Accident Investigation Board
Denmark

Final Report

HCLJ510-000449

Accident to Bombardier DHC-8-402
Registration LN-RDI
At Copenhagen Airport Kastrup (Denmark)
On 27 October 2007

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GLOSSARY OF ABBREVIATIONS

AIB	Accident Investigation Board, Denmark
ATD	Actual Time of Departure
AIP	Aeronautical Information Publication
ATC	Air Traffic Control
ATA	Air Transport Association
ACARS	Aircraft Communication Addressing and Reporting System
AMM	Aircraft Maintenance Manual
ATPL	Airline Transport Pilot's License
ACC	Area Control Centre
CA1	Cabin Attendant assigned to station no 1
CA2	Cabin Attendant assigned to station no 2
CAS	Calibrated Air Speed
CVR	Cockpit Voice Recorder
UTC	Coordinated Universal Time
DLI	Dead Load Index
DME	Distance Measurement Equipment
DN	Down
DOI	Dry Operating Index
DOM	Dry Operating Mass
DOW	Dry Operating Weight
EASA	European Aviation Safety Agency
FAR	Federal Aviation Regulation
FDR	Flight Data Recorder
FL	Flight Level
FWD	Forward
GVI	General Visual Inspection
GEO	Geographic
GP	Glide Path
GPWS	Ground Proximity Warning System
IPC	Illustrated Parts Catalog
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ICAO	International Civil Aviation Organization
JAR	Joint Aviation Regulation
LDG	Landing Gear
LAM	Landing Mass
LAW	Landing Weight
LMC	Last Minute Change
LITOM	Loaded Index at Take-Off Mass

LITOW	Loaded Index at Take-Off Weight
LIZFM	Loaded Index at Zero Fuel Mass
LIZFW	Loaded Index at Zero Fuel Weight
MAG	Magnetic
MLG	Main Landing Gear
MAC TOM	Mean Aerodynamic Cord at Take-Off Mass
MAC TOW	Mean Aerodynamic Cord at Take-Off Weight
MSL	Mean Sea Level
MSV	Mechanical Sequence Valve
MHz	Megahertz
NAS	National Aerospace Standard
NTSB	National Transportation Safety Board, USA
NLG	Nose Landing Gear
PAX	Passengers
PA	Pressure Altitude
PSEU	Proximity Switch Electronics Unit
QRH	Quick Reference Handbook
RA	Radio Altimeter
STD	Scheduled Time of Departure
SSV	Solenoid Sequence Valve
TOF	Take-Off Fuel
TOM	Take-Off Mass
TOW	Take-Off Weight
TWR	Tower
TCAS	Traffic Alert and Collision Avoidance System
TSB	Transport Safety Board, Canada
TIF	Trip Fuel
UNDLD	Under Load
VOR	Very High Frequency Omni Directional Radio Range
VFR	Visual Flight Rules
WOW	Weight On Wheels
ZFM	Zero Fuel Mass
ZFW	Zero Fuel Weight

FINAL REPORT

HCLJ510-000449	**Accident**		
Aircraft:	Bombardier Aerospace Inc. DHC-8-402	A/C registration:	LN-RDI
Engines:	2 Pratt & Whitney PW150A	Type of Flight:	Scheduled, IFR
Crew:	4 - No injuries	Passengers:	40 - No injuries
Place:	Copenhagen Airport Kastrup (EKCH) RWY 04R	Date and time:	27.10.2007 1453 UTC

All times in this report is UTC.

The Area Control Centre at Copenhagen Airport, Kastrup (EKCH) notified the Accident Investigation Board, Denmark (AIB) on October 27th 2007, at 1525 hrs.

The Transportation Safety Board (TSB), Canada, Statens Havarikommisjon for Transport (SHT), Norway, the International Civil Aviation Organization (ICAO) and the European Aviation Safety Agency (EASA) were notified on October 27th 2007. The TSB, Canada, had, in accordance with ICAO Annex 13 appointed an accredited representative for the investigation.

Synopsis

The accident flight was a scheduled IFR flight from Bergen Flesland Airport (ENBR) in Norway to Copenhagen Airport Kastrup (EKCH) in Denmark.

During the approach to EKCH, the flight crew was unable to fully extend the right Main Landing Gear (MLG).
After a number of unsuccessful alternate extension attempts, the flight crew declared that the landing would be an emergency landing. The MLG was stuck in an almost up position.

The aircraft landed on runway 04R and came to rest on taxiway C area. The aircraft was evacuated within 50 seconds and no one was injured.

The accident occurred in daylight and under visual meteorological conditions (VMC).

Summary

The summary contains findings and factors that was established in the investigation.

The Solenoid Sequence Valve (SSV) down port and up port filter elements may not withstand normal Landing Gear hydraulic operational pressure fluctuations and may collapse. At a given time prior to the accident, the SSV down port filter element collapsed and the O-ring located adjacent to the filter element migrated into the hydraulic line.

The Mechanical Sequence Valve (MSV) was of such a design that it was impossible for the O-ring to pass through the MSV on its way from the SSV down port to the MLG Retraction/Extension Actuator Retract Port Restrictor. However, the MSV was replaced on 22nd October 2007.
The operator maintenance organization had only Nose Landing Gear (NLG) MSV's on stock. Therefore, the MSV supplied from stock on 22nd October 2007 was a NLG MSV P/N 48303-7 S/N FAH-0345 having Reducers installed to fit the NLG.
The information, as a unified whole given by both the aircraft manufacturer and the operator computerized data system was unclear, not easily seen through and misleading to the maintenance personnel; misleading the maintenance personnel to reconfigure the delivered Authorized Release Certificate approved NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG MSV. There were no procedures available for reconfiguring the MSV.
For that reason by a maintenance action, the rogue O-ring was transferred from the SSV side of the hydraulic line to the Actuator side of the hydraulic line while trapped inside a Union when the Unions from the removed MSV Valve Body P/N 48303-103 S/N FAH-0107 were reused on the NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG.
It was not observed that the O-ring was trapped inside one of the reused Unions. The circumstances were human factor related. A thorough inspection of the Unions according to a defined inspection procedure might have led to a finding of the rogue O-ring, but the maintenance personnel had no procedures available.

The Main Landing Gear (MLG) Retraction/Extension Actuator had no protection (in-line filter) against hydraulic fluid contamination.
At a given time during retraction of the MLG, the O-ring was able to enter the Retract Port Restrictor of the Actuator. While trapped inside the restrictor, the O-ring was damaged and cut into several pieces.

On the accident flight on 27th October 2007 during extension of the Landing Gear, the right MLG extension fluid flow had enough flow to force a part of the damaged O-ring through the small orifice hole in the floating valve in the Retract Port Restrictor which blocked off the hydraulic fluid flow.
The MLG Retraction/Extension Actuator was hydraulically locked by the blocked Retract Port Restrictor, which caused the right MLG to be stuck in the almost up position. In this situation, it was not possible to extend the right MLG.

Safety recommendations

As a result of the investigation of this accident, the Accident Investigation Board, Denmark made two recommendations to the European Aviation Safety Agency (EASA).

1. Factual information

1.1 History of the flight

(For more details see appendix A: Flight history – timetable)

The aircraft departed Bergen, Flesland (ENBR) on the 27th October 2007. The planned destination was Copenhagen Airport, Kastrup (EKCH). The flight crew contacted Copenhagen Approach (119,800 MHz) and was informed that they could expect an ILS approach to runway 04L. At first contact with Kastrup Tower (119,350 MHz) the flight was cleared to land on runway 04R.

