Havarikommissionen
Accident Investigation Board Denmark

Report 2020-424

Serious incident to OE-IMI (Dassault Falcon 900EX) in Kangerlussuaq (BGSF) on 3-12-2020.

ISSUED NOVEMBER 2021

INTRODUCTION

This report reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of EU Regulation 996/2010, the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the safety investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The safety investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this report for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

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GENERAL

State file number:	2020-424
UTC date:	3-12-2020
UTC time:	18:32
Occurrence class:	Serious incident
Location:	Kangerlussuaq (BGSF)
Injury level:	None
Aircraft registration:	OE-IMI
Aircraft make/model:	Dassault Falcon 900EX
Current flight rules:	Instrument Flight Rules (IFR)
Operation type:	Private
Flight phase:	Landing
Aircraft category:	Fixed wing
Last departure point:	Vienna (LOWW)
Planned destination:	BGSF
Aircraft damage:	Minor
Engine make/model:	3 x Honeywell TFE731-60

SYNOPSIS

Notification

All times in this bulletin are UTC.

On 3-12-2020 at 21:21 hours (hrs), the commander notified the Aviation Unit of the Danish Accident Investigation Board (AIB) of the serious incident.

The Danish AIB notified the Danish Transport, Construction and Housing Authority (DTCHA), the Austrian Federal Safety Investigation Authority (FSIA), the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA), the European Aviation Safety Agency (EASA), the Directorate-General for Mobility and Transport (DG MOVE), and the International Civil Aviation Organization (ICAO) on 4-12-2020 at 09:43 hrs.

The FSIA and the BEA accredited non-travelling representatives to the AIB safety investigation.

Summary

Conditions for application of the recommended, but not required, "Operation on Contaminated Runways" procedure were present at departure.

The flight crew partially applied the procedure, and the aircraft touched down with three frozen blocked brakes resulting in loss of directional control and rupture of hydraulic brake unit lines.

The serious incident occurred in darkness and under Visual Meteorological Conditions (VMC).

In the effort of preventing future landing scenarios with frozen brakes, the AIB issued two safety recommendations.

1 FACTUAL INFORMATION

1.1 History of flight

The serious incident occurred during a private IFR flight from Vienna (LOWW) to Kangerlussuaq (BGSF).

On the serious incident flight, the commander, in accordance with operator procedures, sat in the right-hand (RH) pilot seat and acted as Pilot Monitoring (PM). The first officer sat in the left-hand (LH) pilot seat and acted as Pilot Flying (PF). The first officer was the holder of a commander rating as well.

Approximately 1½ hours before departure, personnel towed the aircraft out of the hangar and parked it in the General Aviation (GA) area.

Arriving at the aircraft, the flight crew noticed light contamination on the aircraft and the beginning of light precipitation. For that reason, the flight crew decided to perform a de- and anti-icing of the aircraft.

Block-off time was 12:44 hrs.

During taxi to the remote de-icing stand and from the remote de-icing stand to runway 16, the flight crew observed few millimetres (mm) of snow/slush on the platform in the GA area and light contamination of snow/slush on the remote de-icing stand. Otherwise, the taxiways and runway 16 were clear.

The two-step de- and anti-icing procedure (type I and type IV) started at 12:54 hrs and ended at 12:59 hrs.

To the flight crew, the perceived presence of on ground contamination in LOWW was limited and did not require application of the “Operations on contaminated runways” procedure.

In take-off position on runway 16, the flight crew performed a static take-off.

At 13:05 hrs, the aircraft got airborne and shortly after, the flight crew selected the wing anti-icing system to ON, and due to the previous de-icing of the aircraft, the brake heating system to ON as well.

Approximately three minutes after departure, passing approximately 7,700 feet (pressure altitude), and after climbing through a thin cloud layer, the flight crew selected the wing anti-icing and the brake heating systems to OFF and continued climbing toward the cruising level.

The climb and cruise phase of the flight was uneventful.

At initial radio contact with Sondrestrom Approach (126.200 MegaHertz (MHz)), the approach controller communicated the following landing details:

- To expect radar vectors for the Localizer (LLZ) or visual approach for landing on runway 09.
- Wind conditions to be 100° and 12 knots (kt).
- Meteorological visibility to be more than 10 kilometres (km).
- No clouds detected.
- Temperature -15° Celcius (C) and dewpoint -20° C.
- QNH 1027 hectopascal (hPa).
- Transition Level 90.

- Runway 09 contaminated 25% of 3 millimetres (mm) compacted or rolled snow, and 10% of 3 mm ice. Braking Action (BA) for runway 09: 85, 85, and 85 measured by Tapleymeter. Taxiway A and apron north BA good.

The flight crew considered the weather and runway conditions to be good and that there was no need for using the anti-icing systems during neither the descent nor the approach.

The flight crew performed an approach briefing for the LLZ approach for runway 09 and completed the descent checklist. The descent phase was uneventful. New reported QNH was 1026 hPa.

The approach controller radar vectored the aircraft for the LLZ approach for runway 09, and the flight crew completed the approach checklist.

The flight crew obtained visual contact with the runway system. However, they decided to continue flying the LLZ approach procedure.

The approach phase was uneventful.

The approach controller reported the wind conditions to be 110° and 7 kt and cleared the aircraft to land on runway 09.

The flight crew completed the final checklist.

On final for runway 09, the aircraft was stabilized in landing configuration. Throughout the final approach, the flight crew had visual contact with the approach and runway lighting system for runway 09.

Immediately upon touchdown of the main wheels, the PF lost aircraft directional control, and the aircraft uncontrollably started veering to the left. After touchdown of the nose wheel, it was the perception of the flight crew that no braking capability was available.

The flight crew in cooperation managed to regain directional control, and due to their suspicion that the aircraft had been exposed to a flat tire, they decided to vacate the runway via taxiway C.

On taxiway C, the flight crew stopped the aircraft for further inspection.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal			
Serious			
None	3		

1.3 Damage to aircraft

There were damages to the main wheel rims and tires #1 and #2 (LH), the associated hydraulic brake unit lines (LH), the LH Main Landing Gear (MLG) door, and the main wheel tire #4 (RH).

Figure 1. Damages to the main wheel rims and tires and the hydraulic brake unit lines (LH side)

Figure 2. Damage to the main wheel tire (RH side)

1.4 Other damage

Blocked aircraft main wheels and disintegrated main wheel tires caused tire rubber skid marks and sporadic scratches on runway 09 and taxiway C. See section 1.12.1.1.

1.5 Personal information

1.5.1 The commander

1.5.1.1 Licence and medical certificate

The commander – male, 45 years – was the holder of a valid Airline Transport Pilot Licence (ATPL (A)) initially issued by the Civil Aviation Authority Netherlands on 6-11-2007.

The ATPL (A) contained the following rating:

- Falcon 50/900/IR/PBN valid until 31-1-2022.

The medical certificate (class 1) was valid until 19-8-2021. The medical certificate held no limitations.

1.5.1.2 Flying experience

	Last 24 hours	Last 90 days	Total
All types	8:30	100:00	6,774:00
This type	8:30	100:00	2,700:00
Landings this type	1	51	-

1.5.1.3 Flying experience at the operator

Falcon 900EX: 2,400 hrs

E135: 500 hrs

1.5.1.4 Operator training

- On 21-11-2020, the commander performed a combined Licence Proficiency Check (LPC)/Operator Proficiency Check (OPC).
- On 9-7-2020, the commander performed his latest line check.
- On 29-3-2020, the commander performed his latest Cold Weather Operations (CWO) training.

1.5.1.5 Flight and duty time (FDT)

Before departure from LOWW, the commander felt at ease and well rested.

AIB extracted FDT data – see appendix 5.1.

NOTE: The AIB removed the name of the operator and the commander.

1.5.2 The first officer

1.5.2.1 Licence and medical certificate

The first officer – male, 43 years – was the holder of a valid Airline Transport Pilot License (ATPL (A)) initially issued by Austro Control GmbH on 26-5-2017.

The ATPL (A) contained the following ratings:

- Falcon 50/900/IR valid until 20-6-2021.
- C525 PIC/IR valid until 30-9-2021.

The medical certificate (class 1) was valid until 16-6-2021. The medical certificate held no limitations.

1.5.2.2 Flying experience

	Last 24 hours	Last 90 days	Total
All types	8:25	66:00	5,352:36
This type	8:25	58:00	1,500:00
Landings this type	1	12	-

1.5.2.3 Flying experience at the operator

Falcon 900EX: 1,500 hrs.

C525: 1,720 hrs.

1.5.2.4 Operator training

- On 27-6-2020, the first officer performed a combined LPC/OPC.
- On 13-5-2020/19-5-2020, the first officer performed his latest line check.
- On 19-11-2020, the first officer performed his latest CWO training.

1.5.2.5 Flight and Duty Time (FDT)

Before departure from LOWW, the first officer felt at ease and well rested.

AIB extracted FDT data – see appendix 5.2.

NOTE: The AIB removed the name of the operator and the first officer.

1.5.3 Flight crew training on the brake heating system

The flight crew received familiarization training on use of the brake heating system ensuring system and operational knowledge.

The flight crew training simulator used by the operator was not equipped with a brake heating system.

The flight crew CWO training contained discussions on use of the brake heating system.

1.6 Aircraft information

1.6.1 General information

Manufacturer:	Dassault Aviation
Type:	Falcon 900EX
Serial number:	087
Manufactured in year:	2001
Airworthiness review certificate:	Valid until 3-9-2021
Engine manufacturer:	Honeywell
Engine type:	TFE731-60
Maximum take-off mass (MTOM):	49,000 pounds (lbs)
Maximum landing mass (MLM):	44,500 lbs
Fuel on board (at take-off):	20,800 lbs
Aircraft total flight hours at take-off:	7,770:19 hrs

1.6.2 Maintenance on the brake system

Brake #2 and brake #4 were replaced on 13-10-2020 at 7,707:20 hrs during a scheduled maintenance check.

1.6.3 Mass and balance

Before departure from LOWW, the flight crew prepared a mass and balance calculation – see appendix 5.3.

NOTE: The AIB removed flight crew names and signatures.

1.6.4 Landing performance

Landing performance data for runway 09 at BGSF – see appendix 5.4.

