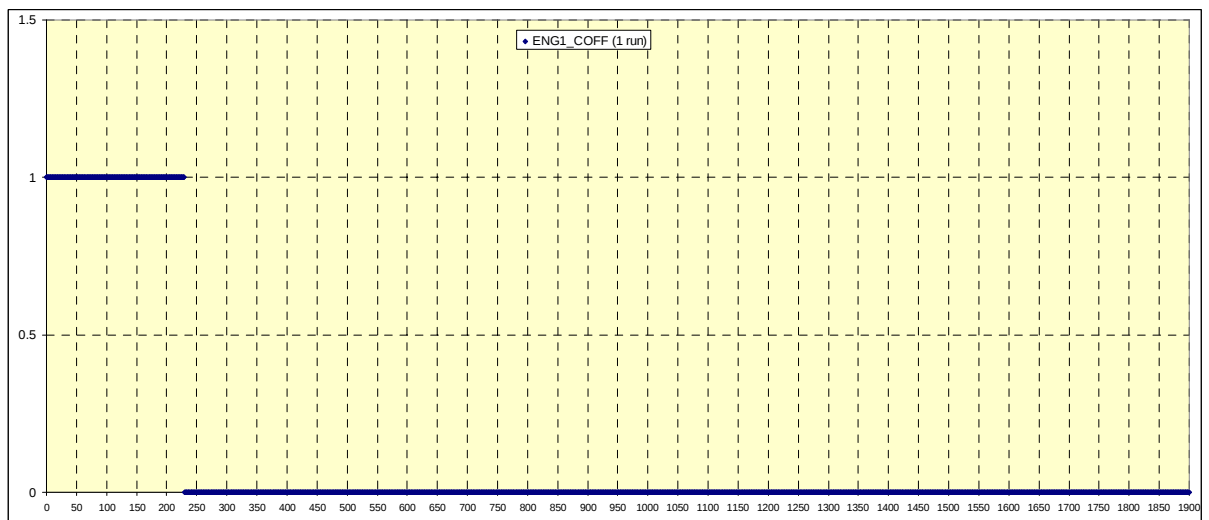
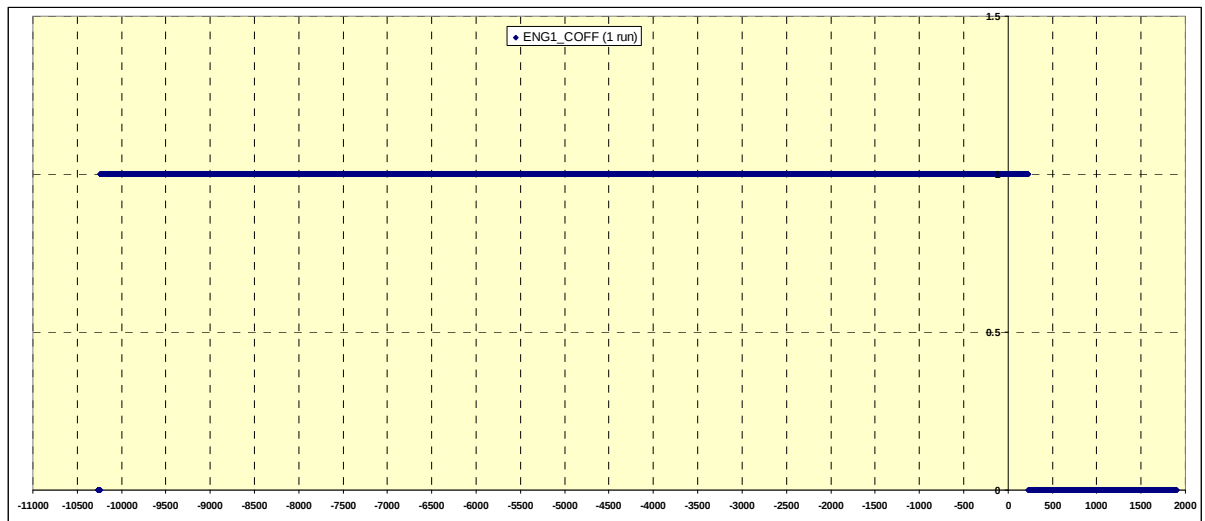


The TLA showed varying positions for the throttle lever up to engine shut down.

Combined TLA graph (engine #1 and engine #2

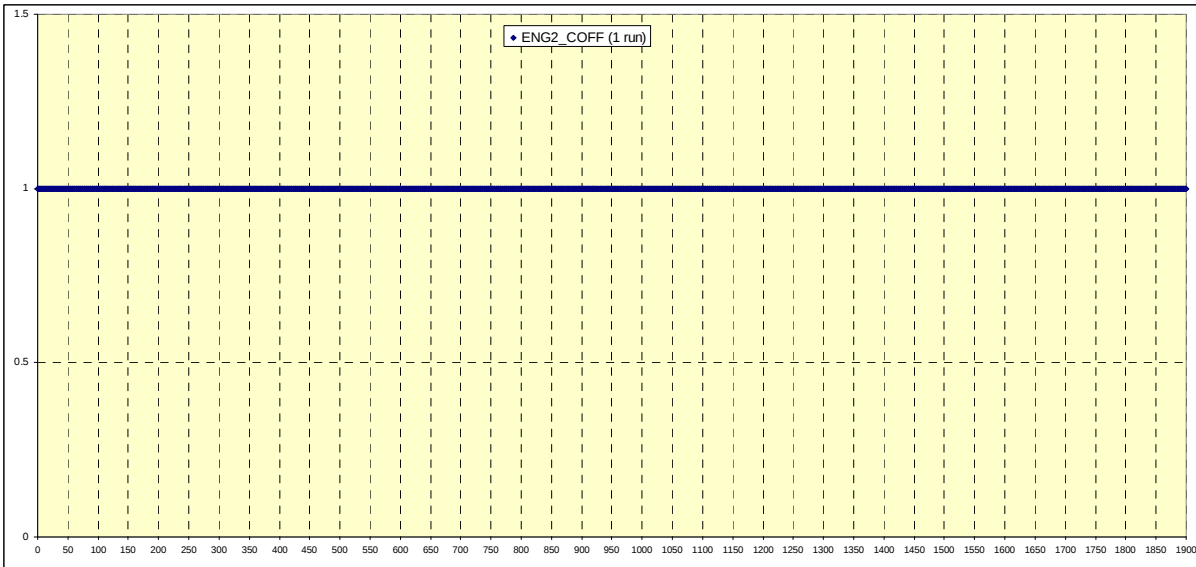
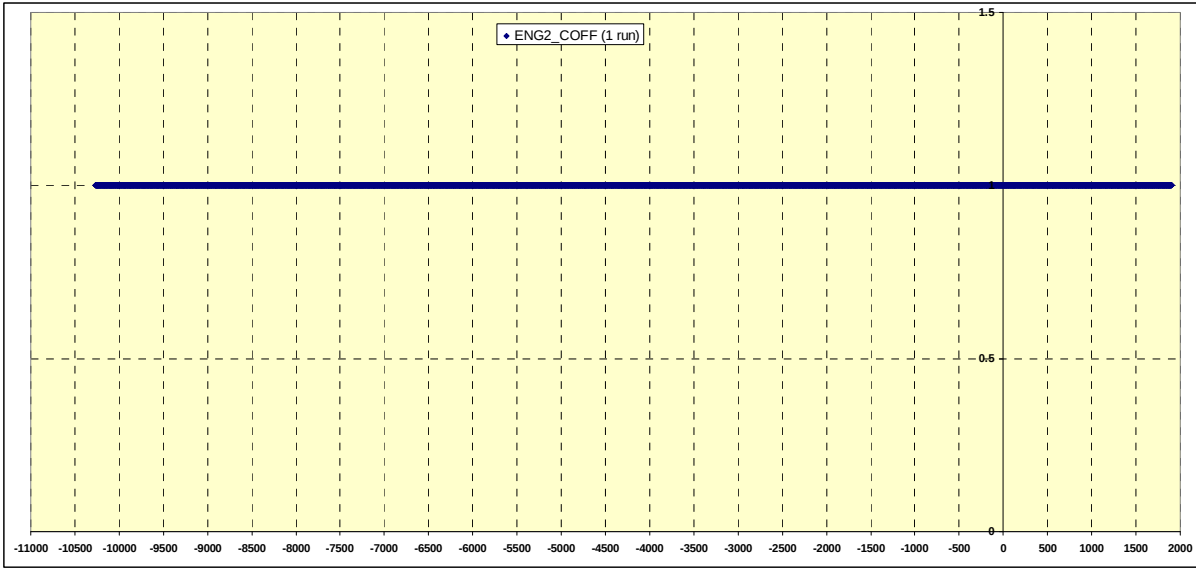