While the aircraft was descending through 1245 ft Radio Altimeter (RA), the Landing Gear was selected down. The Landing Gear indication was: Nose Landing Gear (NLG) down and locked, left Main Landing Gear (MLG) down and locked and right MLG in Transit. A go around was initiated.

A few seconds later, the Landing Gear was selected up and the Landing Gear was up. The Landing Gear up indication was normal. Kastrup Tower was informed about the Landing Gear problem and that the aircraft was making a go around. The flight crew was instructed to contact Copenhagen Approach on the frequency 118.450 MHz.

Copenhagen Approach was informed that the aircraft was going around due to a Landing Gear problem. In order to solve the Landing Gear problem, the flight crew requested radar vectors around the area.

The Landing Gear was selected down at 1351:11 hrs and the Landing Gear indication was: NLG down and locked, left MLG down and locked and right MLG in Transit.

The commander made radio contact with the operator technical department. He explained that the right MLG would not extend. The commander asked if he should use the Alternate Landing Gear Extension procedure. A decision was made to use the Alternate Landing Gear Extension procedure. The commander went through different Landing Gear procedures using the Quick Reference Handbook (QRH) trying to find the appropriate procedure. The commander found the Alternate Landing Gear Extension procedure and followed the procedure using the QRH. Without success, the commander manually tried to pump the Landing Gear down.

The cabin crew was informed that they should expect an Emergency Landing in about 20 to 25 minutes.

The operator technical department was informed that the Alternate Landing Gear Extension procedure was unsuccessful and that the right MLG was now in the up position.

The commander made a passenger briefing explaining that the landing would be an Emergency Landing and that the landing was expected in about half an hour.

Copenhagen Approach instructed the first officer to contact Kastrup Final on the frequency 119.100 MHz. The first officer made radio contact with Kastrup Final and was informed that the flight was the only flight on the frequency.

The flight crew went through the tasks and procedures before the Emergency Landing. The cabin crew informed the commander that the Emergency Landing briefing was completed.

Once more, the flight crew tried to pump the Landing Gear down. At this time, they were concerned about the remaining amount of fuel.

Kastrup Final (119.100 MHz) was informed that the aircraft was ready for the approach.

The flight crew made an approach briefing and completed the Approach Checklist.

The flight crew decided to shut down the right engine. The right Engine Condition Lever was set to Fuel Off. At the same time, the warning horn started to sound.

Kastrup Final cleared the aircraft to land and informed the crew that the wind was from 100 degree at 3 knots. The commander informed Kastrup Final that the right engine had been shutdown.

When flaps 15° were set, the Landing Gear Warning started to sound. Trough the remaining flight, the warning continued.

While the aircraft was passing through approximately 800 feet RA, the commander instructed the passengers to brace for impact. Thereafter and until the aircraft came to a full stop, the cabin attendants repeated the command to brace for impact.

The Ground Proximity Warning System (GPWS) started issuing warnings "*Too Low Gear*" when the aircraft passed 531 feet RA. During the remaining flight, the GPWS continued issuing warnings with shorter and shorter intervals.

Abeam taxiway B3, the aircraft left MLG touched down on runway 04R. After touch-down, the left Engine was selected to reverse and the power was increased. The aircraft followed the runway centreline in approximately 20 seconds. The aircraft right propeller, aft fuselage and right wingtip made contact with the runway surface. The aircraft started to turn to the right and as it departed the runway it damaged two runway edge lights.

The aircraft came to rest on taxiway C area heading southeast 120°.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	-	-	-
Serious	-	-	-
Minor/None	4	40	-

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

The runway surface was found to have several scratch marks from the aircraft tail section, right wing tip, right propeller and the nose landing gear. When the aircraft departed the runway 04R to the right into taxiway C area, the aircraft hit two runway lights.

1.5 Personnel information

The commander: Male, 48 years.
Certificate: Airline Transport Pilot License (ATPL).
Medical: Class 1, Valid.

Flying experience:	Last 24 hrs	Last 90 days	Total
All types	6:01 hrs	86:53 hrs	11.156 hrs
DHC-8	6:01 hrs	86:53 hrs	2.876:23 hrs
Landings	2	37	990

First officer: Male, 46 years.
Certificate: Airline Transport Pilot License (ATPL).
Medical: Class 1, Valid.

Flying experience according to the operator:	Last 24 hrs	Last 6 months	Total
All types	3:55 hrs	267 hrs	8.135 hrs
DHC-8	3:55 hrs	267 hrs	-

1.6 Aircraft information

1.6.1 General aircraft information

The aircraft was a twin engine DHC-8-402 (Q400) manufactured by Bombardier Aerospace Inc.

Year of manufacture:	2000
Serial number:	4024
Registration:	Registered in Norway as LN-RDI on 1st July 2003
Certificate of airworthiness:	Issued by the Civil Aviation Authority Norway (CAAN) on 6th September 2007 was valid until 30th September 2008
Engines:	2 ea Pratt & Whitney PW150A
Propeller:	2 ea Dowty Aerospace R408/6-123-F/17
MTOW:	28.998 kg
Aircraft total flight hours:	12.071,36
Aircraft cycles:	14.967
Maintenance:	The aircraft maintenance records were verified to be in compliance with the established maintenance program
The last Line-check:	Was accomplished on 12th October 2007
The last "A" inspection:	Was accomplished on 1st September 2007

1.6.2 Right Main Landing Gear parts replaced October 2007.

The following Right Main Landing Gear system parts were replaced in the period from the 16th October 2007 to the 24th October 2007 in connection with trouble shooting:

Part removed: Date: 16.10.2007 Solenoid Sequence Valve P/N: 48302-3 S/N: FAH-0083	Part installed: Date: 16.10.2007 Solenoid Sequence Valve P/N: 48302-3 S/N: FAH-0200
Part removed: Date: 21.10.2007 Door Actuator P/N: 46830-5 S/N: MAL-0307	Part installed: Date: 21.10.2007 Door Actuator P/N: 46830-5 S/N: MAL-0095
Part removed: Date: 22.10.2007 Mechanical Sequence Valve P/N: 48303-5 S/N: FAH-0107	Part installed: Date: 22.10.2007 Mechanical Sequence Valve P/N: 48303-7 S/N: FAH-0345
Part removed: Date: 24.10.2007 MLG Retraction/Extension Actuator P/N: 46550-9 S/N: MAL-0117	Part installed: Date: 24.10.2007 MLG Retraction/Extension Actuator P/N: 46550-9 S/N: MAL-0074

1.6.3 Mass and Centre of Gravity (extract from Load Sheet Final)

The aircraft version: 76 passengers.

BGO	CPH	LN-RDI	Crew 2/2
DOW dry operating weight (kg):	18.530 kg		
ZFW zero fuel weight (kg):	22.343 kg	MAX	26.308 kg
TOF take-off fuel (kg):	2.900 kg		
TOW take-off weight (kg):	25.243 kg	MAX	28.998 kg
TIF trip fuel (kg):	1.500 kg		
LAW landing weight (kg):	23.743 kg	MAX	28.009 kg
UNDLD under load (kg):	3.755 kg		
PAX M passengers:	38/0/2	TTL	38/0/2
DOI dry operating index:	20		
DLI dead load index:	29		
LIZFW loaded index at zfw:	27		
LITOW loaded index at tow:	27		
MAC TOW mean aerodynamic cord at tow:	30		
BALANCE LIMITS BEFORE LMC			
FWD / AFT:	12 / 32	AT ZFW	
	10 / 32	AT TOW	

The aircraft was within the mass and balance limitations. The estimated mass of the aircraft at the time of the accident was approximately 23.143 kg (ZFW plus 800 kg fuel).