1.6.5 Brake heating system

1.6.5.1 General information

The aircraft was equipped with a brake heating system. The purpose of the system was to heat and dry the brakes in case of contamination from water, snow, slush etc.

The system was not incorporated on all Falcon 900 aircraft, but the aircraft manufacturer incorporated the system as a basic feature on OE-IMI during production.

The system used bleed air from the engines. On each wing anti-ice duct, downstream of the wing anti-icing valve, a pick-off provided brake unit heating. The brake heating system could only be operated, when the wing anti-icing system was operating.

The descriptions in section 1.6.5.1, 1.6.5.2, and 1.6.5.3 are extracts from the Falcon 900EX Crew Operational Documentation for Dassault non EASy (CODDE 1) section 30-90 issued on 8-3-2017.

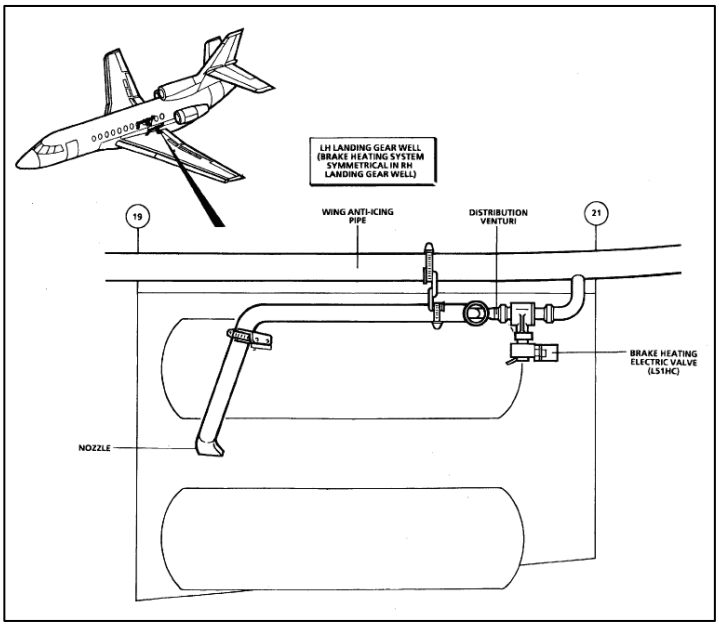


Figure 3. Graphic illustration of the brake heating system

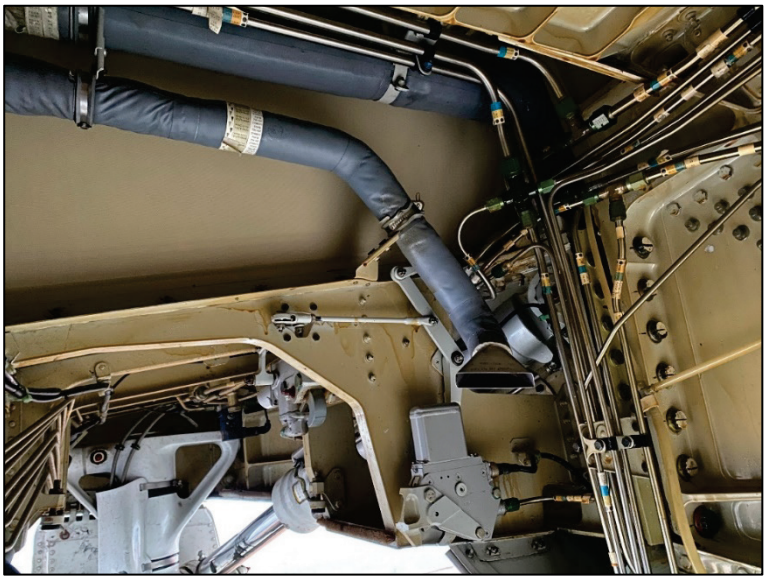


Figure 4. The brake heating system duct and nozzle in the wheel well

1.6.5.2 Location of cockpit controls

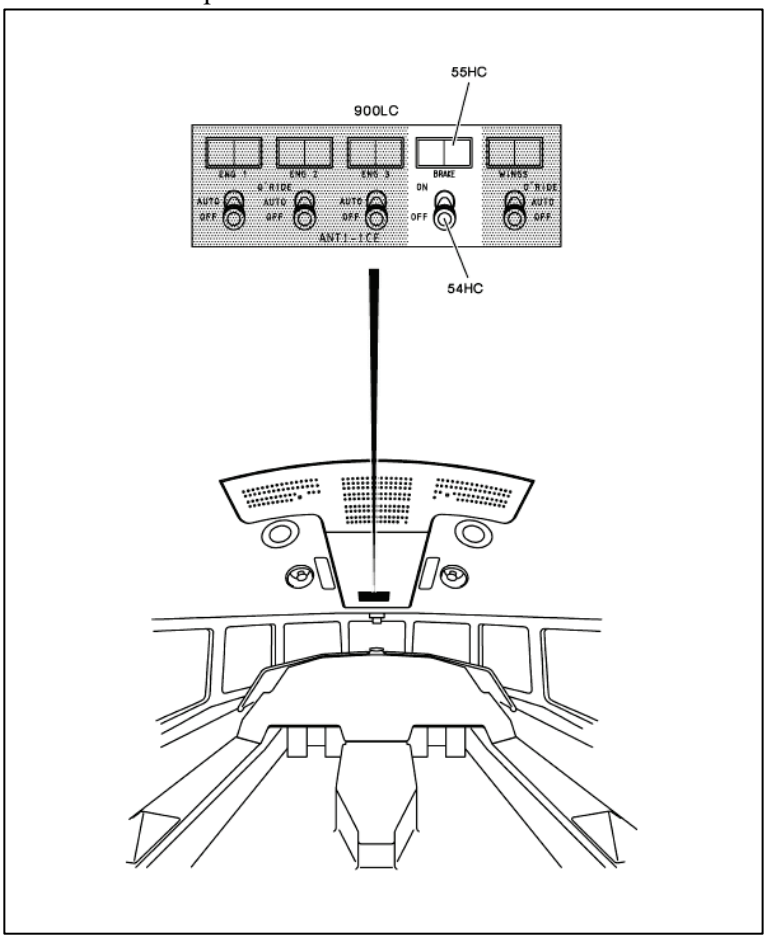


Figure 5. Location of cockpit controls

1.6.5.3 Function of cockpit controls

A. "ANTI-ICE - BRAKE" switch (**54HC**)

(1) Set to "OFF"

Both brake heating valves (**L51HC**) and (**R51HC**) are closed: the brake heating system is not active.

(2) Set to "ON"

Both brake heating valves (**L51HC**) and (**R51HC**) are open: the brake heating system is active.

B. BRAKE light (**55HC**)

(1) Green light

(a) Green light extinguished

"ANTI-ICE - BRAKE" switch (**54HC**) is set to "OFF": the brake heating system is not active.

(b) Green light illuminated

"ANTI-ICE - BRAKE" switch (**54HC**) is set to "ON": the brake heating system is active.

(2) Amber light

(a) Amber light extinguished

1 "ANTI-ICE - BRAKE" switch (**54HC**) is set to "OFF": the brake heating system is not active.

2 "ANTI-ICE - BRAKE" switch (**54HC**) is set to "ON", the brake heating system is active. There is no failure in the brake heating system.

(b) Amber light illuminated

"ANTI-ICE - BRAKE" switch (**54HC**) is set "ON", the brake heating system is active. Illumination of the amber light indicates either that wing anti-icing valve (**3HJ**) is not fully open or that one brake heating valve (**L51HC**)/(**R51HC**) is not open.

NOTE: Simultaneously with amber light illumination, the green light extinguishes, thus indicating a failure of the brake heating system.

Figure 6. Function of cockpit controls

1.6.6 Airplane Flight Manual (AFM)

The AFM was authority-approved by EASA.

1.6.6.1 Flight procedures

The following extracts are from AFM revision 15 issued on 16-11-2018.

AFM section 4-150 – Normal Procedures – Flight Procedures

After take-off, cruise, descent, and approach – see appendix 5.5.

NOTE: The AIB inserted a yellow marking on the use of brake heating.

1.6.7 Falcon 900EX Operational Documentation

The Falcon 900EX Crew Operational Documentation for Dassault non EASy (CODDE 2) was to be reviewed by a National Aviation Authority during an operator approval process.

1.6.7.1 Flight procedures - Brake heating system

The following extracts are from the Falcon 900EX CODDE 2 revision 5 issued on 16-11-2018.

03-05-40 – Normal Operations – Flight Phases – Taxi

NOTE

If the aiplane:
- Has been parked for a period of time in conditions that could have resulted in moisture contamination of the wheel and brake assemblies and whenever this contamination is suspected, or,
- Uses ramps and/or taxiways contaminated by standing water (regardless of the OAT), slush or snow (whatever the runway surface condition will be when take-off is accomplished),

It is recommended to follow the "taxi", "after take-off", "descent" and "before landing" procedures described in the **OPERATIONS ON CONTAMINATED RUNWAYS** procedure (section 03-15-25), even if the conditions at the day/time of departure would not require the use of those procedures. This should prevent possible freezing of the brakes. ➔

Figure 7. Extract from CODDE 2 section 03-05-40

03-05-70 - Normal Operations – Flight Phases – After take-off

➔ **2. ANTI-ICE BRAKE**

If the airplane:
- Has been parked for a period of time in conditions that could have resulted in moisture contamination of the wheel and brake assemblies and whenever this contamination is suspected,

or,
- Has used ramps, taxiways and/or runways contaminated by standing water (regardless of the OAT), slush or snow,

it is recommended to follow the "after take-off" procedure described in the OPERATIONS ON CONTAMINATED RUNWAYS sub-sub-section, even if the conditions at the day/time of departure would not require the use of those procedures. This should prevent possible freezing of the brakes.