17. CUTOFF (discrete) Engine #1:



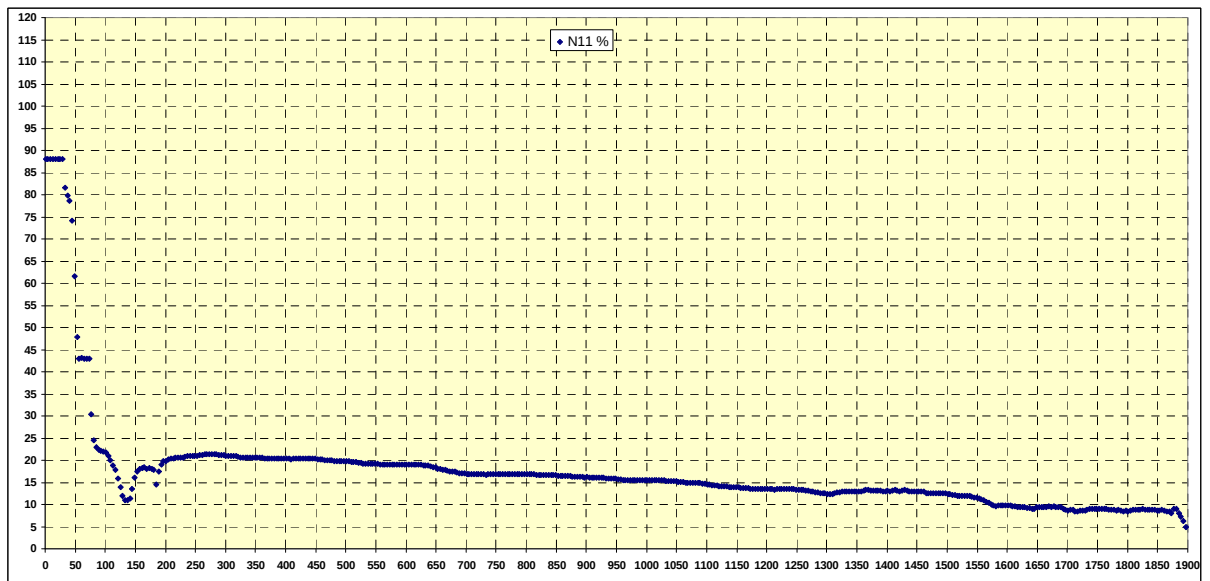
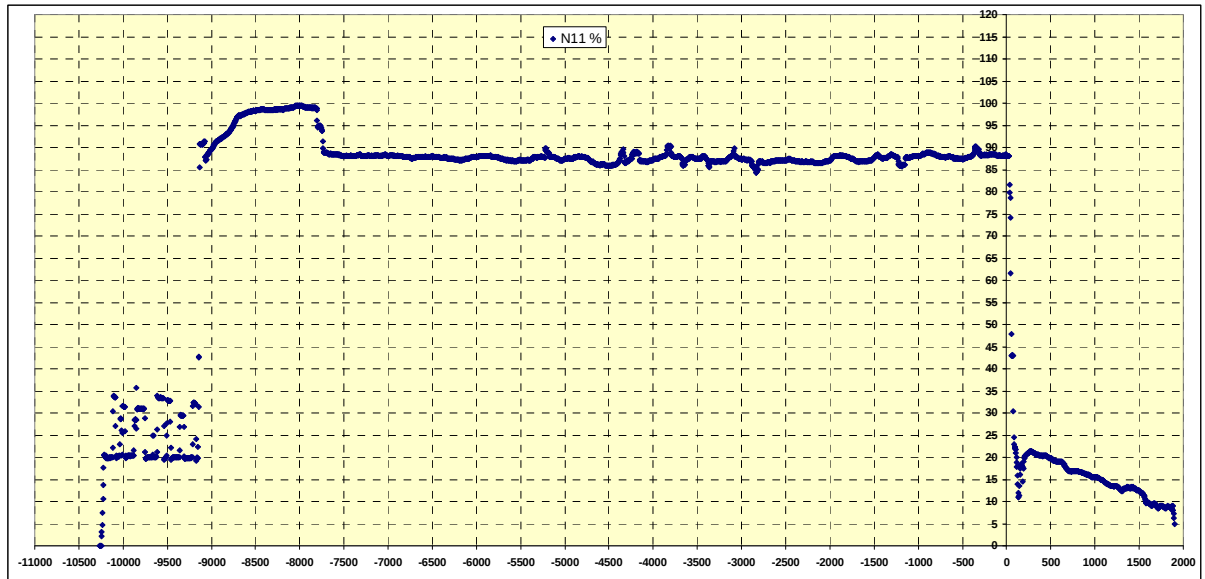
Start lever was moved to shut down position at about 230 seconds (204 seconds after receiving "oil press caution", 201 seconds [3 minutes, 21 seconds] after retarding the throttle lever to idle position)

18. CUTOFF (discrete) Engine #2:



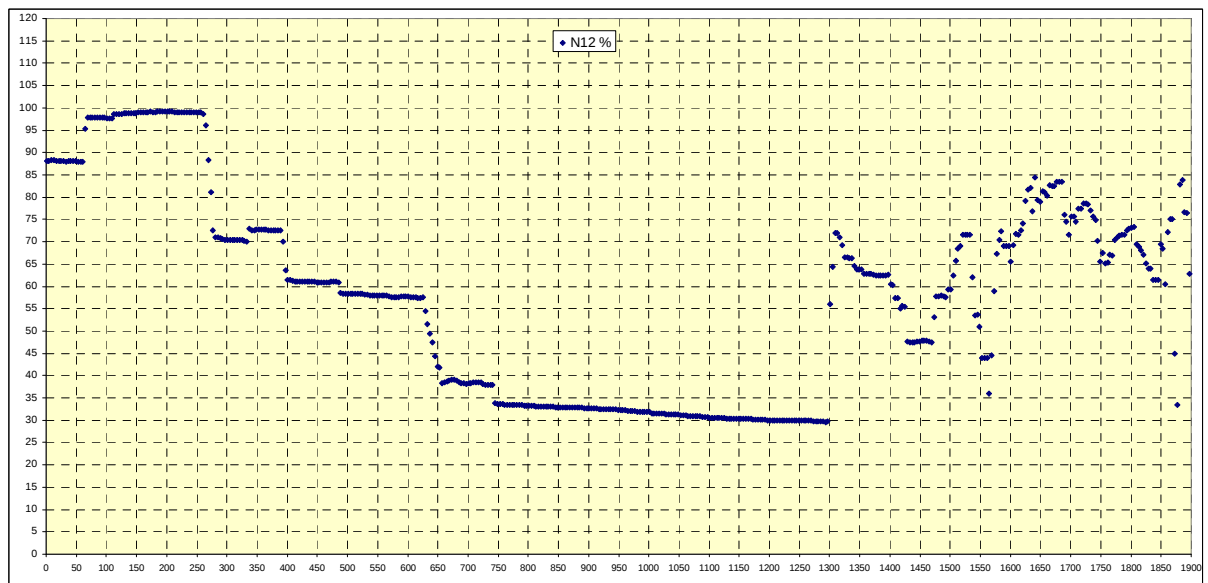
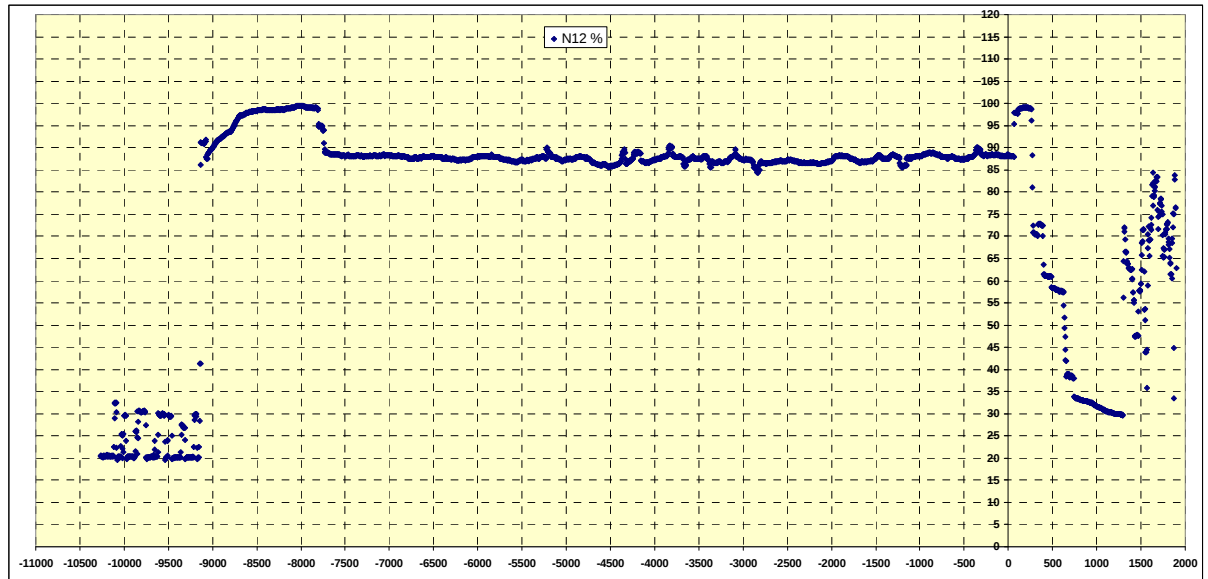
Engine number 2 continued operation up to the end of recording.