1.6.4 Landing Gear system information

1.6.4.1 General description

The tricycle gear is a retractable dual wheel installation. The Right and Left Main Landing Gear (MLG) retract aft into the nacelles and the Nose Landing Gear (NLG) retracts forward into the nose section. Gear doors completely enclose the Landing Gear when it is retracted and partially enclose the gear when it is extended.

The cockpit advisory lights show the position of gear doors and down-locks. An audible warning sounds if the gear is not extended and the aircraft is in a landing configuration.

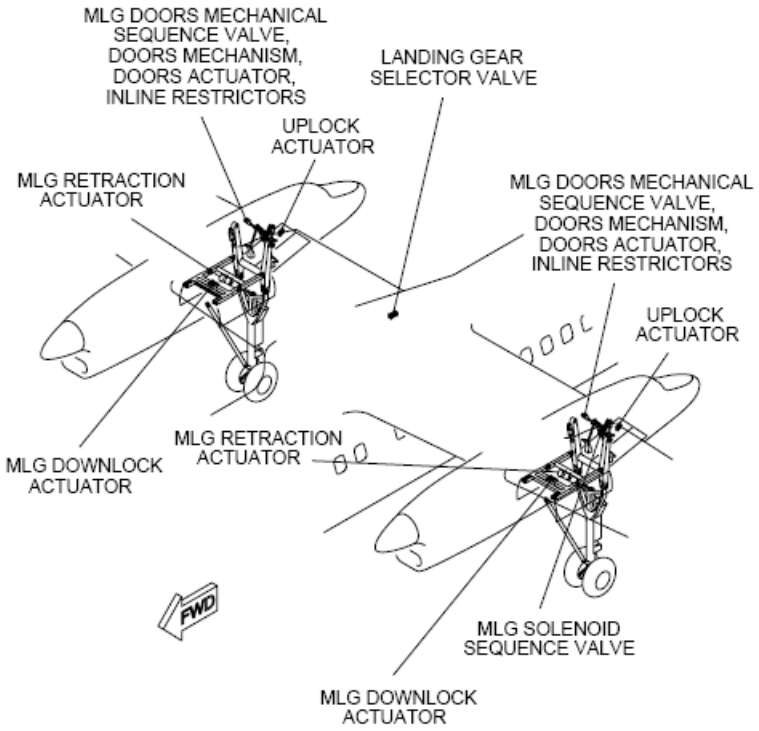
A Proximity Switch Electronics Unit (PSEU) monitors and controls the operation of the Landing Gear components.

An alternate Landing Gear extension method can be used to extend the gear if the primary extension method fails. There is also an alternate down-lock verification system.

Landing Gear operation is controlled and monitored from the Landing Gear Control Panel, adjacent to the Engine Display in the cockpit. The Landing Gear is selected up or down by moving the Landing Gear

Selector Lever. A Lock Release selector lever must be held down to let the gear selector lever move in either direction. An alternate down-lock verification system confirms down-lock engagement if the primary down-lock indication is in doubt. Three green down-lock verification lights are located under the Landing Gear Alternate Extension door in the cockpit floor.

MLG and the location of the components are shown on the following drawing.



1.6.4.2 Main Landing Gear retraction

Hydraulic pressure is supplied to each MLG down-lock release actuator to release the down-lock. Hydraulic pressure is supplied through an energized Solenoid Sequence Valve (SSV) to the open side of the MLG aft door actuators. This causes the MLG aft doors to open. The operation of the down-lock release actuator and the MLG aft door actuators are monitored by the PSEU. The MLG door mechanism operates a Mechanical Sequence Valve (MSV) to interlock the retraction/extension part of the hydraulic system. This continues until the doors are wide enough open for the Landing Gear to retract so that it does not touch the doors. At approximately 93 percent travel of the MLG aft door, the MLG aft door linkage activates the MSV. When the MSV has been activated, hydraulic pressure is supplied to the up side of the MLG Retraction /Extension Actuator. The MLG starts to travel to the fully retracted position where it is locked in place by the mechanical up-lock hook. The proximity sensors monitor the gear and door positions.

When the PSEU receives the input signals that the MLG is up and locked, the PSEU de-energizes the SSV. This causes the SSV to supply pressure to the close side of the MLG door actuators and close the doors. At approximately 7 percent reverse travel of the MLG doors, the MSV's stop their operation. This action removes hydraulic flow from the up side of the MLG Retraction/Extension Actuators. Inline restrictors bypass the MSV and keep the MLG Retraction/Extension Actuators pressurized to 3000 psi.

Pressure is kept at 3000 psi until the Landing Gear hydraulic system is depressurized upon completion of the retraction cycle.

1.6.4.3 Main Landing Gear extension

When the Landing Gear selector lever is moved to the DN position, the SSV remain de-energized. The de-energized SSV supply hydraulic pressure to the open side of the MLG aft doors actuators to open the MLG aft doors. At approximately 93 percent travel of the MLG aft door, the MLG aft door linkage activates the MSV. The valve supplies hydraulic pressure to the up-lock release actuators and to the down side of the MLG Retraction/Extension Actuators. The in-line restrictors slow hydraulic flow to, and pressure built up in the MLG Retraction/Extension Actuator and the up-lock release actuator, until the doors reach the 93 % open position at which point the activation of the MSV ports full flow to the two actuators.

The MLG starts to travel to the down and locked position. There are four proximity sensors used to monitor the MLG extension sequence. Each MLG has two down and locked sensors and one MLG aft door closed sensor. When the PSEU receives input signals that the MLG is down and locked, the PSEU energizes the SSV. Pressure is supplied to the MLG aft door actuators to close the MLG aft doors. At approximately 7 percent reverse travel of the MLG doors, the MSV's stop their operation. This action removes hydraulic flow from the up side of the MLG Retraction/Extension Actuators. Inline restrictors keep the MLG Retraction/Extension Actuators pressurized to 3000 psi at the end of the extension sequence.

The advisory light sequence during extension starts with the LEFT, NOSE, and RIGHT red unsafe lights and the amber gear selector handle light coming on. Then the amber door advisory lights illuminate to indicate the hydraulically operated gear doors are open. When the MLG is fully extended the over centre lock links are brought into lock by springs. The actuator maintains them in that position.

When the Landing Gear is locked in the down position, the red unsafe lights and the selector handle light go out. Then the green LEFT, NOSE, and RIGHT advisory lights come on. Finally, the gear door advisory lights go out when the hydraulically operated doors are closed.

The solenoid selector valve stays powered to allow for continued hydraulic pressure acting on the gear when down and locked, but primary down-lock is by the over-centre locks.