Figure 8. Extract from CODDE 2 section 03-05-70

03-05-80 - Normal Operations - Flight Phases - Climb, Cruise, Descent – Descent

➔ **1. ANTI-ICE BRAKE**

If the airplane:
- Has been parked for a period of time in conditions that could have resulted in moisture contamination of the wheel and brake assemblies and whenever this contamination is suspected, or,
- Has used ramps, taxiways and/or runways contaminated by standing water (regardless of the OAT), slush or snow,

it is recommended to follow the "Descent" procedure described in the **OPERATIONS ON CONTAMINATED RUNWAYS** procedure (section 03-15-25), even if the conditions at the day/time of departure and arrival would not require the use of those procedures. This should prevent possible freezing of the brakes. ➔

Figure 9. Extract from CODDE 2 section 03-05-80

03-05-100 - Normal Operations - Flight Phases - Landing - Before landing

If the airplane:
- Has been parked for a period of time in conditions that could have resulted in moisture contamination of the wheel and brake assemblies and whenever this contamination is suspected, or,
- Has used ramps, taxiways and/or runways contaminated by standing water (regardless of the OAT), slush or snow,

it is recommended to follow the "before landing" procedures described in the **OPERATIONS ON CONTAMINATED RUNWAYS** procedure (section 03-15-25), even if the conditions at the day/time of departure and arrival would not require the use of those procedures. This should prevent possible freezing of the brakes. ➔

Figure 10. Extract from CODDE 2 section 03-05-100

03-15-25 - Normal Operations - Special Procedures - Operations on contaminated runways. See appendix 5.6.

NOTE: The AIB inserted a yellow marking on the use of brake heating.

1.7 Meteorological information

1.7.1 Terminal Aerodrome Forecast (TAF) for LOWW and BGSF

TAF AMD LOWW	031001Z 0310/0415 12007KT 2500 BKN020 TX04/0415Z TNM02/0311Z TEMPO 0310/0312 4500 -FZDZ -SN BKN004 BECMG 0312/0314 BKN004 TEMPO 0313/0320 -DZSN OVC003 PROB30 TEMPO 0313/0320 0900 -FZDZ BECMG 0323/0402 16018KT
TAF LOWW	031115Z 0312/0418 12006KT 5000 BKN010 TX03/0418Z TNM01/0315Z TEMPO 0312/0320 2000 -DZSN OVC003 PROB40 TEMPO 0312/0320 1200 -FZDZ BECMG 0323/0402 16018KT TEMPO 0406/0418 16020G33KT BECMG 0410/0413 FEW020=
TAF BGSF	030509Z 0306/0323 06010KT 9999 FEW200=
TAF BGSF	031059Z 0312/0323 06010KT 9999 FEW200=
TAF BGSF	031659Z 0318/0323 06010KT 9999 FEW200=

1.7.2 Aviation Routine Weather Report (METAR) For LOWW and BGSF

METAR LOWW	031120Z 12004KT 8000 -FZDZ FEW003 BKN005 M01/M02 Q1011 R88/690295 TEMPO -RASN BKN004=
METAR LOWW	031150Z 12004KT 6000 -FZDZ FEW003 SCT005 BKN011 M01/M02 Q1011 R88/690295 TEMPO -RASN BKN004=
METAR LOWW	031220Z 13004KT 8000 FEW003 SCT005 BKN010 M00/M01 Q1011 R88/690295 TEMPO -RASN BKN004=
METAR LOWW	031250Z 13004KT 5000 BR FEW003 BKN008 M01/M01 Q1010 R88/690295 TEMPO BKN005=
METAR BGSF	031650Z AUTO 07011KT 9999NDV NCD M21/M25 Q1029=
METAR BGSF	031750Z AUTO 07012KT 9999NDV NCD M15/M20 Q1027=
METAR BGSF	031850Z AUTO 07008KT 9999NDV NCD M14/M20 Q1025=

1.7.3 SNOWTAMs for LOWW

1.7.3.1 Serial number 0019

Aerodrome: a) loww

Date/time of observation: b) 12030937 b) 12030945

Runway designators: c) 11 c) 16

Cleared runway length (meters): d) d)

Cleared runway width: e) e)

Deposits over total runway length: f) 6/6/6 f) 6/6/6

Mean depth (mm): g) 002/002/002 g) 002/002/002

Breaking action on each third of RWY (measuring equipment): h) 5/5/5 h) 5/5/5

Critical snowbanks: j) j)

Runway lights: k) k)

Further clearance: l) l)

Further clearance expected to be completed by: m) m)

Taxiway: n) 57 n) 57

Taxiway snowbanks: p) p)

Apron: r) 57

Next planned observation/measurement is for: s)

Plain language remarks: t) contamination rwy 11 100/100/100 rwy 16 100/100/100 percent – ice patches on twys and apron, rwys twys and apron chemically treated, twys a1, a2, a4, a6, a12, b1, b2, b6, b8, b10, b12 cleared.

1.7.3.2 Serial number 0020

Aerodrome: a) loww

Date/time of observation: b) 12031340 b) 12031350

Runway designators: c) 11 c) 16

Cleared runway length (meters): d) d)

Cleared runway width: e) e)

Deposits over total runway length: f) 2/2/2 f) 2/2/2

Mean depth (mm): g) 000/000/000 g) 000/000/000

Breaking action on each third of RWY (measuring equipment): h) 5/5/5 h) 5/5/5

Critical snowbanks: j) j)

Runway lights: k) k)

Further clearance: l) l)

Further clearance expected to be completed by: m) m)

Taxiway: n) 6 n) 6

Taxiway snowbanks: p) p)

Apron: r) 6

Next planned observation/measurement is for: s)

Plain language remarks: t) contamination rwy 11 100/100/100 rwy 16 100/100/100 percent - rwys twys and apron chemically treated, twys a1, a2, a4, a6, a12, b1, b2, b6, b8, b10, b12 cleared.

1.7.4 Panoramic images in LOWW

The below images (direction towards the south) represent a limited area of the main apron.

Figure 11. Panoramic image from LOWW at 11:30 hrs (source: Panomax GmbH)

Figure 12. Panoramic image from LOWW at 13:00 hrs (source: Panomax GmbH)

1.7.5 Aftercast valid for BGSF at 18:32 hrs

General:	A high-pressure area over the central part of Greenland caused outflow of dry and cold air from the ice cap at lower levels near BGSF. At medium levels (above approximately Flight Level (FL) 100), there was a southerly or southwesterly flow in connection with a warm front/occlusion approaching from the southwest.
Visibility:	More than 10 kilometers (km), most likely more than 50 km.

Clouds and icing:	Almost sky clear. The only present clouds were very thin cirrus clouds – maybe barely noticeable – with bases above FL 200. No icing.

1.7.6 Significant weather (SIGWX) chart valid for Greenland

SIGWX valid for Greenland at 18:00 hrs – see appendix 5.7.

1.8 Aids to navigation

There were no reports of deficiencies on the operational status of aids to navigation at BGSF.

1.9 Communication

The flight crew were in radio contact with Sondrestrom Approach (126.200 MHz).

At the time of the serious incident, Air Traffic Control (ATC) frequencies for Sondrestrom Approach and Sondrestrom Tower (118.300 MHz) were combined.

The AIB obtained the involved ATC voice recordings. The recordings were of good quality and useful for the AIB safety investigation.

1.10 Aerodrome information

1.10.1 General information

Aerodrome Reference Point:	67 01 01.09N 050 41 21.57W
Elevation:	165 feet
Runway directions:	09 (061.6° GEO / 091.6° MAG) 27 (241.6° GEO / 271.6° MAG)
Runway dimensions	2,810 meter (m) x 60 m
Runway surface:	Asphalt

1.10.2 Aerodrome chart for BGSF

See appendix 5.8.

1.10.3 Runway inspection

At 17:53 hrs, aerodrome personnel at BGSF performed the latest runway inspection. There were no remarks.

1.11 Flight recorders

1.11.1 General

The aircraft was equipped with a Solid State Flight Data Recorder (SSFDR) and a Solid State Cockpit Voice Recorder (SSCVR).

	SSCVR	SSFDR
Manufacturer:	Honeywell	Honeywell
Part number:	980-6044-003	980-4700-025
Serial number	010-04137	5983

The AIB removed the SSFDR and the SSCVR from the aircraft and shipped the recorder units to the BEA for download and decoding.

Both recorder units were in good condition. The BEA successfully downloaded and decoded the recorded data. The data was of good quality and useful to the AIB safety investigation.

1.11.2 Solid State Flight Data Recorder

The SSFDR contained flight data from the entire sequence of events.

The AIB analysed the recorded data. The SSFDR did not record the activation of the brake heating system as a parameter. However, the N1 parameters of the three engines provided an indication on the deactivation of the anti-ice systems.

179 seconds after gear up selection, the SSFDR recorded a N1 increase on all three engines, from 96 % to 98 %, without change in power lever angle or auto throttle mode, indicating a reduction in bleed air demand, i.e. anti-ice systems selected to OFF.

252-259 seconds after touchdown (weight on wheels), the SSFDR recorded the shut down of all three engines and associated hydraulic low pressure (<1500 PSI) from all three engine driven hydraulic pumps.

1.11.3 Solid State Cockpit Voice Recorder

In four separate audio channels, the SSCVR contained 6 hours 17 minutes and 50 seconds of audio recording:

- Observer channel.
- LH pilot seat channel.
- RH pilot seat channel.
- Cockpit Area Microphone (CAM).

Upon parking on taxiway C in BGSF and with the Axillary Power Unit (APU) running, the SSCVR continued a looped audio recording.

For that reason, the SSCVR only contained audio recording of the last 3 hours and 40 minutes of the flight and did not contain the departure from LOWW.

The four audio channels of the SSVCR recorded the sequence of events. However, the SSCVR download revealed a severe pollution of the signal associated to a very poor dynamic of the CAM sensor. This made the CAM audio data unusable for the AIB safety investigation.

1.12 AIB safety investigation

1.12.1 Operational safety investigation

1.12.1.1 Tire rubber skid marks on runway 09

Tire rubber skid marks indicated, that the aircraft touched down approximately 504 m from the threshold on runway 09, and that the main wheels #1, #2, and #4 were blocked at touchdown.

Figure 13. Tire rubber skid marks on runway 09

Scratches on the runway from wheel rim #1 and #2 were still sporadically visible.

The tire rubber skid mark of wheel #4 was visible all the way to the aircraft parking position on taxiway C. From the beginning of taxiway C, a trace of spilled hydraulic fluid was visible all the way to the aircraft parking position.

On a position approximately 1,018 m from the threshold on runway 09, the AIB measured the distance farthest away from the runway centreline to wheel #1 to be 19.4 m.

The distance from the centreline to the runway edge was 30 m.

1.12.2 Technical safety investigation

1.12.2.1 On-site safety investigation

By shortly activating the brake heating system with engines running at idle power, the AIB tested the brake heating system. The test revealed air blowing from the wheel well ducts.