19. N1 Engine #1 (N11):



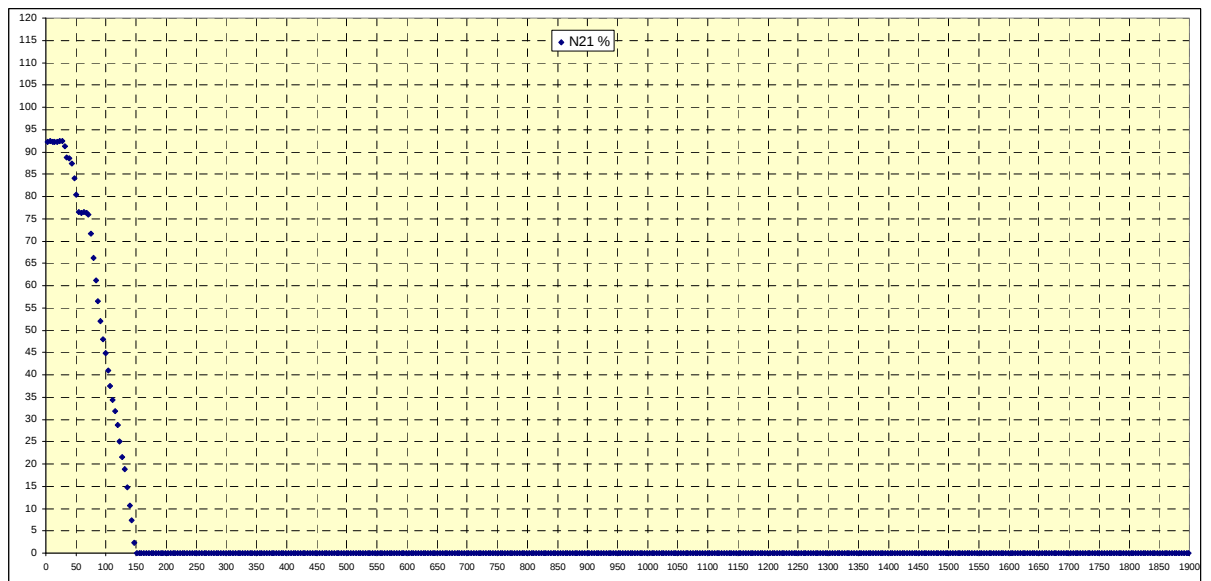
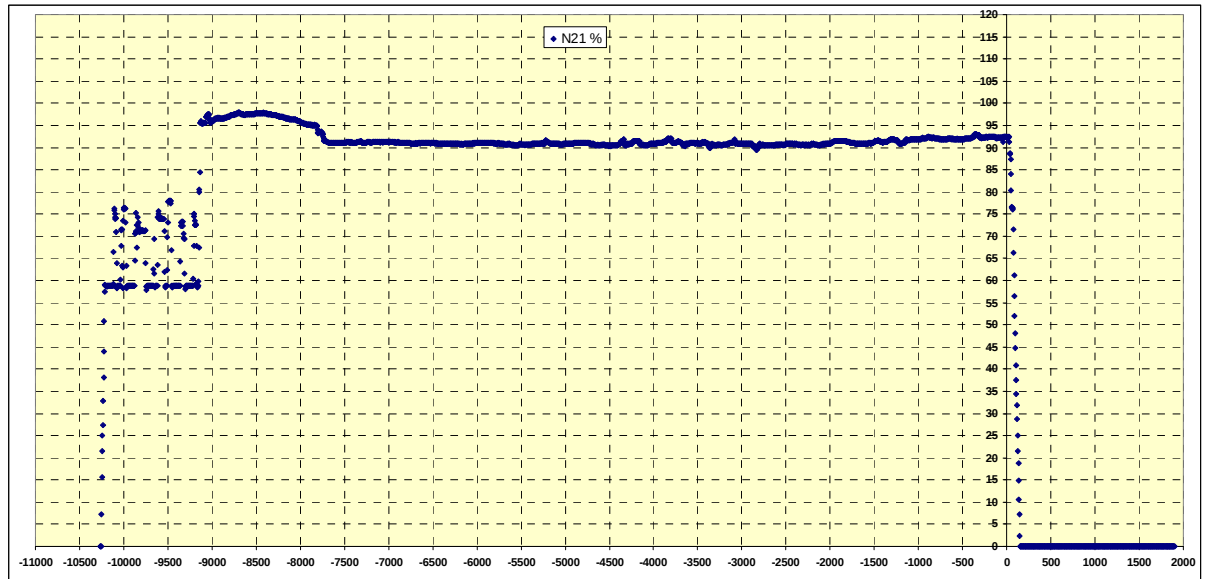
N11 was showing 88 % at zero second (cruise). At almost 29 seconds, the N11 dropped sharply reaching only about 11% at about 133 seconds. N11 varied again from about 20 % up to zero at the end of recording

20. N1 Engine #2 (N12):



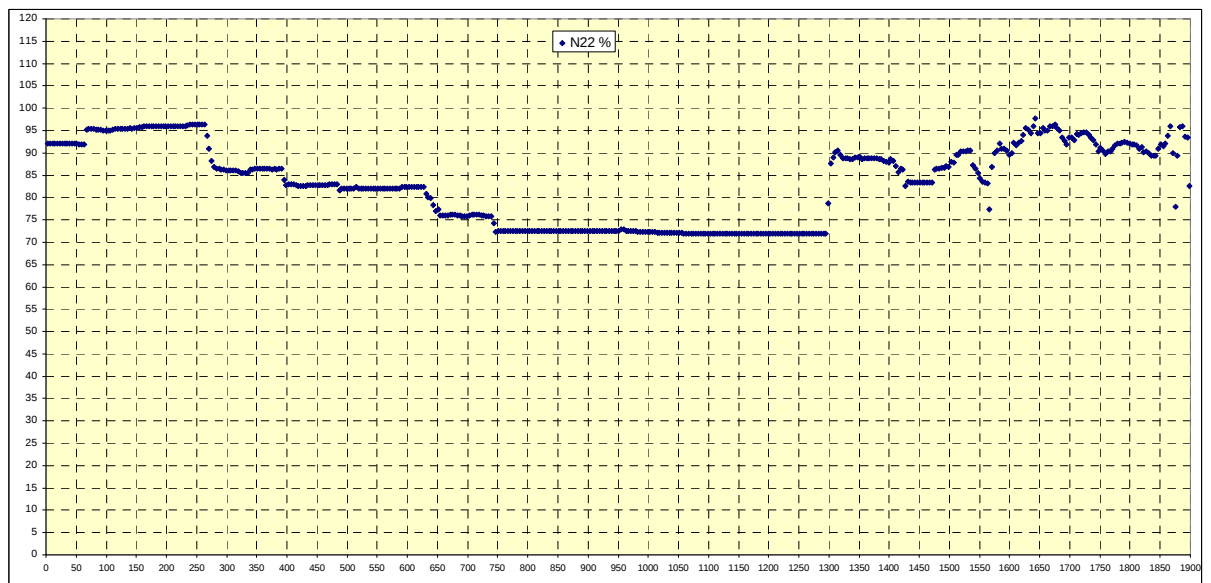
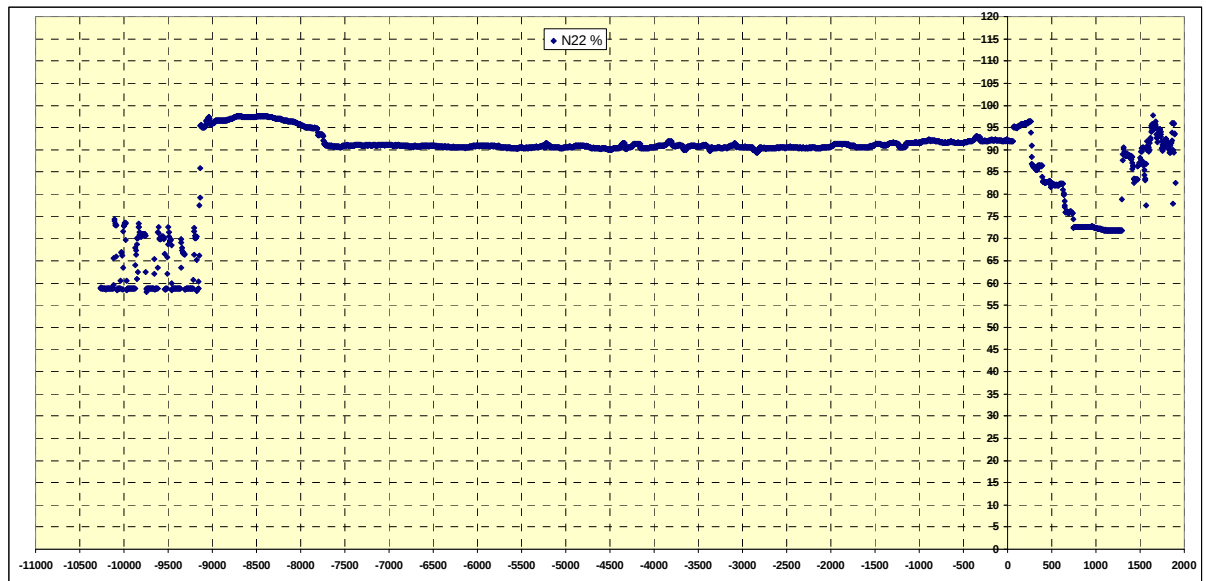
N12 was about 88 % up to about 61 seconds then it started increasing up reaching about 99 %