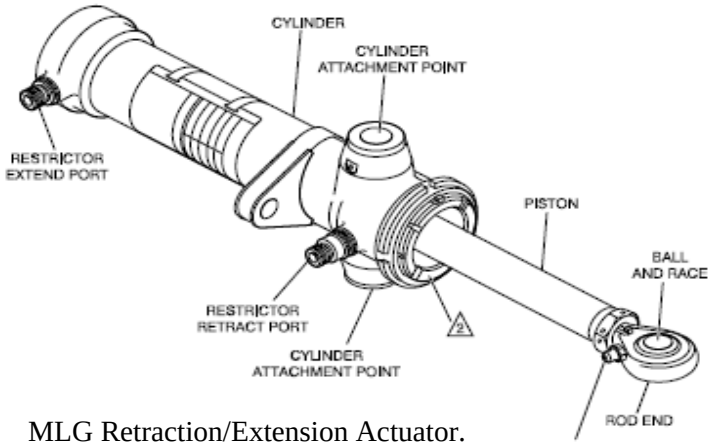
1.6.4.4 Landing Gear alternate extension

The Landing Gear extension Inhibit switch is installed in the cockpit ceiling, adjacent to the Main Landing Gear alternate release door. The switch sends a signal to the PSEU to remove power from the Landing Gear selector valve and the door SSVs. Additionally, the PSEU will bring on the LG INOP caution light. When the main Landing Gear alternate release door on the cockpit ceiling is opened it mechanically opens a bypass valve in the normal hydraulic extension system, porting the UP and DN lines to return and gives access to the MLG release handle. Pulling the handle releases the MLG doors and up-lock hooks. The main gear will free fall but may not fully lock.

The Landing Gear alternate extension door, on the cockpit floor, must then be fully opened giving access to the alternate extension hand-pump and the NLG release handle. Opening the door mechanically operates the MLG alternate selector valve. If the MLG does not reach the down and locked position, the extension pump handle, located behind the right pilot seat, is inserted into the pump handle socket and operated to complete main gear extension and subsequent down-lock. Both the Landing Gear alternate extension door and the MLG alternate release door must be left fully open after alternate Landing Gear extension. When the NLG release handle is pulled, the nose gear up-lock and doors are released and the nose gear free falls to a down and locked position, assisted by the airflow.

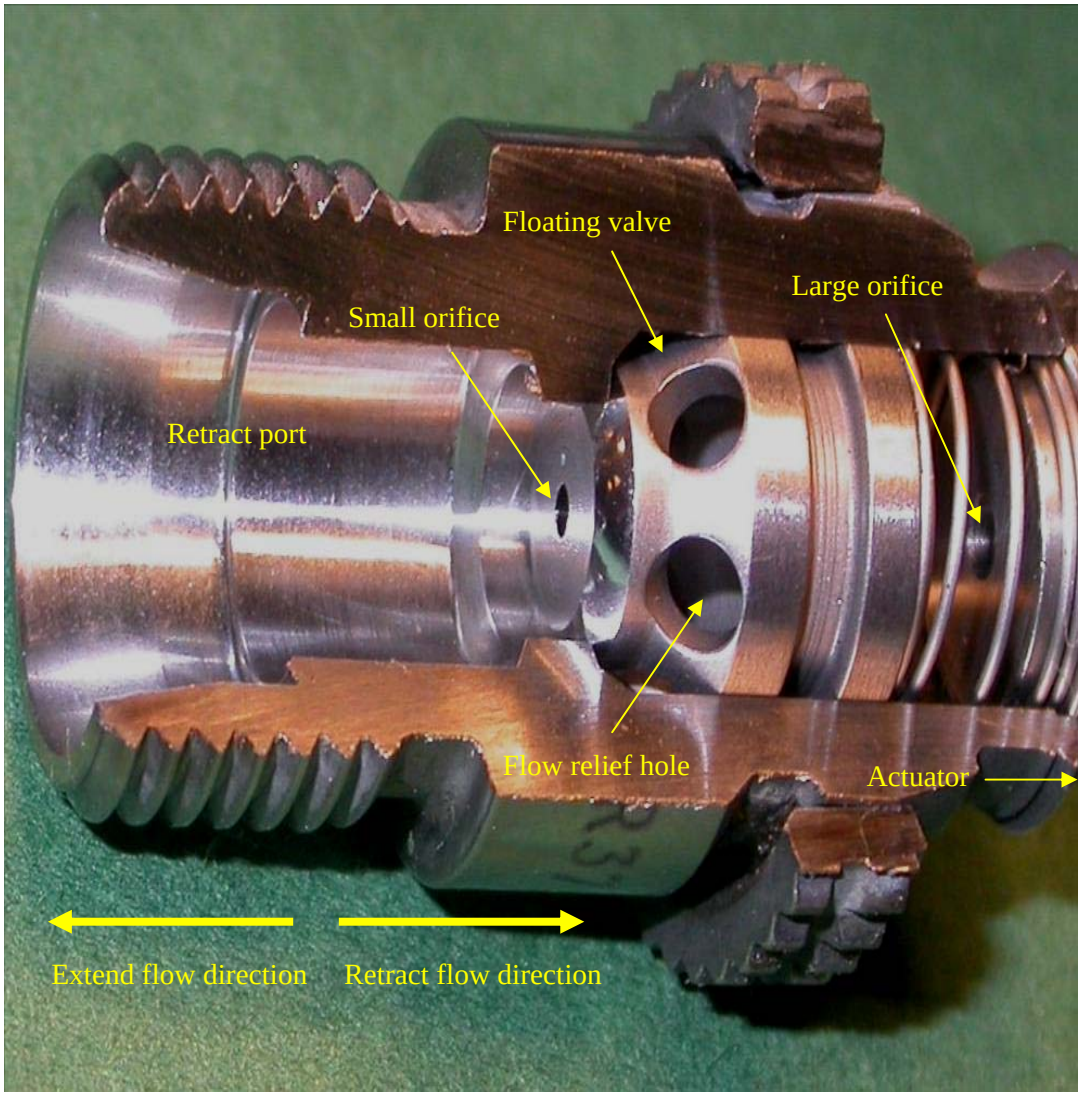
1.6.4.5 Main Landing Gear Retraction/Extension Actuator

The MLG Retraction/Extension Actuator, shown on the following drawing, is a hydraulic device that has two ports. There are restrictors in both retract and extend ports. The rod end of the actuator piston has a spherical rod-end with a lubrication fitting. The MLG Retraction/Extension Actuator cylinder is attached to the lower front of the MLG yoke cross beam. The rod end is attached to the centre top of the MLG shock strut.



MLG Retraction/Extension Actuator.

The Retraction/Extension Actuator acts as a damper through the restrictor in the retract port, when the gear is moving to the down position.
The Retract Port Restrictor, shown on the following picture in a cut away view, allows a larger volume of hydraulic fluid to pass when the gear is retracting (Floating Valve open) and less fluid when the gear is extending (Floating Valve closed).