Inspection of the LH MLG revealed that the hydraulic lines for the brakes were damaged, and that hydraulic fluid from both systems had leaked. The spilled hydraulic fluid was visible from the beginning of taxiway C, and a large puddle surrounded the LH MLG.

Both hydraulic reservoirs were found to be completely empty.

The LH MLG door was damaged.

Figure 14. LH MLG

Figure 15. Hydraulic fluid on taxiway C

The inspection of the RH MLG revealed no damages.

Airport personnel found tire #1 on the runway. An inspection of the tire revealed a significant flat spot.

Figure 16. Tire #1

After jacking the aircraft, wheel rim #1 was able to rotate.

Maintenance personnel removed rim #1. The inspection of rim #1 revealed rub marks on the inboard and outboard side together with small nicks all around the circumference.

Figure 17. Rim #1

Maintenance personnel inspected brake #1. Ice was found on the disks and inside the torque tube on brake #1.

The brake had a “rough” sound when rotated. Maintenance personnel removed brake #1 and stored it at room temperature. After a few hours, the ice had melted, and the brake discs were able to rotate without a “rough” sound.

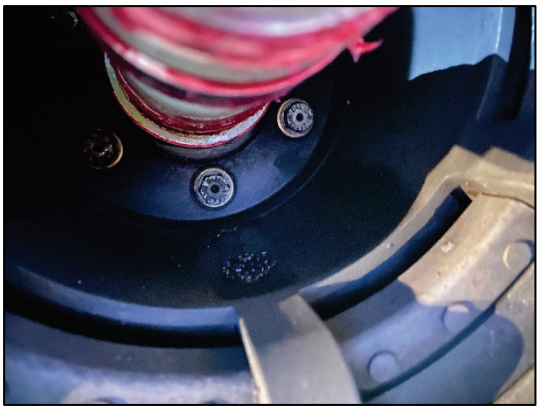


Figure 18 & 19. Brake #1

Tire #2 had disintegrated but was still loosely sitting on the rim. Maintenance personnel had to cut tire #2 to remove it and allow access for a jack. Inspection of the #2 tire revealed a significant flat spot.

Figure 20. Tire #2

Rim #2 had a rub mark and small nicks all around the circumference. After jacking the aircraft, the rim was able to rotate.

Figure 21. Rim #2

There were no defects or ice on brake #2. The brake also had a “rough” sound, when the discs were rotated.

Maintenance personnel removed brake #2 and stored it at room temperature. After a few hours, the brake disks were able to rotate without making a “rough” sound.

Wheel #3 was pressurized. The disassembly and inspection revealed no damages or abnormalities on the #3 wheel or brake.

Figure 22. RH MLG

After jacking of the aircraft, wheel #4 was unable to rotate. After removal of wheel #4, a significant flat spot on the tire part that had been facing downwards was visible.

Figure 23. Tire #4

Two out of three disks on brake #4 were able to rotate. The center disk was unable to rotate. Maintenance personnel removed brake #4 and stored it at room temperature. After few hours, approximately 5 ml of liquid had emerged, and all three brake disks were able to rotate smoothly.

Figure 24. Brake #4 and liquid

AIB personnel collected the liquid and sent it out for analysis. See section 1.16.1.

Maintenance personnel inspected and tested the antiskid system. They removed all six wheel speed sensors (tacho generators) and measured these along with landing gear wiring harnesses without locating any faults. The functional test of the antiskid system revealed no problems with the braking system.

Following the repair of the hydraulic lines, the maintenance personnel measured brake hydraulic pressure and found the pressure to be within Aircraft Maintenance Manual (AMM) limits.

The flight and maintenance crew performed an aircraft acceleration/stop test of the braking system prior to release of the aircraft. The braking system operated normally.

1.12.2.2 Testing, disassembly and inspection of brakes

The AIB obtained the support from BEA and the brake manufacturer to perform testing, disassembly and inspection of the removed brake #1, #2 and #4. AIB arranged shipment of the three brakes each packed in a separate box.

The courier responsible for the shipment lost the box containing brake #2. The courier conducted a thorough search for the box, but the search was unsuccessful.

Due to COVID-19 restrictions, the AIB was unable to be physically present at the inspection of the remaining brake #1 (SNR: 01204) and brake #4 (SNR: 01493). The BEA and the brake manufacturer performed the test, inspection and disassembly and prepared a report. The report concluded:

> CONCLUSION ON CARBON BRAKE ASSEMBLIES INVESTIGATION
>
> During the inspection of the carbon brake assy PNR: C20181100-8 SNR: 01204, it has been noticed:
>
> - A missing elbow union and a wear take up mechanism in position extended,
> - The thrust plate is found askew when it is assembled with the carbon brake assy but the flatness test on marble is compliant,
> - Carbon discs free to rotate when the supply pressure is below or equal to 6 bars,
> - No damage on the rotor and stator discs,
> - Leakage and functional tests results are compliant with the [Component Maintenance Manual] CMM requirements.
>
> The thrust plate is found askew before tests on the hydraulic test bench due to one wear take up mechanism in position extended.
>
> The wear take up mechanism extended came back to its retracted position during pressure test. After disassembly, it appears that this one is bent.
>
> This may be the result of a greater force applied to the frozen discs or the wear take up mechanism momentary freezed.
>
> Since the wear take up mechanism retracted itself during pressure test, it could not be a cause of the brakes locking.
>
> Regarding the inspection of the carbon brake assy PNR: C20181100-8 SNR: 01493, it has been noticed:
>
> - Carbon discs free to rotate when the brake is not under pressure,
> - No damage on the rotor and stator discs,
> - Leakage and functional tests results are compliant with the CMM requirements.
>
> Both carbon brake assy were functional and compliant with the CMM requirements.
>
> POSSIBLE ROOT CAUSE OF THE EVENT
>
> According to the investigation results and observations made by the maintenance staff on and off wing in Kangerlussuaq, the tire burst event is likely due to the ingestion of melted snow during take-off. The snow then froze during the flight, trapping the discs preventing the rotors to freely rotate during landing phase leading to a wheel locked.

The brake manufacturer collected a sample of the hydraulic fluid from the brakes. The sample was visually clean, most likely due to recent bleeding after brake replacements on both MLGs.

The AIB sent the hydraulic fluid sample for analysis at a laboratory. All parameters of the fluid were within the limits of the AMM.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival aspects

The flight crew and the cabin crewmember were using seatbelts.

Neither seats nor seatbelts were overstressed or suffered from malfunctioning.

1.16 Tests and research

1.16.1 Liquid from brakes

The AIB onsite inspection of the brakes revealed ice on brake #1. The AIB did not manage to collect the ice.

After brake #4 had been stored at room temperature a small amount of liquid emerged. See section 1.12.2.1.

AIB collected the small amount of liquid and sent it out for analysis. The analysis concluded that the liquid was odourless, but the laboratory did not reach a firm conclusion on the type of liquid, as the amount of liquid was insufficient for a proper analysis.

1.17 Organization and management

1.17.1 List of specific approvals

The serious incident flight was a private flight but commercially managed by an operator.

The operations of the operator were non-commercial operations with complex motor-powered aircraft (NCC).

On 2-5-2019, Austro Control (issuing Austrian authority) issued a list of specific approvals to the NCC operator.

The list of specific approvals for non-commercial and specialised operations contained:

Aircraft:	Dassault Falcon 900EX – OE-IMI
RVSM:	Worldwide
LVO:	Take-off 125 m

1.18 Additional information

1.18.1 General information about frozen brakes

A frozen brakes scenario may occur, when water or slush enters the brakes. When an aircraft climbs, and the temperature decreases below 0° C, the water freezes and locks the brake discs in place.

The water may originate from precipitation on runways, taxiways, aprons or water used for aircraft washing.

The phenomenon may theoretically lock up any type of brake, but carbon brakes are more subject to this phenomenon. The AIB is not aware of scenarios with blocked steel brakes at touchdown due to ice.

One reason for carbon brakes being more exposed than steel brakes is the higher porosity of the carbon disc surface. This allows the carbon disc to absorb more water and extends the drying time.

Any aircraft type fitted with carbon brakes may be subject to brakes blocked by ice.

1.18.2 Historical events

In the past, the Falcon 900 fleet had suffered occurrences with blocked brakes at touchdown due to ice.

On 29-1-2008, a Bombardier BD700 Global Express (registration VP-CRC) touched down in London Luton Airport with the #2 wheel blocked due to a frozen brake. The United Kingdom (UK) Air Accident Investigation Branch (AAIB) conducted a safety investigation, which resulted in AAIB safety recommendation 2008-073 recommending EASA, Transport Canada (TC) and the US Federal Aviation Authorities (FAA) to raise awareness about the potential issue.

1.18.3 Preventative measures taken prior to the occurrence

The three above-mentioned regulators published EASA Safety Information Bulletin (SIB) no. 2008-89, TC AV-2008-08 and FAA Special Airworthiness Information Bulletin (SAIB) NM-09-18 to raise awareness about the frozen brakes landing scenario.

In 1988, the aircraft manufacturer designed modification M746 for installation of a brake heating system on the Falcon 900. On the Falcon 900EX, modification M2675 was introduced for installation of the brake heating system. The modification was initially optional, but became a basic feature in new aircraft in 2011.

On 20-9-2000, the aircraft manufacturer issued Service Bulletin (SB) F900EX-002 to allow for retrofit of M2675 on aircraft in operation.

Section 1.6.5 describes the brake heating system installed in OE-IMI.

The aircraft manufacturer published and updated several Service Advisories to raise awareness about the issue.

In 2011, the aircraft manufacturer revised the operational procedures, to emphasize the need for applying the contaminated runway procedures, even if only taxiways, ramps or aprons were contaminated.

1.18.4 Initial and continued airworthiness

1.18.4.1 Initial airworthiness

The French Aviation Authority (DGAC) certified the Falcon 900EX in 1996 in accordance with Part-21 (Airworthiness and Environmental Certification of Aircraft – previously JAR) and Certification Specifications (CS – previously JAR) CS-25 (large aeroplanes).

When formed in 2003, EASA grandfathered the certification.