21. N2 Engine #1 (N21):



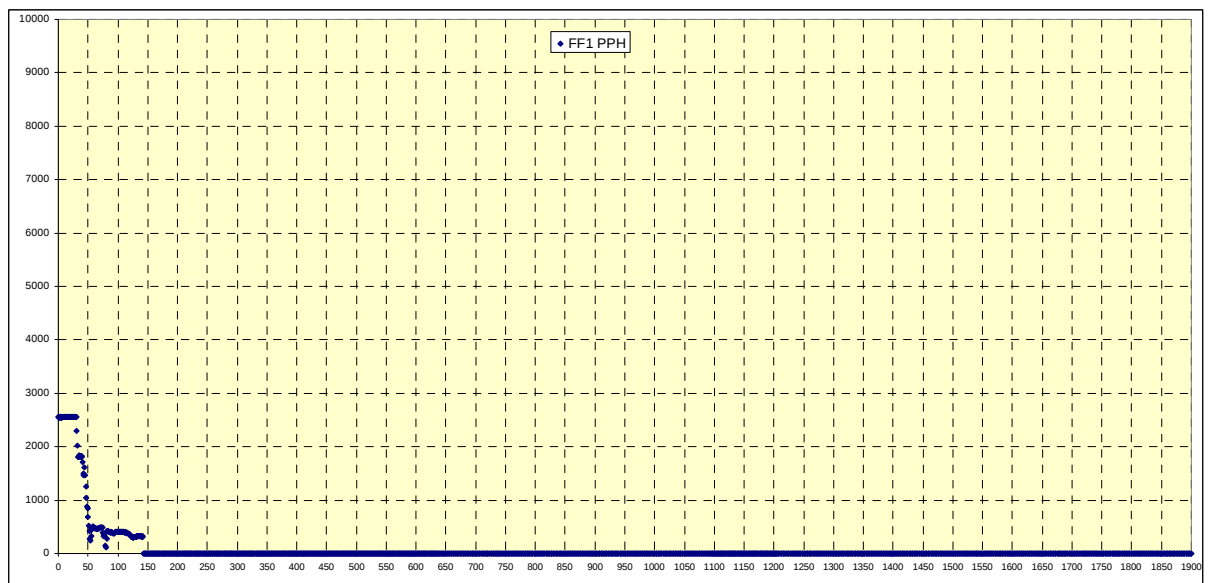
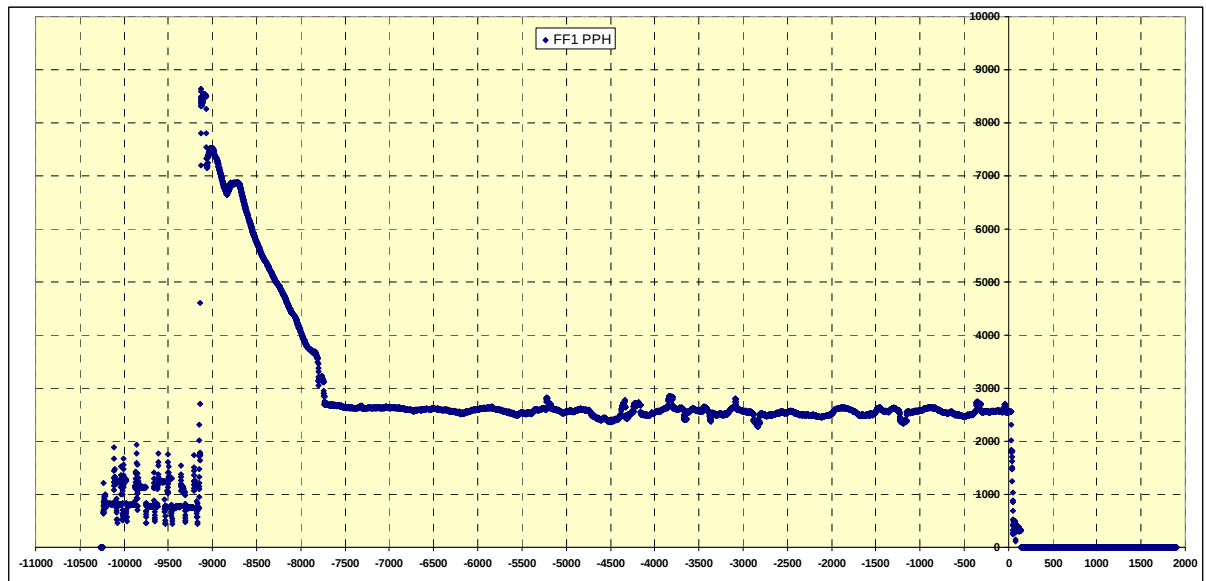
N21 was showing 92 % at zero second (cruise). At almost 27 seconds, the N21 dropped sharply reaching 0% at about 151 seconds.