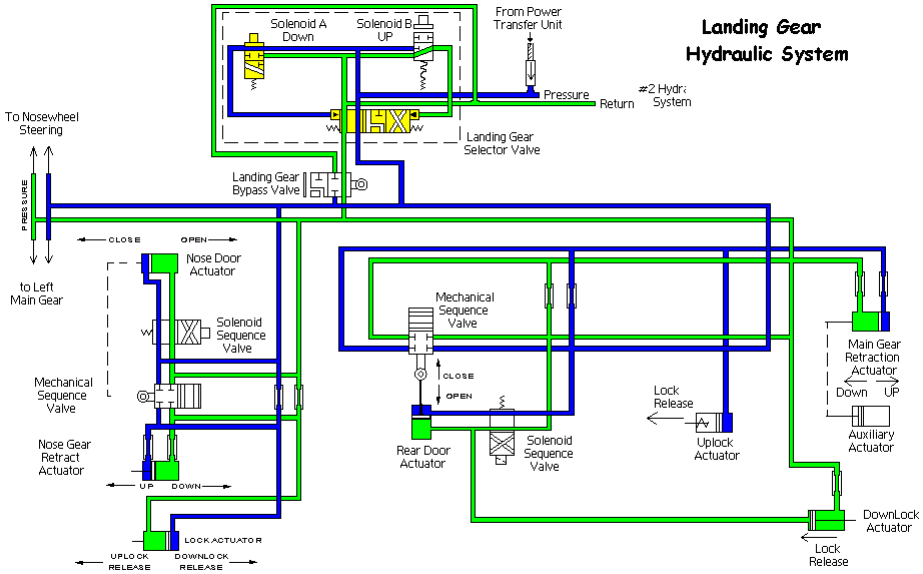


1.6.4.6 Landing Gear down operation

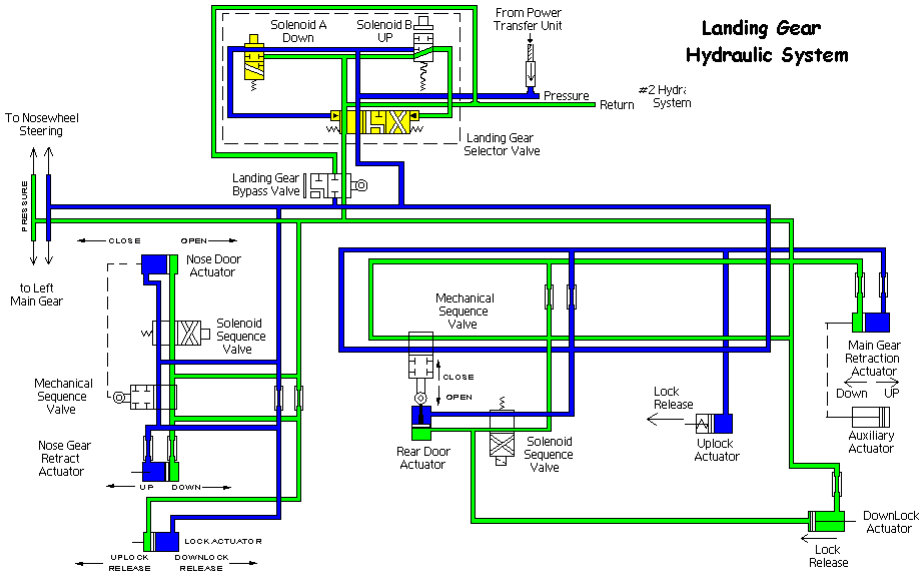
The Landing Gear system is powered by the No. 2 hydraulic system.

Selecting gear down the PSEU will energize Solenoid A and re-position the Landing Gear Selector Valve and provide pressure to the down side of the actuators (shown on the following figure).

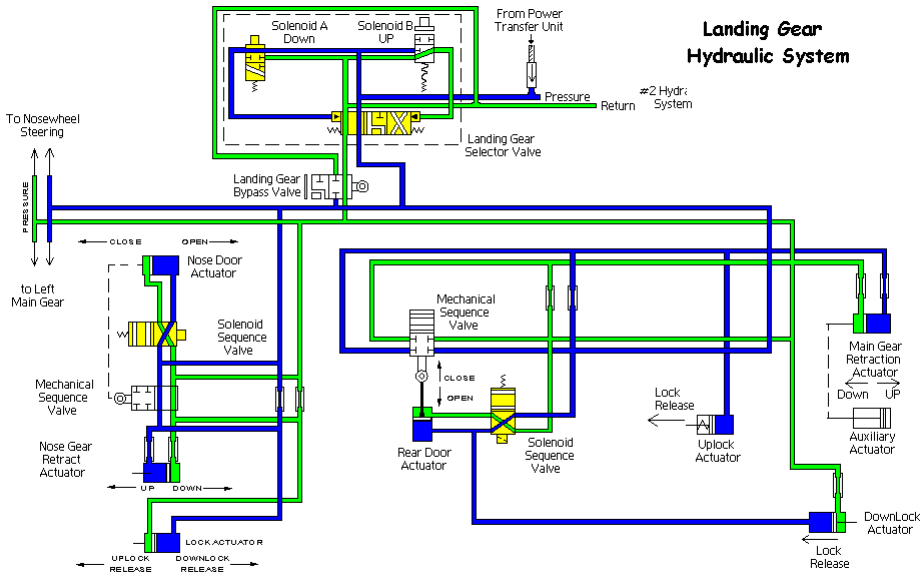
Pressure = blue. Return = green.



The figure below shows the system before all the doors and gears start to move. The restrictors slow the return flow from the actuators to allow time for the doors to fully open. Once the MSVs open the system has an un-restricted return path. The Retraction/Extension Actuator acts as a damper through the restrictor in the retract port, when the gear is moving to the down position (shown on the following figure).



Once the PSEU register the gear is down and locked it Energizes the SSVs and the doors close and the Downlock Actuator engages (shown on the following figure).



1.6.4.7 Warning systems

The warning system (horns) will be activated in situations where a power lever is retarded to a certain position or flaps are selected but the Landing Gear is not down and locked.

The Ground Proximity Warning System (GPWS) will be activated when the aircraft descends below a certain altitude if the Landing Gear is not down and locked.

1.6.5 Quick Reference Handbook (QRH).

The Alternate Landing Gear Extension checklist (page 14.1 of the QRH) and the Emergency Landing checklist (page 8.1 – 8.2 of the QRH) are enclosed as appendix B.

The above mentioned QRH are based on the aircraft manufacturers QRH as required by the authorities.

As a result of two other DHC-8 aircraft accidents in the year of 2007 caused by Landing Gear collapse, the Alternate Landing Gear Extension checklist in the QRH was revised.

The following note was added to the QRH:

*"If **one** Main Gear remains unsafe after Alternate Landing Gear Extension, **consider** Engine Shutdown according to Engine Failure/Fire/Shutdown checklist page 5.10 on affected side and/or reseating of passengers sitting in rows adjacent to the propeller on affected side, due to risk of propeller debris entering the cabin at touchdown."*

With reference to Chapter 1.1 History of the flight and Appendix A Flight history – timetable based on the CVR and FDR data:

Without success, the flight crew followed the Alternate Landing Gear Extension checklist.

The right MLG remained in an almost up position which changed the conditions into a situation where the Emergency Landing checklist would have been the one to follow.
The Emergency Landing checklist was not performed or not adequately performed. The first item on the checklist was "*Pull the GPWS CB (A1 & B1 – Avionics CB Panel)*". Because the CB's was not pulled, the flight crew was disturbed by the GPWS warning horns during the remaining flight.

The Alternate Landing Gear Extension checklist did not contain information/references to the Emergency Landing, Forced Landing Emergency Evacuation checklist in a situation where the use of this checklist did not solve a Landing Gear unsafe problem.

It must be added that there are no certification requirements for checklists (manufacturers and/or operators) to refer to other relevant checklists.

The above mentioned issues were also issues in the AIB investigation on the DHC-8 accident at Aalborg Airport on September 9th 2007 (report HCLJ510-000433).
In the Aalborg accident, the flight crew found that the QRH was not helpful. Twice without success, they used the Alternate Landing Gear checklist. The crew was going to do an emergency landing and the Emergency Landing checklist was the one to follow. This checklist was not used which caused disturbance (GPWS warning horns) of the flight crew during the remaining flight.