During certification of the aircraft, the aircraft manufacturer submitted a Post-Failure Situation Sheet (PFSS – Safety Analysis document) to DGAC for the scenario of "Landing with at least one leg with blocked wheels" (reference T210-1). The PFSS was submitted in French.

The PFSS stated that the scenario could lead to the following:

- Loss of control of the aircraft.
- Increase of stopping distance.
- Risk of various damages by pieces from the tire in the event of a burst.

The PFSS included the following comment (among others):

"Experience in Falcon service demonstrated that this situation has no critical consequences."

Under the headline "Consequence of the post failure situation on the airworthiness of the aircraft", the estimated probability was set at "0.4 10^{-5}", and the classification was "essential".

The PFSS – See appendix 5.9.

1.18.4.2 Continued airworthiness

In 2008, the aircraft manufacturer produced a Significant Event Review (SER) document on request from EASA concerning frozen brakes on the Falcon fleet.

The document included statistical information, events description, corrective actions taken, airworthiness considerations and EASA position and conclusion.

Under the headline "airworthiness considerations", it was stated that:

- The case of landing with at least one leg with blocked wheels is studied in the Safety Analysis document [PFSS] for the braking system.
- On F900, the situation is classified Essential (with a probability 0.4 10^{-5}) in the G6 sheet.
- On F2000, PFSS 32_4-BRK-11 classifies this case as Major.
- Based on available experience, there is no reason to change this classification, as the freezing of one or more brakes has never led to critical consequences.

The document had been revised several times. The latest revision 5 was dated 25-1-2021, when the document was closed.

Extract from SER 08/04 – See appendix 5.10.

1.19 Useful or effective investigation techniques

Not applicable.

2 ANALYSIS

2.1 General

The following revealed findings had, in the AIB's opinion, no influence on the sequence of events:

- Licenses, qualifications, and total/recent Falcon 900EX flying experience held by the flight crew.
- The operational approval of the operator.
- The pre-flight technical status of the aircraft.
- The pre-flight operational flight planning including performance calculations for BGSF.
- The aircraft mass and balance.
- Flight and duty times with no symptoms of neither accumulated nor acute fatigue.
- The technical status of the aids to navigation at BGSF with no recorded deficiencies.
- The runway status at BGSF with no remarks to the runway inspection at 17:53 hrs (minimum risk of runway Foreign Object Debris (FOD)).

The forecasted weather conditions in LOWW and BGSF were generally consistent with the actual weather reports. Forecasted en route weather conditions were generally consistent with the actual en route weather conditions perceived by the flight crew.

2.2 Frozen brakes

Tire rubber skid marks on the runway and the damages to main wheels no #1, #2, and #4 indicated that the aircraft touched down with three blocked main wheels.

In the opinion of the AIB, the only likely scenario was the presence of three frozen main wheel brakes at touchdown. The following findings supported this scenario:

- Traces of ice on main wheel brake #1. The main wheel brake made a rough sound when rotating the discs. After a storage at room temperature for few hours, the sound, when rotating the discs, was no longer present.
- No traces of ice on main wheel brake #2 but a rough sound when rotating the discs the same way as brake #1. After storage at room temperature, a rough sound, when rotating the discs, was no longer present.
- Main wheel #4 and the centre disc of brake #4 were still unable to rotate, when the aircraft had parked. It seems likely that the rotation of main wheel #3 reduced the stress on main wheel tire and brake #4 and prevented a complete tire burst and release of the brake. After a storage at room temperature, liquid emerged and the brake #4 discs rotated freely.
- Even though, the sample of liquid from main wheel brake #4 was insufficient to perform a proper lab analysis, the AIB suspects water freezing to be the causal factor of the frozen main wheel brakes #1, #2, and #4.
- Test and inspection of brake #1 and #4 performed by the brake manufacturer and BEA did not provide any other technical explanation, apart from frozen brakes.

2.3 Procedures on use of the brake heating system

To the AIB, the following weather observations in LOWW justified an application of the brake heating system according to the AFM and the CODDE 2:

- Parking for 1½ hours in the GA area in light precipitation.

- A few mm of snow/slush on the platform in the GA area and on the remote de-icing stand (flight crew observations).
- Issued SNOWTAM in METAR (METAR MOTNE format) at 12:20 and at 12:50 hrs indicating the presence of on ground slush (all runways).
- SNOWTAM (0019 – issued approximately 3 hrs 20 minutes before departure / 0020 – issued approximately 45 minutes after departure) indicating at the time of departure the possibility of either wet snow or slush on taxiways and aprons.
- Panoramic images indicating varying presence of snow, slush and water from approximately 1½ hours before departure until the time of departure.

An AIB comparison of the AFM normal procedures with the associated CODDE 2 procedures on the recommended use of the brake heating system revealed inconsistencies (descent and approach) and, in the AIB's opinion, even a mistimed required flight crew action (approach).

However, the AIB does not consider these inconsistencies to have had a direct influence on the sequence of events.

Because of the pre-flight de- and anti-icing procedure, the flight crew activated the brake heating system upon departure from LOWW for approximately three minutes and not for the recommended ten minutes. The flight crew did not activate the brake heating system during the descent inbound BGSF.

The AIB would like to highlight that the perception by an experienced Falcon 900EX flight crew of the actual on ground contamination at LOWW did not trigger the application of the recommended CODDE 2 "Flight procedures" and the related "Operations on contaminated runways" procedures on use of the brake heating system.

The decision making process of the flight crew to only activate the brake heating system for three minutes during climb might unknowingly have been affected by the status and wording of the CODDE 2 "Flight procedures".

To the AIB, the installation, though optional, of a brake heating system is a safety system and a systemic safety barrier requiring the same objective awareness and attention like for instance the use of wing anti-ice ("As required").

In the opinion of the AIB, the interaction on application of the brake heating system between the AFM normal procedures ("As necessary"), the CODDE 2 "Flight procedures" ("It is recommended") and the related "Operations on contaminated runways" prepared the ground for subjective flight crew decisions.

The CODDE 2 "Flight procedures" precursors for activation of the brake heating system or preventive flight crew actions, if a brake heating system was not installed, were objective, clear, and unambiguous. However, to a flight crew, the subsequent procedural wording "recommended" and "as necessary" might have downgraded and diluted the preventive flight safety effect of these specific procedures.

2.4 Airworthiness considerations

The tire rubber skid marks on runway 09 indicated that main wheel #1 at its farthest away position during the landing roll came 19.4 meters away from the runway centreline.

The runway at BGSF was wide (60 meters).

During the sequence of events, the LH MLG hydraulic brake unit lines ruptured.

In the PFSS and SER the aircraft manufacturer stated that:

- Experience in Falcon service demonstrated that this situation has no critical consequences.
- Based on available experience, there is no reason to change this classification, as the freezing of one or more brakes has never led to critical consequences.

The DGAC accepted the above statements during initial airworthiness certification, and EASA accepted the continuous airworthiness events review.

Based on this safety investigation, the AIB does not share this point of view, and considers blocked wheels during landing to be an area of safety and airworthiness concern.

In the opinion of the AIB, a narrower runway than in BGSF, the potential loss of all hydraulic pressure at an early stage, or a more severe loss of aircraft directional control, could potentially have resulted in a runway excursion and consequentially an accident.

3 CONCLUSIONS

3.1 Findings

1. Licenses, qualifications, and total/recent Falcon 900EX flying experience held by the flight crew had no influence on the sequence of events.
2. The pre-flight technical status of the aircraft had no influence on the sequence of events.
3. The pre-flight operational flight planning including performance calculations for BGSF had no influence on the sequence of events.
4. The aircraft mass and balance had no influence on the sequence of events.
5. Flight and duty times, with no symptoms of neither accumulated nor acute fatigue, had no influence on the sequence of events.
6. The technical status of the aids to navigation at BGSF with no recorded deficiencies had no influence on the sequence of events.
7. The runway status and condition at BGSF, with no remarks to the runway inspection at 17:53 hrs, had no influence on the sequence of events.
8. The forecasted weather conditions in LOWW and BGSF were generally consistent with the actual weather reports.
9. Forecasted en route weather conditions were generally consistent with the actual en route weather conditions perceived by the flight crew.
10. Tire rubber skid marks on the runway and the damages to main wheels no #1, #2, and #4 indicated that the aircraft touched down with three blocked main wheels.
11. The only likely scenario was the presence of frozen main wheel brakes at touchdown.
12. The weather observations in LOWW justified a frozen brakes risk reducing application of the brake heating system (upon departure from LOWW and during descent inbound BGSF).
13. An AIB comparison of the AFM normal procedures with the associated CODDE 2 procedures on the recommended use of the brake heating system revealed inconsistencies.
14. The flight crew activated the brake heating system upon departure from LOWW for approximately three minutes and not for the recommended ten minutes.
15. The flight crew did not activate the brake heating system during the descent inbound BGSF.
16. To the AIB, the installation, though optional, of a brake heating system is a safety system and a systemic safety barrier requiring the same objective awareness and attention like for instance the use of wing anti-ice.
17. To the AIB, the interaction on application of the brake heating system between the AFM normal procedures (“As necessary”), the CODDE 2 “Flight procedures” (“It is recommended”) and the related “Operations on contaminated runways” prepared the ground for subjective flight crew decisions.
18. The CODDE 2 “Flight procedures” precursors for activation of the brake heating system or preventive flight crew actions, if a brake heating system was not installed, were objective, clear, and unambiguous.
19. To a flight crew, the procedural wording “recommended” might have downgraded and diluted the preventive flight safety effect of the CODDE 2 procedures.

20. The tire rubber skid marks on runway 09 indicated that main wheel #1 at its farthest away position during the landing roll came 19.4 meters away from the runway centreline.
21. A narrower runway than in BGSF, the potential loss of all hydraulic pressure at an early stage, or a more severe loss of aircraft directional control, could potentially have resulted in a runway excursion and consequently an accident.

3.2 Factors

1. The weather observations in LOWW justified a frozen brakes risk reducing application of the brake heating system (upon departure from LOWW and during descent inbound BGSF).
2. The flight crew activated the brake heating system upon departure from LOWW, though just for approximately three minutes and not for the recommended ten minutes.
3. The flight crew did not activate the brake heating system during the descent inbound BGSF.
4. The only likely scenario was the presence of frozen main wheel brakes at touchdown.

3.3 Summary

Conditions for application of the recommended, but not required, “Operation on Contaminated Runways” procedure were present at departure.