22. N2 Engine #2 (N22):



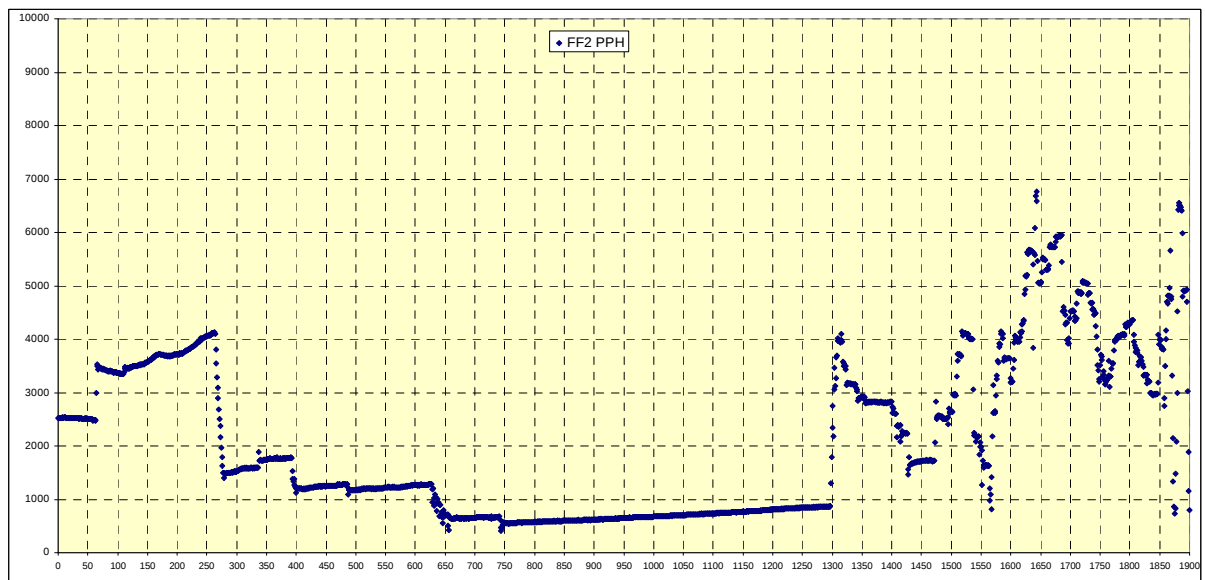
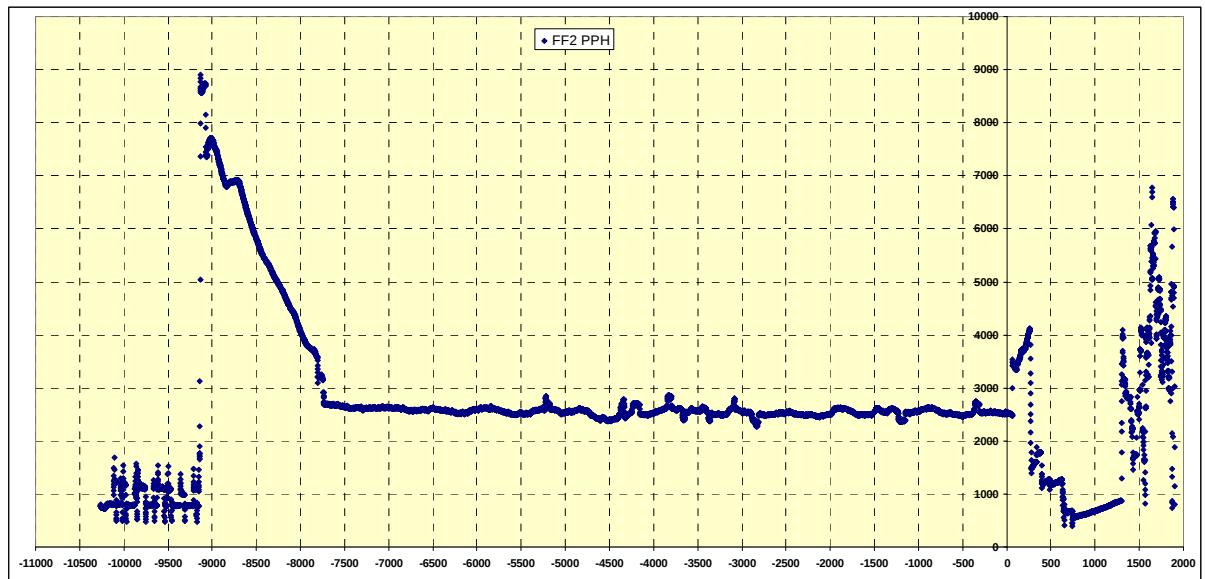
N22 was about 92 % up to about 63 seconds then it started varying after that (max value was almost 96 %, min value was about 72 %).

23. Fuel Flow Engine #1 (FF1):



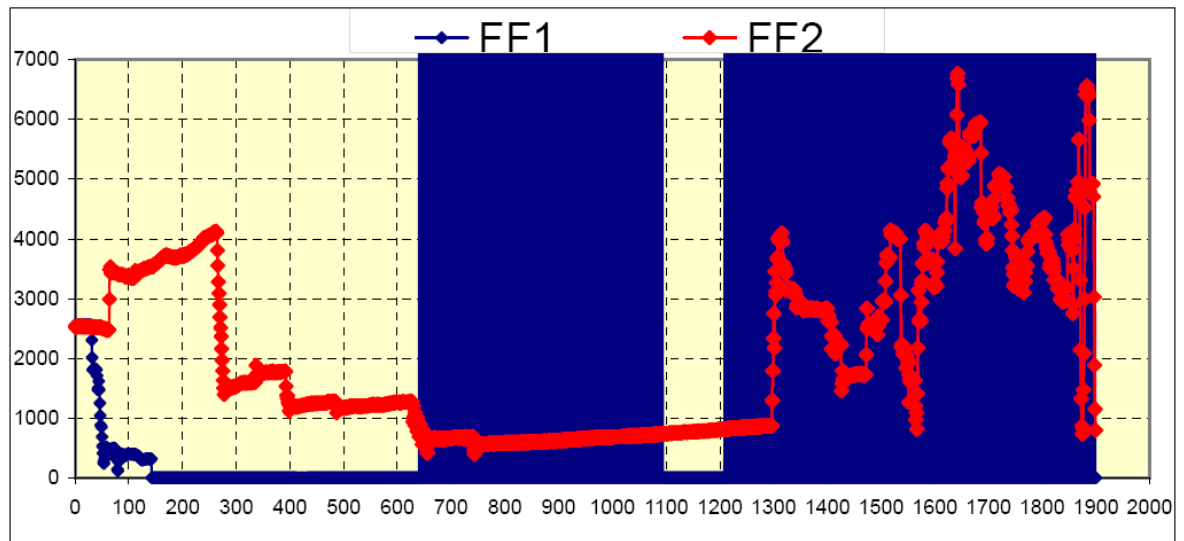
FF1 was about 2560 kg/hr during cruise. At almost 30 seconds, the FF1 dropped sharply reaching zero at almost 143 second (Start lever was moved to cut off at 230 seconds)

24. Fuel Flow Engine #2 (FF2):

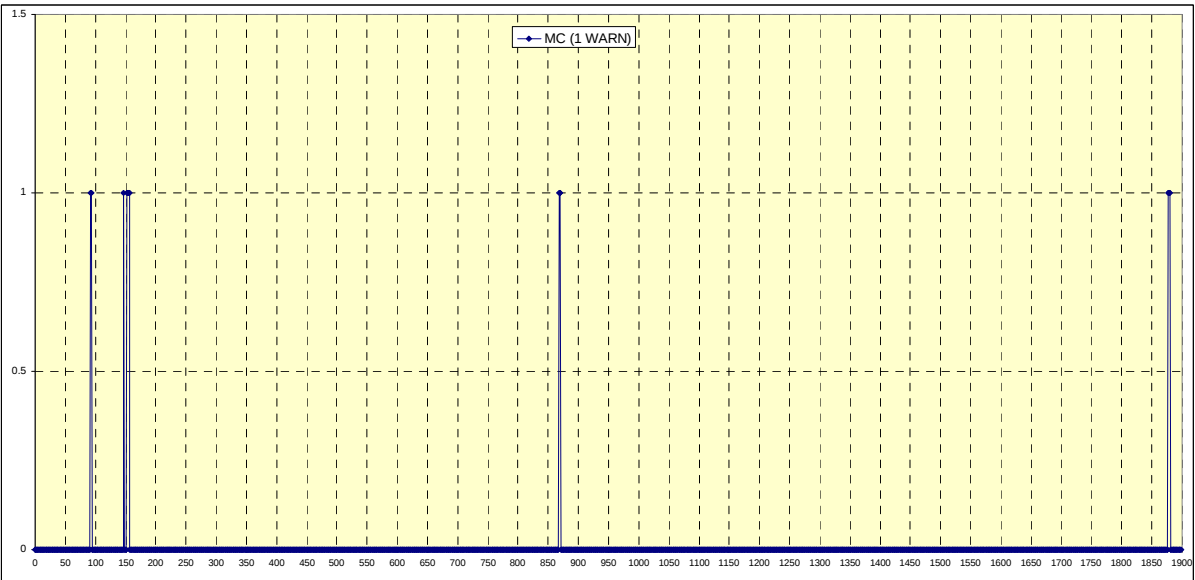
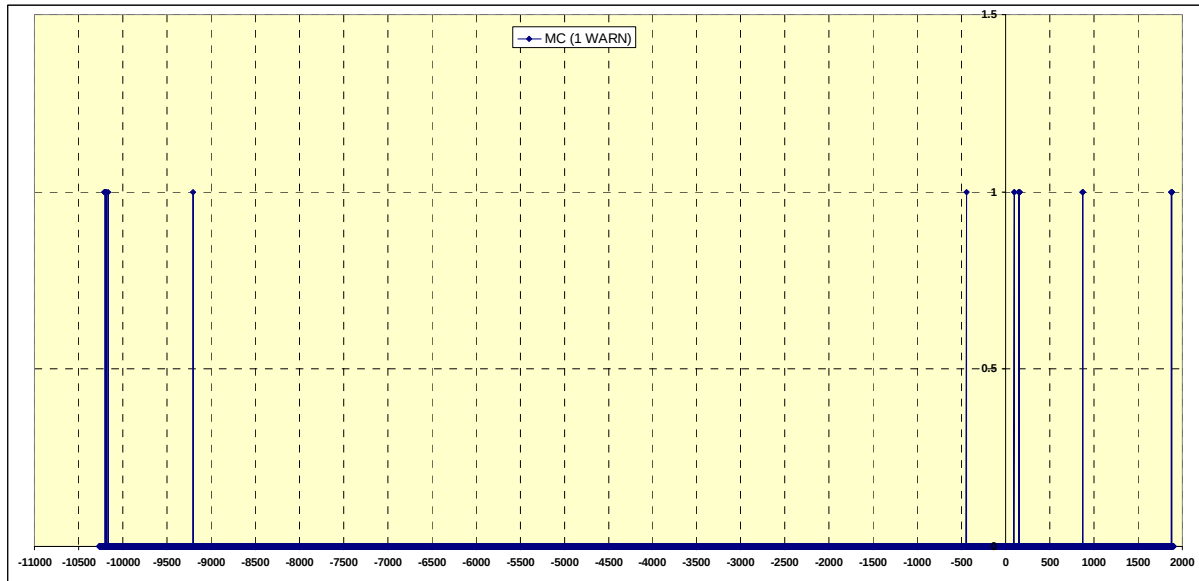