1.7 Meteorological information

The TAF and METAR reports from October 27th 2007 around the time of the accident at EKCH:

271100 TAF-FC ekch 271140z 271221 08003kt 6000 few008 sct020 becmg 1618 4000 br becmg 1820 22003kt prob30 1821 0300 bcfg=
271400 TAF-FC ekch 271440z 271524 vrb03kt 8000 few008 sct020 becmg 1618 4000 br tempo 1820 2000 prob40 2024 0300 bcfg=

271420 METAR ekch 271420z 07002kt 8000 few013 bkn035 11/08 q1026 tempo 6000=
271450 METAR ekch 271450z 09003kt 8000 ovc034 10/08 q1026 tempo 6000=
271520 METAR ekch 271520z 11003kt 8000 few014 bkn033 10/08 q1026 tempo 6000=

1.8 Aids to navigation

At the time of the accident, Copenhagen Airport, Kastrup had the following radio navigation and landing aids for runway 04R: ILS/DME category I, VOR/DME, Approach and Runway lighting system, PAPI-L (3.0°), and ATC radar approach control.
At the time of the accident, all navigation aids were functioning without remarks.

1.9 Communications

The flight crew was in radio contact with following ATC units: Kastrup Tower (119.350 MHz), Copenhagen Approach (118.450 MHz) and Kastrup Final (119.100 MHz). The flight crew was in radio contact with ATC using the normal routine frequencies until 14:20:09 hrs. At that time, the flight was assigned its unique controller, Final (119.100 MHz). The flight remained on that frequency (119.100 MHz) through the remaining flight.
The communication between ATC and the flight crew was recorded and was used in the investigation.

1.10 Aerodrome information

Name:	Copenhagen Airport, Kastrup
Location indicator:	EKCH.
Position:	4.4 nm southeast of Copenhagen (55 37 04.50N / 012 39 21.50E).
Traffic permitted:	IFR / VFR.
Fire fighting and rescue:	Approved to category 9 (ICAO Annex 14) and rescue boats.
Runway 04R:	Asphalt, dimensions 3.300 x 45 m, elevation 12 ft.
Taxiway C south:	South of runway 04R, concrete/asphalt total width 60 m.

The approach and landing was performed on runway 04R. The runway 04R was selected for the landing by ATC because the runway was the most suitable for these kinds of operations. The runway 04R did not have crossing road tunnels and the runway had many access taxiways and roads.

Airport map from the Aeronautical Information Publication (AIP) Denmark is enclosed as appendix C.

1.11 Flight recorders

1.11.1 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a Honywell CVR, type SSCVR part number 980-6022-011 serial number 0847. On the day of the accident, the CVR was removed from the aircraft. The data from the CVR was of good quality and was used in the investigation.

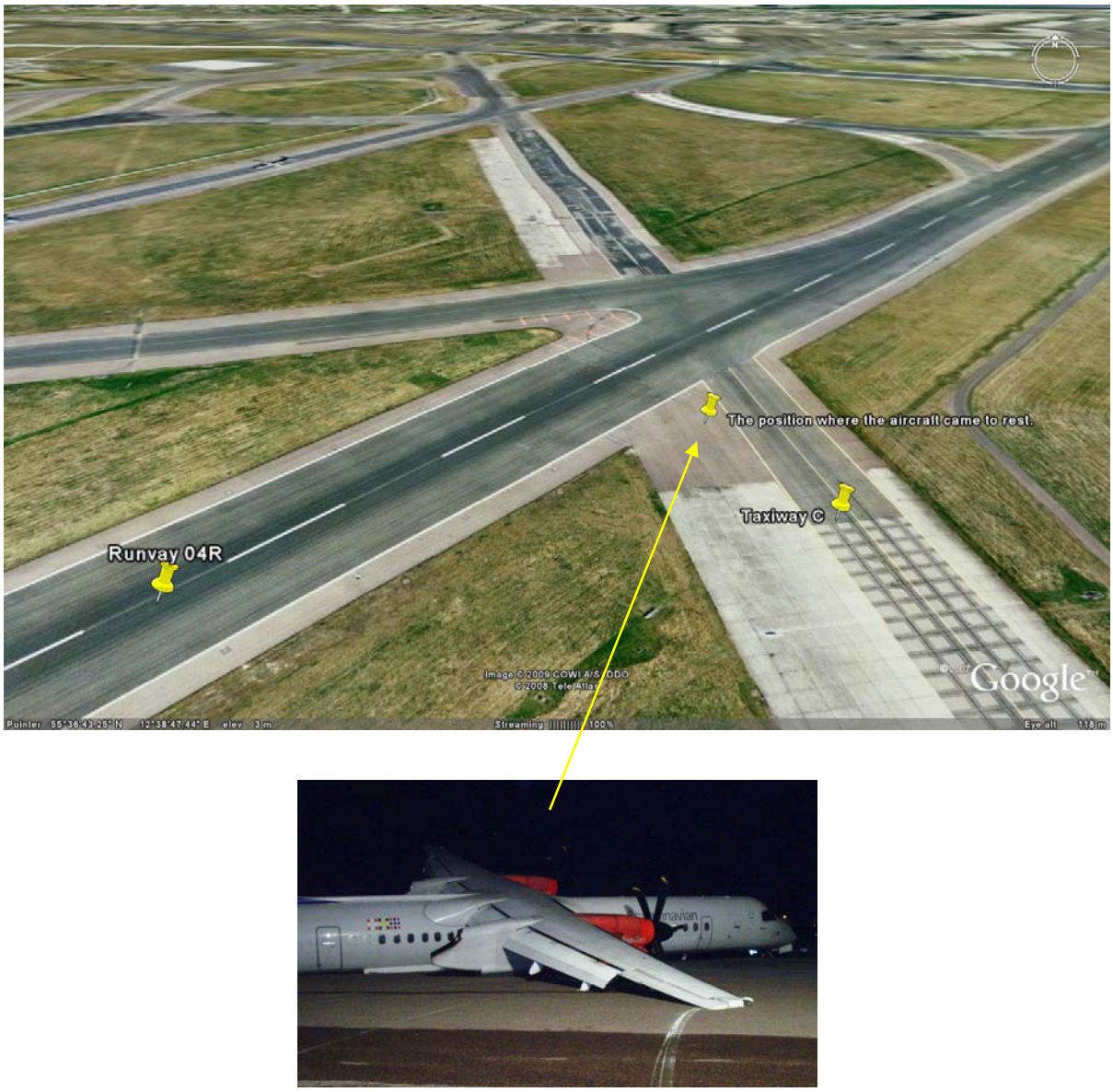
1.11.2 Flight Data Recorder (FDR)

The aircraft was equipped with a Honywell FDR, type SSFDR part number 980-4700-027 serial number 3691. On the day of the accident, the FDR was removed from the aircraft. The time reference used in the FDR was a cockpit clock (the commander). The time reference used by the FDR was 59 seconds ahead of UTC. The data from the FDR was of good quality and was used in the investigation.

1.12 Wreckage and impact information

1.12.1 General

After touchdown, the aircraft rolled 7 seconds before the right propeller and the aft part of the fuselage made contact with the runway surface. 15 seconds after touchdown, the right wingtip made contact with the runway surface. 27 seconds after touchdown, the aircraft came to rest on taxiway C area heading southeast 115°.