The flight crew partially applied the procedure, and the aircraft touched down with three frozen blocked brakes resulting in loss of directional control and rupture of hydraulic brake unit lines.

4 SAFETY RECOMMENDATIONS

4.1 Dialogue with EASA

In April 2021, the AIB started a series of meetings with EASA on mainly two topics, namely status and understanding of the AFM normal procedures and the CODDE 2 procedures on preventing landing scenarios with frozen brakes and an AIB airworthiness concern on landing scenarios with frozen brakes leading to rupture of hydraulic brake unit lines.

4.2 Preventive actions

Because of this safety investigation, the aircraft manufacturer updated and corrected the inconsistencies of the CODDE 2 procedures on use of the brake heating system.

The aircraft manufacturer distributed the corrected procedures to all aircraft operators.

4.3 Safety recommendations

In the effort of preventing future landing scenarios with frozen brakes, the AIB issued two safety recommendations.

4.3.1 Flight crew operational documentation

4.3.1.1 Motivation

To the AIB, the interaction between the AFM normal procedures and the CODDE 2 procedures on prevention of frozen brakes supported optionality and subjective flight crew decision making on whether or not to use a safety system or alternatively (if not installed) perform preventive flight crew actions.

4.3.1.2 Safety recommendation no. DK.SIA-2021-0001

In order to prevent landings with frozen brakes, the AIB recommends that EASA in cooperation with the aircraft manufacturer modify in a more directive and explicit manner the AFM normal procedures (including the use of the brake heating system) and that the aircraft manufacturer accordingly modifies the CODDE 2.

4.3.2 Airworthiness and safety concern

4.3.2.1 Motivation

The PFSS and SER did not reflect the prevention of blocked wheels at touchdown and consequently rupture of hydraulic brake unit lines to be a critical area of safety or airworthiness concern.

4.3.2.2 Safety recommendation no. DK.SIA.2021-0002

The AIB recommends that EASA in cooperation with the aircraft manufacturer re-evaluate the initial airworthiness Post-Failure Situation Sheet for blocked wheels and the continued airworthiness Significant Event Review for frozen brakes.

5 APPENDICES

5.1 FDT for the commander

Return to flight and duty time

DATE	DUTY	START DUTY	CHECK-OUT	FDT	REST BEFORE FDT
16-11-2020z	OFF / OFF	00:00z	23:59z		
17-11-2020z	OFF / OFF	00:00z	23:59z		
26-11-2020z	OFF / OFF	00:00z	23:59z		
27-11-2020z	OFF / OFF	00:00z	23:59z		
28-11-2020z	OFF / OFF	00:00z	23:59z		
29-11-2020z	OFF / OFF	00:00z	23:59z		
30-11-2020z	LOWW - UUWW	16:15z (split)	21:30z	2h55	>36h
01-12-2020z	UUWW - LTAI	08:15z	12:30z (split)		
01-12-2020z	LTAI - UUWW	17:15z (split)	20:30z	10h38	10h45
02-12-2020z	UUWW - LOWW	20:30z	23:45z	3h15	24h
03-12-2020z	LOWW - BGSF	12:15z	18:40z	6h25	12h30

Totals

	Annual 01.01.2020 - 04.12.2020	Selected Period 15.11.2020 - 04.12.2020
Block Time:	204h25	17h10
Duty Time:	420h45	24h55
Duty Days:	71	4
Off Days:	131	7
Sick Days:	0	0
Vacation Days:	0	0
Local Days:	0	0

Appendices

5.2 FDT for the first officer

Return to flight and duty time

DATE	DUTY	START DUTY	CHECK-OUT	FDT	REST BEFORE FDT
18-11-2020z	LOWW - LEBL	10:15z			
18-11-2020z	LEBL - LEDC		16:40z	6h25	>36h
20-11-2020z	LEDC - LOWW	12:45z	16:20z	3h35	>36h
24-11-2020z	LOWW - UUWW	15:00z	18:50z	3h50	>36h
26-11-2020z	UUWW - UWGG	03:15z			
26-11-2020z	UWGG - UUWW		15:00z	11h45	32h25
27-11-2020z	UUWW - EDDM	07:15z			
27-11-2020z	EDDM - LOWW		13:50z	6h35	16h15
30-11-2020z	LOWW - UUWW	16:15z (split)	21:30z	2h55	>36h
01-12-2020z	UUWW - LTAI	08:15z	12:30z (split)		
01-12-2020z	LTAI - UUWW	17:15z (split)	20:30z	10h38	10h45
02-12-2020z	UUWW - LOWW	20:30z	23:45z	3h15	24h
03-12-2020z	LOWW - BGSF	12:15z	18:40z	6h25	12h30

Totals

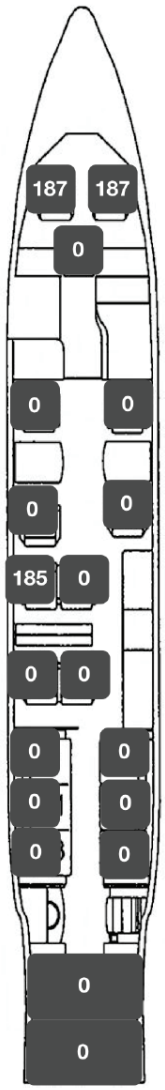
	Annual 01.01.2020 - 04.12.2020	**Selected Period** 15.11.2020 - 04.12.2020
Block Time:	180h15	32h
Duty Time:	473h17	57h05
Duty Days:	74	9
Off Days:	79	0
Sick Days:	0	0
Vacation Days:	16	0
Local Days:	0	0

5.3 Mass and balance

Return to mass and balance

OEIMI F900EXW TFE73160

Generated Thu, 03 December 2020 12:08 UTC with version 6.1.5

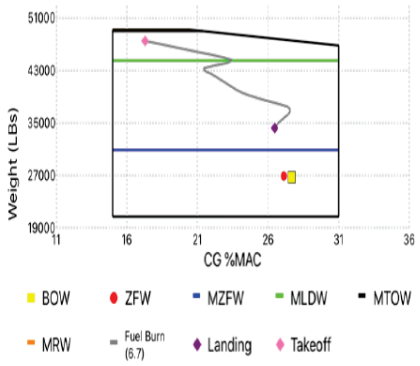


	Weight (lbs)	FWD CG %MAC	CG %MAC	AFT CG %MAC
Empty Weight	25553		33.36	
Pilots	374			
Aircraft Items	782			
BOW	26709		27.68	
Passengers	185			
Cargo	0			
ZFW	26894	15.00	27.12	31.00
Fuel	20800			
Taxi Weight	47694	15.00	16.84	27.09
Taxi Burn	200			
TOW	47494	15.00	17.29	27.96
Takeoff Limit	49000	Structural		
Enroute Burn	13283			
LDW	34211	15.00	26.48	31.00
Landing Limit	44500	Structural		

	Departure	Arrival
ICAO	LOWW	BGSF
Runway	29	09
Shortened		
TORA/LDA	11483	9220
Wind	12004 M	03009 M
Crosswind	1	8
Headwind	-4	5
Temp C	-1	-21
Altimeter	29.85	30.62
Flap	20 DEG	7/40 DEG
Limit Weight	49000 lbs	44500 lbs
Reason	Structural	Structural

29	Departure	Reduced Thrust
Weight	47494 lbs	47494 lbs
V1	123	127
VR	132	132
V2	132	132
VFTO	194	194
Power	94.1	89.1
Trim	-7.40	
To Dist	5292 ft	
Assumed Temp C		42
L/O Altitude	1600 ft	

Departure Options



Flight ID	OEIMI
Flight Date	2020-12-03 13:00:00
PIC	
SIC	
Jumpseat	/
Dept Alternate	
Arrv Alternate	BGBW
POB/CREW/PAX/Infants	3/2/1/0
Prepared By	Crew
Notes	

09	Arrival
Weight	34211 lbs
VFS	161
VAPP	119
VREF	119
LD Dist	2719 ft
1.67 Dist	4532 ft
MA Grad	14.7
Flap	7/40 DEG
Limit Weight	44500 lbs
Reason	Structural

Arrival Options

60% LANDING FACTOR

5.4 Landing performance at BGSF

Return to landing performance

Dassault Falcon 900EX with Winglets
Engine: TFE731-60
AFM: DTM561 Rev 14

LANDING PERFORMANCE
FLAPS 7/40

SFJ / BGSF
KANGERLUSSUAQ
KANGERLUSSUAQ, GRL
Elevation: 165

Configuration:

- NO OPTIONS SELECTED

NOTE: *RWY 09 T/O FROM POSN A - 9220 FT*

Approach Climb Limits:

Approach Flaps 7

GRAD	-20	-10	0	10	20	25	30	35	40	45	50
2.1%	44500	44500	44500	44500	44500	44500	44500	44500	44500	44500	44500

Field Length Weight Limits/Distances:

Landing Flaps 40

RWY: 09
LDA: 9220FT
SLOPE: 0.70%
COND: DRY

WIND (KT)	OAT (°C)	60% FACTOR WEIGHT	60% FACTOR DIST	80% FACTOR WEIGHT	80% FACTOR DIST	UNFACTORED WEIGHT	UNFACTORED DIST
	10	44500	7214	44500	5410	44500	4328
	20	44500	7214	44500	5410	44500	4328
-10	30	44500	7214	44500	5410	44500	4328
	40	44500	7214	44500	5410	44500	4328
	50	44500	7214	44500	5410	44500	4328
	10	44500	6141	44500	4606	44500	3685
	20	44500	6141	44500	4606	44500	3685
0	30	44500	6141	44500	4606	44500	3685
	40	44500	6141	44500	4606	44500	3685
	50	44500	6141	44500	4606	44500	3685
	10	44500	5821	44500	4366	44500	3493
	20	44500	5821	44500	4366	44500	3493
10	30	44500	5821	44500	4366	44500	3493
	40	44500	5821	44500	4366	44500	3493
	50	44500	5821	44500	4366	44500	3493
	10	44500	4538	44500	3404	44500	2723
	20	44500	4538	44500	3404	44500	2723
50	30	44500	4538	44500	3404	44500	2723
	40	44500	4538	44500	3404	44500	2723
	50	44500	4538	44500	3404	44500	2723

RWY: 09
LDA: 9220FT
SLOPE: 0.70%
COND: Wet [115%]