FF2 was about 2528 kg/hr. Then it started varying at almost 63 seconds up to the end of recording.

Combined Fuel Flow Engine #1, Engine #2:



25. Master Warning:



The master warning was shown "On" at several timing as follows:

93, 147, 156, 870, 1880 seconds

1.12 WRECKAGE& IMPACT INFORMATION

- Not Relevant

1.13 MEDICAL& PATHOLOGICAL INFORMATION

- Not relevant

1.14 Fire

- The incident did not result in a fire condition

1.15 SURVIVAL ASPECTS

- No personnel injuries

1.16 TESTS &RESEARCH

- None

1.17 ORGANIZATIONAL& MANAGEMENT INFORMATION

- None

1.18 ADDITIONAL INFORMATION

1.18.1 PILOT REPORT

- During Cruise Engine #1 Failure
 - Low Oil Pressure.
 - Low Oil Qty.
 - Engine Fail Indication.

1.18.2 FLIGHT CREW OPERATIONS MANUAL

- The following text is an extract from the 737 Flight Crew Operating Manual

7.22



737 Flight Crew Operations Manual

ENGINE LOW OIL PRESSURE

LOW OIL
PRESSURE

May or may not be illuminated

Condition: The engine oil pressure is low.

1 Choose one:

◆ Engine oil pressure is in the **yellow band** with **takeoff thrust** set:

Do **not** takeoff.



◆ Engine oil pressure is **at or below** the **red radial**:

▶▶ **Go to the Engine Failure or Shutdown checklist on page 7.14**



Engine Failure or Shutdown

Condition: One of these occurs:

- An engine failure
- An engine flameout
- Another checklist directs an engine shutdown.

- 1 Do an engine shutdown only when flight conditions allow.
- 2 Autothrottle (if engaged) Disengage
- 3 Thrust lever
(affected engine) Confirm Close
- 4 **If** conditions allow:

Run the engine for three minutes at idle thrust.
- 5 Engine start lever
(affected engine) Confirm CUTOFF
- 6 PACK switch (affected side) OFF

This causes the operating pack to regulate to high flow in flight with flaps up.

▼ Continued on next page ▼

1.18.3 Maintenance report regarding the incident:

- The maintenance report regarding the incident included the following:

The pilot reported the following in the technical log book (TLB)

- During Cruise Engine No1 Low Oil Pressure, Low Oil Quantity & Engine Failure Indication
- The aircraft was moved to the maintenance (hanger) shop 7000 for engine #1 examination with the presence of two delegates from Kharkiv Airlines.
- Examination revealed the following:
 - o Engine #1 Oil Tank Empty–
 - o Oil Chips At Oil Chip Detector.
 - o Chips (Metal Particles) At Exhaust.
 - o Fan Rotor Seized

1.18.4 Maintenance carried out on the aircraft:

- Engine #1 was replaced with new overhauled engine as per AMM, found ok.
- Engine #1 operational check was varied out as per AMM, found ok.

1.18.5 Information received from the «Willis Lease» company upon examination of the engine after the event:

- On 23 July, the Aircraft Accident Investigation Central Directorate received a report from Mr Victor Shvets, Accredited Representative, Air Accidents and Incidents Investigations and Mr. Dmitriy Fedosieiev – state inspector, National Bureau of Air Accident and Incident, Investigation of Civil Aircraft of Ukraine, including information about the findings that were obtained by the «Willis Lease» company upon engine examination after the event. (Attached hereafter)



The Power of Flight

ESN 892-707

#3 Ball Bearing Investigation, CFM56-7

March 12, 2014



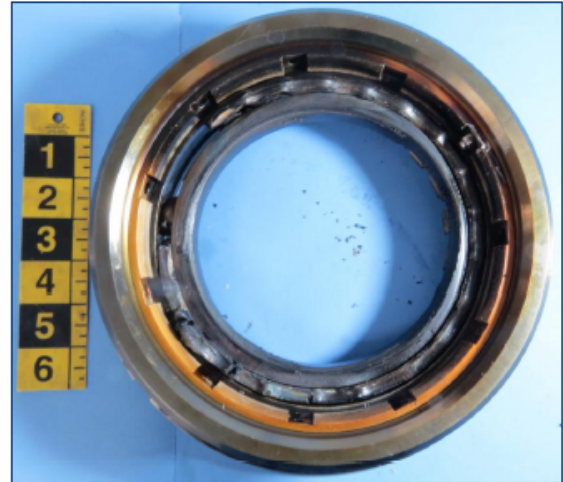
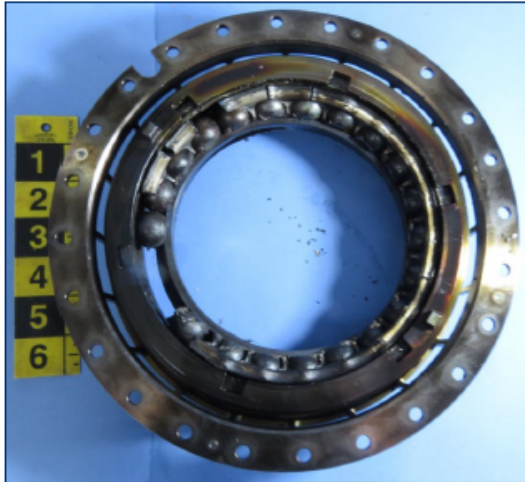
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Event / Engine History



- CFM56-7 engine delivered on March 1, 2007
- UER on Nov 7, 2013 due to IFSD on 10/26/2013
 - TSN/CSN: 13,972/7,127
 - Oil filter analysis: None found in SR
- Engine sent to GE Wales (shop) for Repair
- Bearing sent to GE PSE for investigation
- Engine has one (1) prior shop visits
 - *Nov 22, 2012 – China Eastern returned engine to lease company. However, #3 bearing was not touched per FSE SR attachment.*