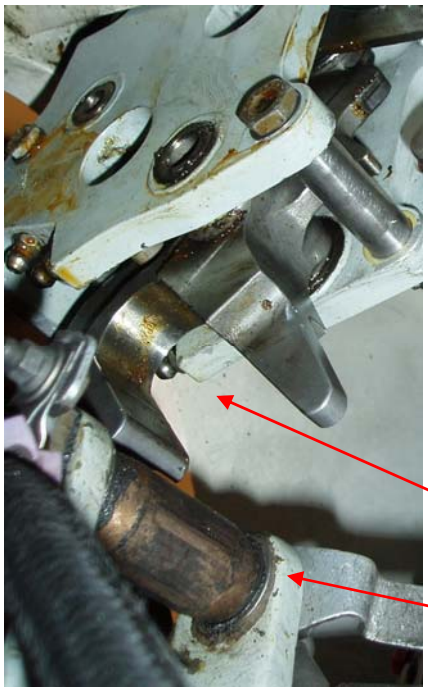


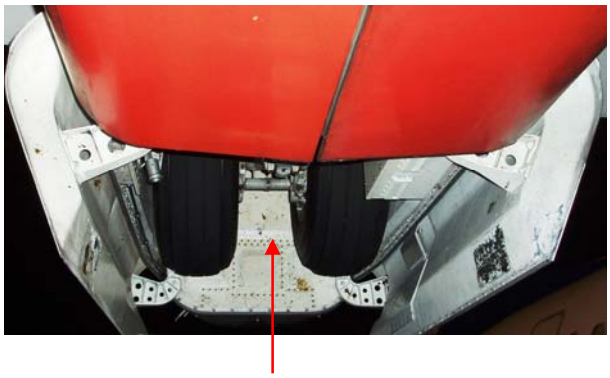
Before landing, the right engine was shut down. Four propeller blades were damaged as a result of ground contact. The aft lower fuselage was damaged while skidding on the runway asphalt. The NLG right tire deflated and the NLG was damaged when the aircraft side slipped into taxiway C. The right outer wing sustained minor damage while skidding on the runway asphalt and concrete. The fuselage surrounding the cabin area was undamaged.

1.12.2 Aircraft recovery and initial Main Landing Gear examination

Air bags were used to lift up the right wing and the wing was then supported by a jack.

The MLG was found released from the up-lock hook but stuck in a position approximately 10 cm down from the hook.





MLG position in the right MLG wheel well

MLG up-lock hook found released

MLG up-lock roller position in relation to the up-lock hook

It was not possible by manpower to move the MLG up or down from its stuck position. The MLG and the components installed in the MLG wheel well were inspected and no abnormalities were found that could explain the stuck MLG. The Retraction/Extension Actuator was intact. One by one, the hydraulic hoses were removed from the Retraction/Extension Actuator. The MLG stayed in the stuck position. Hydraulic fluid samples were obtained from the hoses that were connected to the actuator. No visible contamination of the hydraulic fluid was observed.

When the actuator was dismantled from the MLG yoke cross beam the MLG moved downwards. The actuator was removed from the MLG, the restrictor ports were capped and the gear was fully lowered and locked in the down position.

The aircraft was towed away from taxiway C and placed in a hangar at the airport.

1.12.3 Landing Gear function tests

A Retraction/Extension Actuator serial number MAL-0062 was removed from another DHC-8 aircraft and installed on the right MLG for testing purposes. A hydraulic test unit was connected to the No. 2 hydraulic system.

With focus on the right MLG, a number of hydraulic test cycles of the Landing Gear were performed:

1) 6 normal cycles of retractions/extensions
2) 2 alternate extensions
3) 10 normal cycles of retractions/extensions
4) 1 alternate extension
5) 10 normal cycles of retractions/extensions
6) 1 alternate extension
7) 5 normal cycles of retractions/extensions

The function of the Landing Gear system was found to be normal.

The hydraulic pressure, return and pump case drain filters were removed and for the purpose of examination in a laboratory environment, hydraulic fluid samples were obtained from No. 2 hydraulic system.

The color of the hydraulic fluid was darker than normal but no abnormal contaminations were found in the filters or in the fluid samples. The fluid was compared to a reference sample of unused fluid specified for the aircraft. There were no indications that the fluid was not identical to the reference sample.

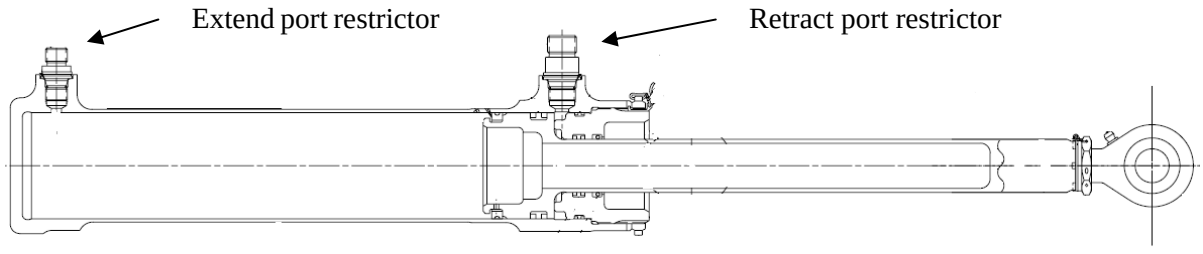
1.12.4 Main Landing Gear Retraction/Extension Actuator examination

Actuator data:

Part number (P/N): 46550-9

Serial number (S/N): MAL-0074

The actuator was repaired by an approved overhaul facility. The cylinder, piston, gland nut, rod end and restrictors were replaced. An authorized release certificate EASA Form 1 was issued on 12th October 2007. The actuator was installed on the aircraft on 24th October 2007.



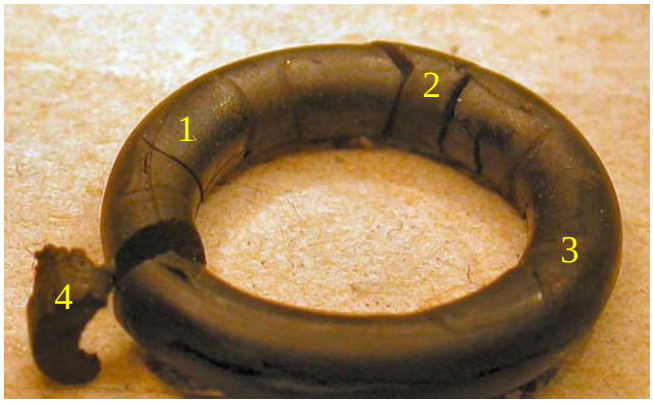
MLG Retraction/Extension Actuator

The extend port restrictor was removed and appeared to be clean as light could be seen through it.
The Retract Port Restrictor was removed and appeared to be blocked, as light could not be seen through it.

Fluids removed from the actuator retract and extend chambers contained particles and appeared to be discolored.
The actuator was disassembled and none of the findings could have caused the actuator to be blocked.

1.12.5 Retract Port Restrictor examination

A detailed examination report is enclosed as appendix D Retract Port Restrictor examination.
Viewing down into the restrictor from the system side, it was evident that the orifice hole was blocked.
X-ray examination did not reveal presence of any metallic particles or other x-ray absorbing material in the flow channels of the restrictor.
Removing the large orifice situated behind the Floating Valve in the restrictor allowed a view of the valve interior. A broken O-ring was partly emerging through one of the flow relief holes. When the Floating Valve was removed from the restrictor housing, a damaged O-ring was found in four pieces. The small orifice in the Floating Valve was blocked by a piece of O-ring material that matched the missing part of the No. 4 piece of O-ring (pictures below).