WIND (KT)	OAT (°C)	60% FACTOR WEIGHT	60% FACTOR DIST	80% FACTOR WEIGHT	80% FACTOR DIST	UNFACTORED WEIGHT	UNFACTORED DIST
	10	44500	8296	44500	6222	44500	4977
	20	44500	8296	44500	6222	44500	4977
-10	30	44500	8296	44500	6222	44500	4977
	40	44500	8296	44500	6222	44500	4977
	50	44500	8296	44500	6222	44500	4977
	10	44500	7062	44500	5297	44500	4238
	20	44500	7062	44500	5297	44500	4238
0	30	44500	7062	44500	5297	44500	4238
	40	44500	7062	44500	5297	44500	4238
	50	44500	7062	44500	5297	44500	4238
	10	44500	6694	44500	5020	44500	4016
	20	44500	6694	44500	5020	44500	4016
10	30	44500	6694	44500	5020	44500	4016
	40	44500	6694	44500	5020	44500	4016
	50	44500	6694	44500	5020	44500	4016
	10	44500	5219	44500	3914	44500	3131
	20	44500	5219	44500	3914	44500	3131
50	30	44500	5219	44500	3914	44500	3131
	40	44500	5219	44500	3914	44500	3131
	50	44500	5219	44500	3914	44500	3131

5.5 After take-off, cruise, descent, and approach

Return to flight procedures

AFTER TAKE-OFF

- **At 400 ft above runway:**
  - ANTI-ICE: WINGS switch ..... As required
  - ANTI-ICE: BRAKE switch (if installed) ..... As necessary
- **At V2 + 25 kt and take-off safety height reached:**
  - Slats-flaps handle ..... CLEAN

CAUTION

To minimize possible flaps asymmetry during take-off, retract the flaps by one notch at a time

- INTERIOR LIGHTS: **FASTEN BELTS** and No smoking light pushbuttons ..... As required
- Mid cabin partition door (if installed) ..... As required
- Power levers ..... MAX. CLIMB
- Cabin pressure and temperature controllers ..... Checked

- LANDING and TAXI lights switches ..... Out
- Altimeters ..... Set
- Passenger door curtain ..... Closed

For A/C with M3697:

- 115 / 230 VAC light pushbutton ..... As required

End

CRUISE

- Engine parameters ..... Checked
- If necessary, fuel quantities ..... Equalized
- Station check ..... Periodically

DESCENT

- Pressure controller ..... Set
- Landing parameters ..... Called out - Set
- INTERIOR LIGHTS: **FASTEN BELTS** light pushbutton ..... On

For CAA registered A/C:

- Mid cabin 2 places settee not occupied ..... Checked

End

- ANTI-ICE ..... As required
- ANTI-ICE: BRAKE switch (if installed) ..... As necessary

CAUTION

When the brake heating system is used (if installed): the minimum required N1 with two or all engines operating must be increased by 1 %.

Appendix 5.5 (continued)

APPROACH

NOTE

If approach is performed in icing conditions, see 4-200-05.

CAUTION

To minimize possible flaps asymmetry during approach, extend the flaps one notch at a time.

- Passenger door curtain ..... Open
- Before airplane is aligned, passengers briefing relative to emergency evacuation, including exit signs, must be performed.

For A/C with M5971 – (Emergency exit pictograms):

NOTE

The green man running pictorial replaces the word "EXIT", and indicates the location of the emergency exit.

For A/C with M3697:

- 115 / 230 VAC light pushbutton ..... OFF

End

- INTERIOR LIGHTS: No smoking light pushbutton ..... On
- Mid cabin partition door: latched in open position (if installed) ..... Checked
  - ☑ **AFT CABIN ISOL** light ..... Off
- Altimeters ..... Set
- DH / MDA ..... Set
- X-BP (all 3) ..... Closed
- LANDING lights switch ..... ON / PULSE - As required
- ANTI-ICE: BRAKE switch (if installed) ..... OFF
- Slat-flap handle ..... Approach position
- Approach mode ..... As required

NOTE

Airbrakes may be used during landing approach provided airspeed is at least VREF + 10 kt.
Increase landing distance (and landing field length) by 15 %.

5.6 Operations on contaminated runways – Normal procedures

Return to flight procedures – brake heating system

OPERATIONS ON CONTAMINATED RUNWAYS - NORMAL PROCEDURES

The following procedures deal only with particular actions or verifications to be performed in addition to normal procedures. They concern exclusively operations on contaminated runways although in certain cases, they will have to be combined with COLD WEATHER OPERATIONS or GROUND DE-ICING AND ANTI-ICING procedures.

NOTE

- If the wheel and brake assemblies are moisturized, wet or contaminated (whatever the reason) before leaving the ramp, or

- If the airplane taxies on surfaces contaminated by standing water (whatever the OAT), slush or snow,

Accomplish the "Taxiing", "After take-off", "Top of climb", "Descent" and "Before landing" procedures, this section. This should prevent from possible freezing of the brakes.

After start

➨ Slats-flap handle ..... CLEAN

Taxiing

■ **If OAT < 10°C (50°F) and visible moisture is present:**

➨ Start selector switches ..... AIR START

➨ Moderate braking .....Applied 3 times until complete stop

NOTE

- Apply moderate pressure in order to warm up the disk brakes.

- Do not exceed 5 stops from a speed of 20 kt in order to mitigate the risk of brakes to overheat.

- If brakes are ice-locked, repeatedly actuate the brakes at maximum pressure until brakes release.

- If nose wheels skid during taxi, release control to avoid damage to nose gear assembly

Take into account the poor braking action. Moreover, a safe distance from preceding airplane allows to stay clear of the jet blast that may blow contaminant.

Line-up

➨ Flight controls ..... Full travel – Free

➨ Start selector switches..... AIR START

➨ Slats-flaps handle .....20° FLAPS + SLATS

Take-off

NOTE

Rolling take-off is prohibited on contaminated runways.

➨ Forward pressure on control column .....Gently released

Gently release the pressure on the control column during the take-off roll to bring it neutral prior to rotate.

Appendix 5.6 (continued)

On a snow covered runway, release forward pressure on the control column as soon as rudder control becomes effective to reduce the amount of snow spread by the nose gear.

- Acceleration ..... Checked

CONTAMINATION	Standing water Slush	Snow	Compacted snow Ice
ACCELERATION CHECK AT 90 kt	G > 0.07	G > 0.12	N/A(*)

(*): On wet, compacted-snow covered or icy runways, check acceleration as usual (no additional drag).

NOTE

Should the acceleration be lower than the minimum, airplane is unlikely to reach VR within the calculated take-off distance. Take-off should be aborted.

After take-off

- Landing gear retraction ..... Delayed 15 sec (performance permitting)

  The rate of climb is reduced by 1.7% when the landing gear is extended and one engine is inoperative.

- **Without brake heating system:**
  - Speed ..... Max 190 kt
  - Landing gear ..... Cycle (up then down)
  - Landing gear ..... Up
- Speed ..... As required
- **With brake heating system:**
  - ANTI-ICE: WINGS switch ..... AUTO
  - ANTI-ICE: BRAKE switch ..... ON

NOTE

Maintain brake heat on in climb for a minimum of 10 minutes.

Top of climb

- **With brake heating system:**
  - ANTI-ICE: BRAKE switch ..... OFF

Descent

- **With brake heating system:**
  - ANTI-ICE: WINGS switch ..... AUTO

Appendix 5.6 (continued)

NOTE

When the brake heating system (if installed) is in use, the minimum N1 all engines or two engines operating by **must be increased** 1%.

Before landing

- Landing gear ..... Down
- **With brake heating system:**
  - ANTI-ICE: BRAKE switch ..... OFF or ON
- **Without brake heating system:**

If take-off was performed from a contaminated runway, whatever the OAT:

- Wait for 5 seconds.
  - BRAKE selector ..... #1/ASKID OFF
  - Apply maximum brake pressure several times
  - BRAKE selector ..... #1/ASKID ON

Do these steps to eliminate any remaining ice.

Anticipate the brake cycling: extend the flight at the initial approach altitude.

After Landing

It is recommended to keep slats-flaps extended to 7° after vacating the runway and until visual inspection of the slats-flaps compartment and mechanism is completed.