Incoming Condition



Hardware Configuration



#3 Ball Bearing
PN: 1665M98P02
SN: MDALM331
TSN: 13972
CSN: 7127

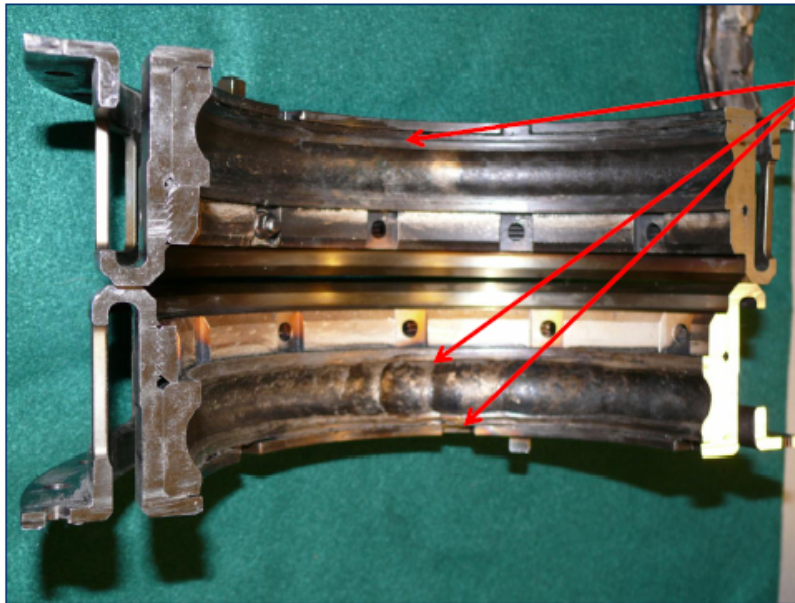
Bearing Observations



- Ball Bearing
 - All components inspected
 - Outer Race
 - Shoulder wear observed
 - Molten ball and cage material deposited on raceway
 - Inner Race
 - Aft inner race exhibited molten ball and cage material deposits
 - Forward inner race showed distortion and extrusion along with ball adherence sliding
 - Cage
 - Circumferentially uniform heat cracks and distortion.
 - Thermally induced fractures at all cage side rails.
 - Balls
 - Flat sliding surfaces exhibited in all balls.
- Photos of relevant surfaces on following pages

5 / CPM Proprietary information subject to restrictions on the cover

Outer Race



Evidence of wear (seen as grooves) on both shoulders. This is caused by hard particles embedding in silver plate of cage and acting as a grinding wheel or cutting tool on outer race

Deposits and smearing of molten rolling element material in raceway
No evidence found of any outer race spallation

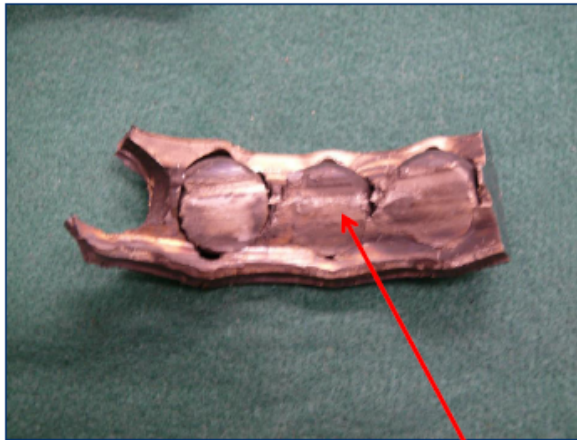
6 / CPM Proprietary Information subject to restrictions on the cover

Inner Races



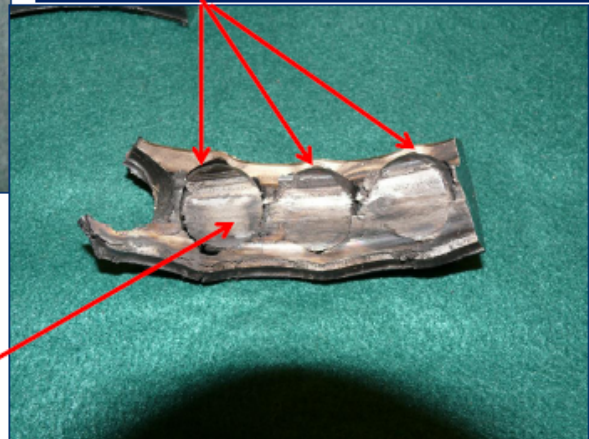
Distortion and extrusion of forward inner race due to the balls sliding and adhering to the surface indicates that the HP rotor was aft loaded at time of failure.

Balls, Cage



Cage shows circumferentially uniform heat distortion. Multiple cage pockets fractured and liberated.

All cage side rails showed cracks or crack initiation with thermally induced distortion



All balls exhibit sliding wear flats. This indicates that rolling elements seized during failure and did not continue to rotate.

8 / CFM Proprietary Information subject to restrictions on the cover

Conclusion



- All visual indications including visible wear on outer race shoulders as well as circumferentially uniform heat damage to bearing cage (i.e. heat distortion and cracking of most side rails) are consistent with a shoulder wear failure mode.
- Sliding wear flats on balls indicate that balls did not continue to rotate during failure which eliminates skidding failure mode.
- Bearing failure occurred at 13,972 hours since production and the bearing has not been exposed. This would be outside the historically seen shop contamination related shoulder wear failures of TSN < 6,000 hrs and most likely indicating environmental hard particle contamination.
 - Oil filter was not available for examination.

Most likely root cause is shoulder wear induced by environmental hard particle debris.

2. ANALYSIS & CONCLUSION

2.1 The Aircraft:

- The aircraft belongs to KHARKIV AIRLINES. The aircraft was operating normal and was eligible for flight, before take off. The aircraft was maintained according to the approved maintenance program.
- As a result of the incident, engine #1 had been damaged and became unserviceable. Engine #1 has been replaced with another engine. The aircraft became serviceable.

2.2 The Aircraft captain:

- The aircraft captain was holding a valid flying license and he was eligible to fly the aircraft according to the approved rules and medically fit. He is experienced on the type, having a number of flying hours on the type Boeing 737-800 at the time of incident of 1320 hour, 34 minute

2.3 The Aircraft First Officer:

- The aircraft F/O was holding a valid flying license and he was eligible to fly the aircraft according to the approved rules and medically fit. His flying hours on the type Boeing 737-800 at the time of incident was 640 hour, 10 minute

2.4 FDR downloads information:

- Main events in chronological sequence, engine #1:

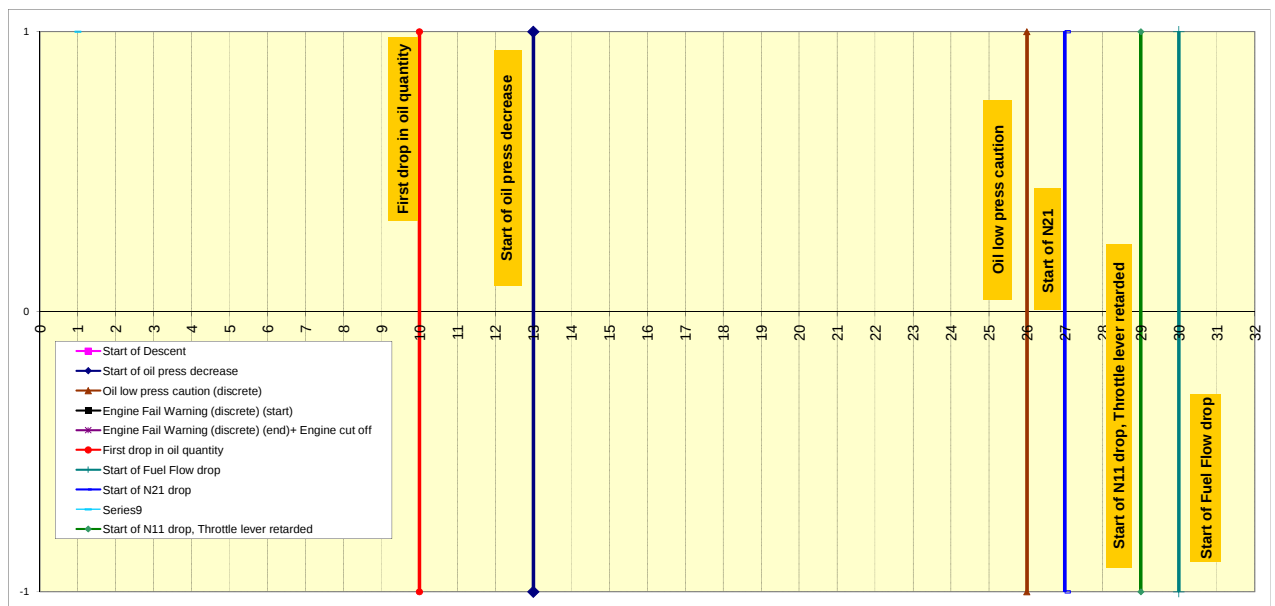
Based on the FDR data, the following table summarizes the main events through the incidents in chronological sequence:

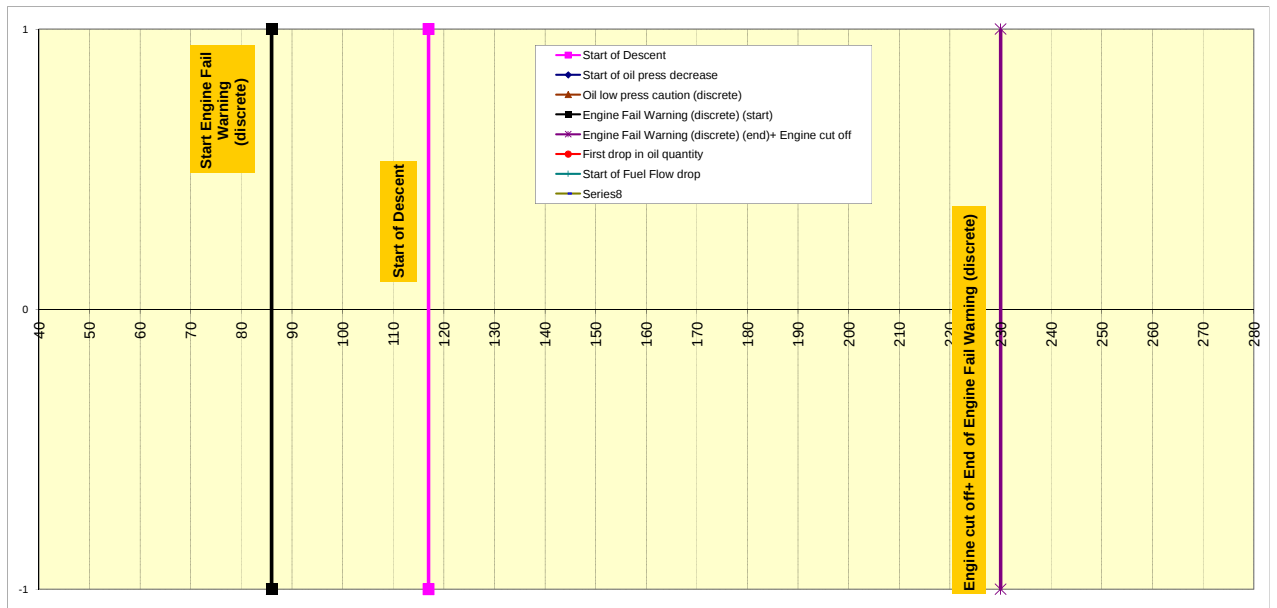
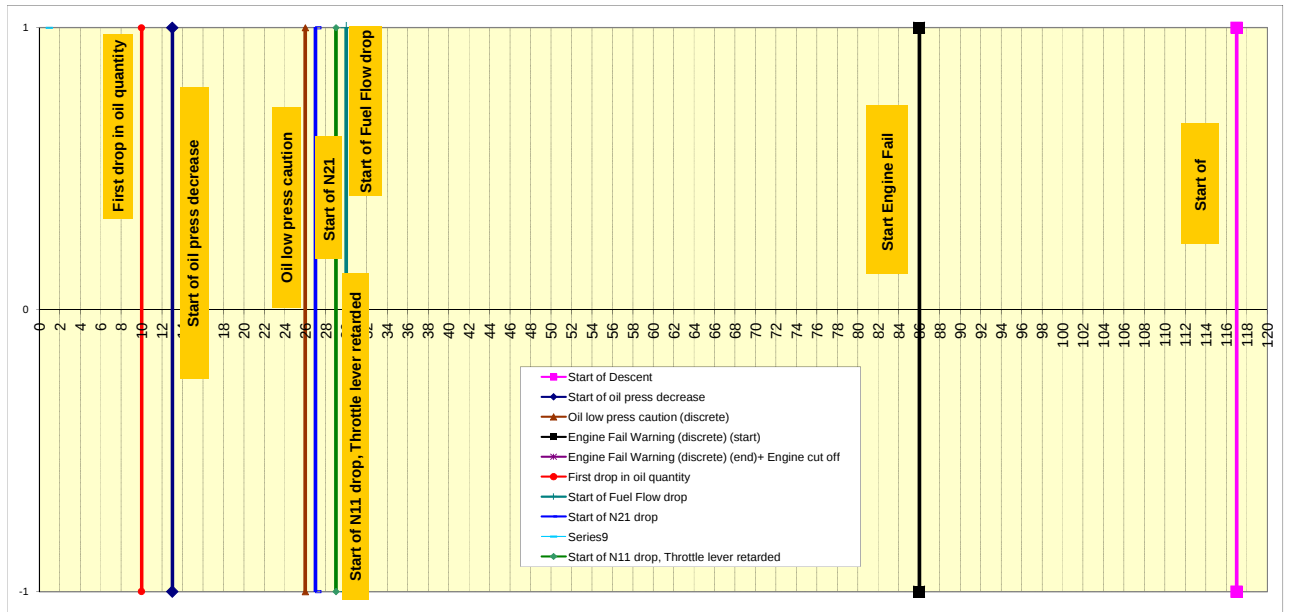
Events	First drop in oil quantity	Start of oil press decrease	Oil low press caution (discrete)	Start of N21 drop	Start of N11 drop, Throttle lever retarded	Start of Fuel Flow drop	Engine Fail Warning (discrete) (start)	Start of Descent	Engine Fail Warning (discrete) (end)+ Engine cut off
Seconds	10	13	26	27	29	30	86	117	230

Main events can be summarized as follows:

- At 10 seconds, the first drop in oil quantity occurred

- At 13 seconds, the oil started press decreasing
- At 26 seconds, the "Oil low press caution (discrete)" came on
- At 27 seconds, the N2 started dropping
- At 29 seconds the N1 started dropping, throttle lever was retarded to idle,
- At 30 seconds, the fuel flow started dropping
- At 86 seconds, the "Engine Fail Warning (discrete)" came on
- At 117 seconds, the aircraft started its descent.
- At 230 seconds, Engine start lever was moved to cut off, 'Engine Fail Warning (discrete)' was terminated.





2.5 The incident:

- The problem started as an oil system problem (start of oil leak, followed by oil press drop, followed by "oil low press caution"). Engine main parameters started dropping (N2 drop, followed by N1 drop, followed by fuel flow drop).
- #1 engine throttle lever was retarded to idle at 29 seconds, i.e. 3 seconds after receiving the "oil low press caution"
- One second later the fuel flow started dropping..
- The engine fail warning came at 86 seconds i.e. 57 seconds after retarding the throttle lever to idle.
- The aircraft started descending at 117 seconds.
- At 230 seconds the start lever was moved to shut down position (204 seconds after receiving "oil press caution", 201 seconds [3 minutes, 21 seconds] after retarding the throttle lever to idle position)
- On landing, #1 engine was at shut down condition, the oil press and the oil quantity were showing zero.
- After the aircraft landing, the Maintenance engineer, belonging to "EgyptAir Company for Maintenance and technical Services" which is assigned to provide the maintenance service to the aircraft, inspected the aircraft. He found damage in engine #1 making the engine unserviceable. Consequently, he reported an engine #1 replacement. Engine #1 was replaced, tested. The aircraft became serviceable for flight.

2.6 Flight Crew Operations Manual (FCOM) instructions

- The following instructions are included in the B737 FCOM in case of engine low press during flight:
 - In the case of engine oil pressure is at or below the red radial, go to the engine failure or shutdown checklist (on page 7.14)
- The engine failure or shutdown checklist includes the following instructions:
 - Do an engine shutdown only when flight conditions allow.
 - Autothrottle (If engaged), disengage.
 - Thrust lever (affected engine) Confirm close.
 - If conditions allow: Run the engine for three minutes at idle thrust
 - Engine start lever (affected engine) Confirm Cutoff
 - APU should be started.
 - Go to the "One Engine Inoperative Landing" checklist.

2.7 Flight Crew behavior through the event:

- Based on the shown FDR data, the following can be concluded.
- The flight crew retarded the throttle lever to idle timely, and then they shut down the engine as per the FCOM relevant checklist instructions. Engine shut down was carried out, 3 minutes, 21 seconds after retarding the throttle lever to idle position.
- The FCOM relevant check list states "If conditions allow: Run the engine for three minutes at idle thrust". The throttle retardation to idle was a little bit late with reference to FCOM instructions (about 21 seconds). This might be related to high work loads at this condition and other cockpit tasks

3. INCIDENT PROBABLE CAUSE

3.1 INCIDENT PROBABLE CAUSE

- Eng. # 1 oil leakage due to #3 bearing failure due to shoulder wear induced by environmental hard particle debris.

4. SAFETY RECOMMENDATIONS

4. SAFETY RECOMMENDATIONS:

The Egyptian Aircraft Accident Investigation Central Directorate recommends the Ukrainian Aircraft Accident Investigation to follow up inspection procedures that would be amended/added by engine manufacturer regarding the event.