OPERATIONS ON CONTAMINATED RUNWAYS - ABNORMAL PROCEDURES

REJECTED TAKE-OFF

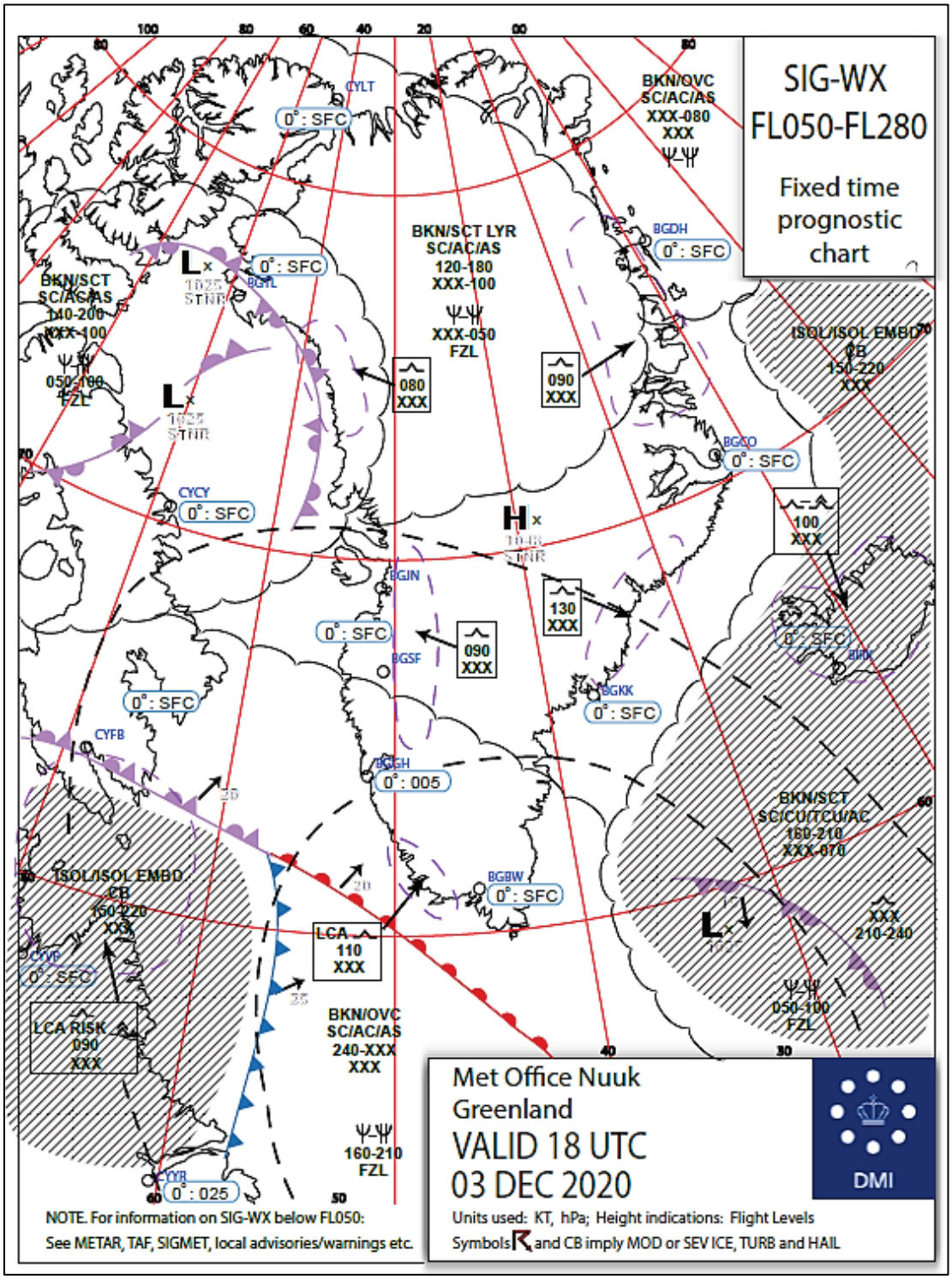
The use of thrust reverser is strongly recommended.

LANDING WITH ONE ENGINE INOPERATIVE

It is strongly recommended to divert to an airport with dry or wet runway(s) (non-contaminated).

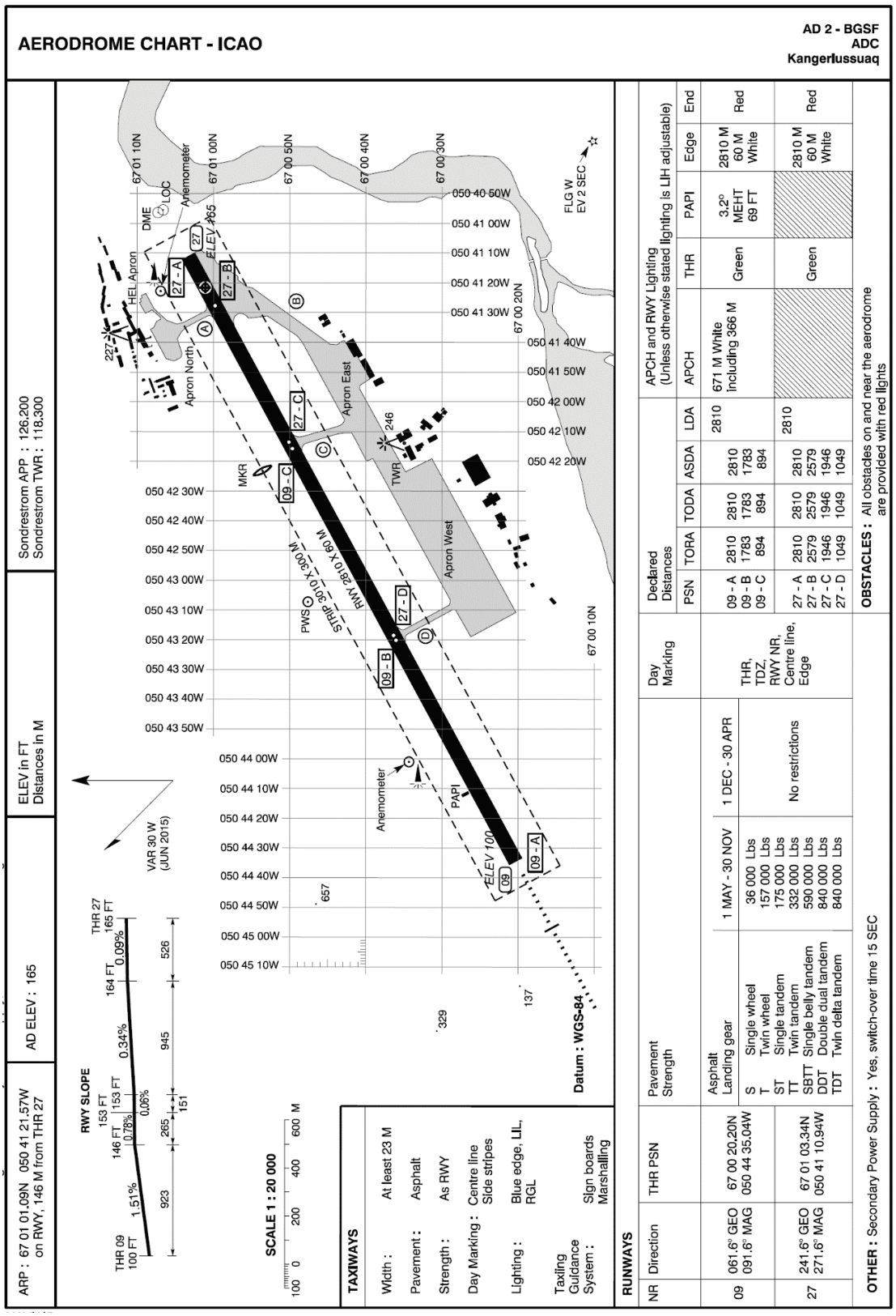
5.7 SIGWX for Greenland at 18:00 hrs

Return to significant weather (SIGWX) chart valid for Greenland



5.8 Aerodrome chart for BGSF

Return to aerodrome chart for BGSF



NR	Direction	THR PSN	Pavement Strength			Day Marking	Declared Distances					APCH and RWY Lighting (Unless otherwise stated lighting is LIH adjustable)				
			Asphalt Landing gear	1 MAY - 30 NOV	1 DEC - 30 APR		PSN	TORA	TODA	ASDA	LDA	APCH	THR	PAPI	Edge	End
09	061.6° GEO 091.6° MAG	67 00 20.20N 050 44 35.04W	S Single wheel	36 000 Lbs	No restrictions	THR, TDZ, RWY NR, Centre line, Edge	09 - A	2810	2810	2810	2810	671 M White Including 366 M	Green	3.2° MEHT 69 FT	2810 M 60 M White	Red
			T Twin wheel	157 000 Lbs			09 - B	1783	1783	1783						
			ST Single tandem	175 000 Lbs			09 - C	894	894	894						
			TT Twin tandem	332 000 Lbs												
27	241.6° GEO 271.6° MAG	67 01 03.34N 050 41 10.94W	SBTT Single belly tandem	590 000 Lbs			27 - A	2810	2810	2810	2810		Green		2810 M 60 M White	Red
			DDT Double dual tandem	840 000 Lbs			27 - B	2579	2579	2579						
			TDT Twin delta tandem	840 000 Lbs			27 - C	1946	1946	1946						
							27 - D	1049	1049	1049						

5.9 Falcon 900 PFSS

Return to initial airworthiness

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5.2.6. FREINAGE EXCESSIF SUR AU MOINS UN DIABOLO

Définition de la configuration du système

- Au cours de l'utilisation d'un des modes de freinage, (#1 ON, #2 OFF, #1 OFF ou P. BRAKE), un ou les deux diabolos se bloquent.

Référence de panne globale: G6

Références des pannes conduisant à la panne globale: SYS2 ou SYS4 ou SYS5 ou SYS8 ou cause extérieure

Effets de la panne globale

- Risque de perte du contrôle de l'avion.
- Allongement de la distance parcourue au sol.
- Risque d'endommagements divers par les morceaux de pneu en cas d'éclatement.

Phase de vol intéressée : Roulements au sol

Phase de vol la plus défavorable : Atterrissage

Justification : Arbre de défaillances

Commentaires :

L'arbre de défaillances montre que les cas de blocages irréversibles ont pour la plupart des origines extérieures au système. La très grande majorité des blocages sont dépendants de l'ordre de freinage : le pilote peut dans une certaine mesure contrôler les embardées dues au freinage excessif dissymétrique. Il dispose en outre de l'inverseur de poussée pour arrêter l'avion.

L'expérience en service de la flotte des MYSTERE-FALCON montre que cette situation n'a pas de conséquences critiques.

Cette situation apparaissant lors d'une accélération-arrêt peut avoir des conséquences critiques. L'objectif de sécurité correspondant est atteint car il faut : un freinage excessif ($0.4\ 10^{-5}$) et une panne moteur lors du décollage ($10^{-4} \times \frac{30}{3600}$ s), soit un taux d'occurrence de $0.33\ 10^{-11}$.

Conséquence de la situation après pannes sur la navigabilité de l'avion :

Probabilité estimée	Classification de la situation après pannes :		
	Non essentielle	Essentielle	Critique
$0.4\ 10^{-5}$	~~Non essentielle~~	Essentielle	~~Critique~~

CE DOCUMENT EST LA PROPRIÉTÉ DES AVIONS MARCEL DASSAULT - BREGUET AVIATION IL NE PEUT ÊTRE UTILISÉ, REPRODUIT OU COMMUNIQUÉ SANS LEUR AUTORISATION

5.10 Extract from SER 08/04

Return to continued airworthiness

DASSAULT AVIATION

REFERENCE	INDEX	DATE
NOT CL DGT n° 115177	5	25/01/2021

SER 08/04

5. AIRWORTHINESS CONSIDERATIONS

The case of landing with at least one leg with blocked wheels is studied in the Safety Analysis document for the braking system.

On F900, the situation is classified Essential (with a probability 0.4 10-5) in the G6 sheet

On F2000, PFSS 32_4-BRK-11 classifies this case as Major

Based on available experience, there is no reason to change this classification, as the freezing of one or more brakes has never led to critical consequences.

In case of multiple tire burst, skidding on the wheel rim provides significant braking.