Top left: Reassembled O-ring from the four pieces found in the floating valve.

Top right: The small orifice hole in the floating valve is seen blocked by a piece of the O-ring.

Bottom left: A small bit of the O-ring was almost punched through the small orifice hole and blocking it.

1.12.6 Analysis of the rogue O-ring

The physical dimensions of the rogue O-ring was similar to that of the National Aerospace Standard P/N NAS1611-110 O-ring identified on the drawings for the door solenoid sequence valve (SSV). It was further determined that the only component in the Landing Gear system that incorporated this type of O-ring was the SSV.

NAS1611-110 O-rings were installed in the UP and DOWN ports of the SSV situated adjacent to a filter element that protects the SSV.

To establish similarity with the rogue O-ring, an O-ring was removed from a second SSV and was examined. The material analysis was carried out by means of infrared spectroscopy.

The O-rings were found to be identical in both size and in material composition that was found to be EPDM (synthetic) rubber compounds.

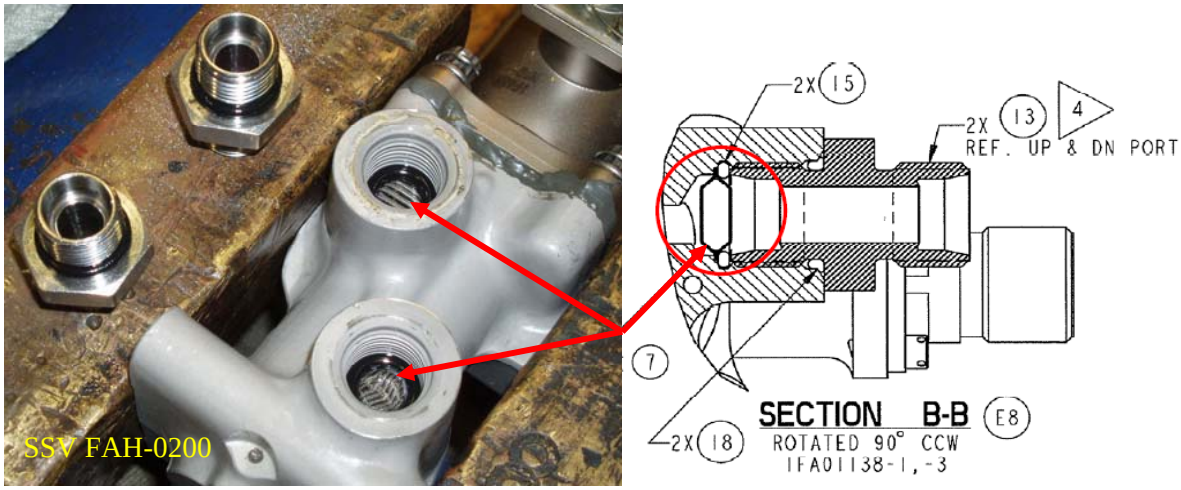
The O-ring dimensions according to the NAS specification sheet were:

Inner diameter: 0.362 in (9.1948 mm) and cross section with: 0.103 in (2.6162 mm).

1.12.7 Solenoid Sequence Valve examination

1.12.7.1 Solenoid Sequence Valve S/N FAH-0200 examination

The SSV S/N FAH-0200 that replaced S/N FAH-0083 on the 16th October 2007 was examined without leading to any findings or remarks. The O-rings P/N NAS1611-110 and the filter elements were in place in both the up and down port of the valve as shown below.



The filter element (7) and O-ring (15) in place in the up and down ports of the valve.
The filter element and the O-ring are held in place by the union, flareless tube (13).

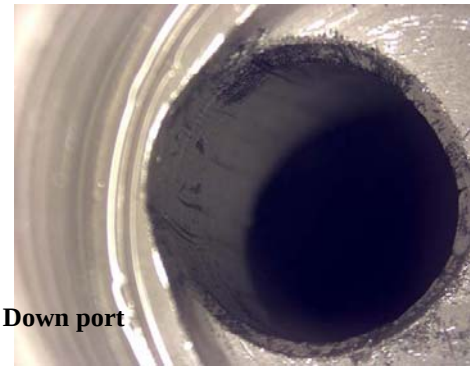
1.12.7.2 Solenoid Sequence Valve S/N FAH-0083 examination

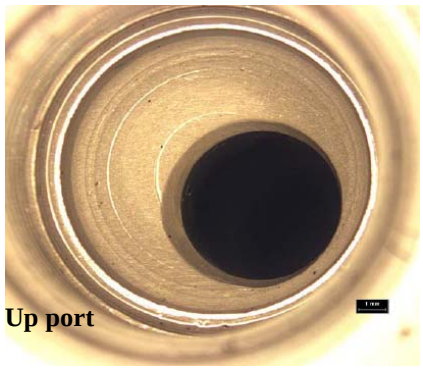
The SSV removed from the aircraft on 16th October 2007 was sent to the Landing Gear manufacturer in Canada for refurbishment. In cooperation with the Transportation Safety Board of Canada, the AIB arranged the SSV to be examined in Canada.

The examination revealed that the filter element and the O-ring were not present in the down port of the SSV (shown below).

Microscopic inspection of the down port, from which the filter and the O-ring were missing, showed damage in form of linear score marks and nicks both inside the drill bore and around the entrance of the bore. For comparison, the up port O-ring and filter were removed and the up port inspected. This port showed no evidence of damage.

The down and up port drill bores is shown below.


Down port


Up port

Examination of the SSV showed that passage of a cross section 0.103 +/- 0.003 inch O-ring (NAS1611-110) was not possible due to the sleeve hole diameter (0.069 inch/0.073 inch) inside the SSV.

Sleeve from SSV S/N FAH-0083 and a NAS1611-110 O-ring are shown below.

The filter element or remains from the filter element was not found in the SSV or in filters of the No. 2 hydraulic system.

The investigation found no information revealing that it was observed and/or reported that the filter element and the O-ring were missing from the down port of the replaced SSV S/N FAH-0083.

1.12.7.3 Solenoid Sequence Valve port filter element collapses

In the course of the investigation, the AIB became aware that past occurrences showed that filter elements in the SSV could collapse and migrate into the Landing Gear hydraulic system. In the past occurrences, O-Rings (situated adjacent to the filter) from the SSV´s are not known to have migrated into the Landing Gear hydraulic system.

Compression from the union, flareless tube on the O-ring is no longer present when a filter element collapse and moves away from the position behind the O-ring. This gives the O-ring the opportunity to migrate into the Landing Gear hydraulic system.

According to the manufacturer and order to solve this problem, a new type of filter element was under development when this accident occurred (reference: Appendix E).

The investigation also became aware that the information regarding the SSV filter element collapse scenario was unknown to the maintenance personnel. The operator engineering department was in possession of information on potential collapse of the SSV filters.

After the accident, an engineering order was initiated by the operator to remove 39 SSV's from the DHC-8 fleet. Inspection of these SSV's (78 up and down ports) revealed the following findings up to and including 11th December 2007:

- 5 damaged filters.
- 20 collapsed filters.
- 3 missing filters.
- 2 damaged O-rings.
- Color marking of the O-rings was not consistent (the picture of SSV S/N FAH-0200 illustrated in section 1.12.7.1 show O-rings without color markings and the picture of SSV S/N FAH-0083 illustrated above in this section show a color marked O-ring). The O-ring found in the restrictor was not color marked.

Finding examples from the above mentioned SSV inspections shown below.

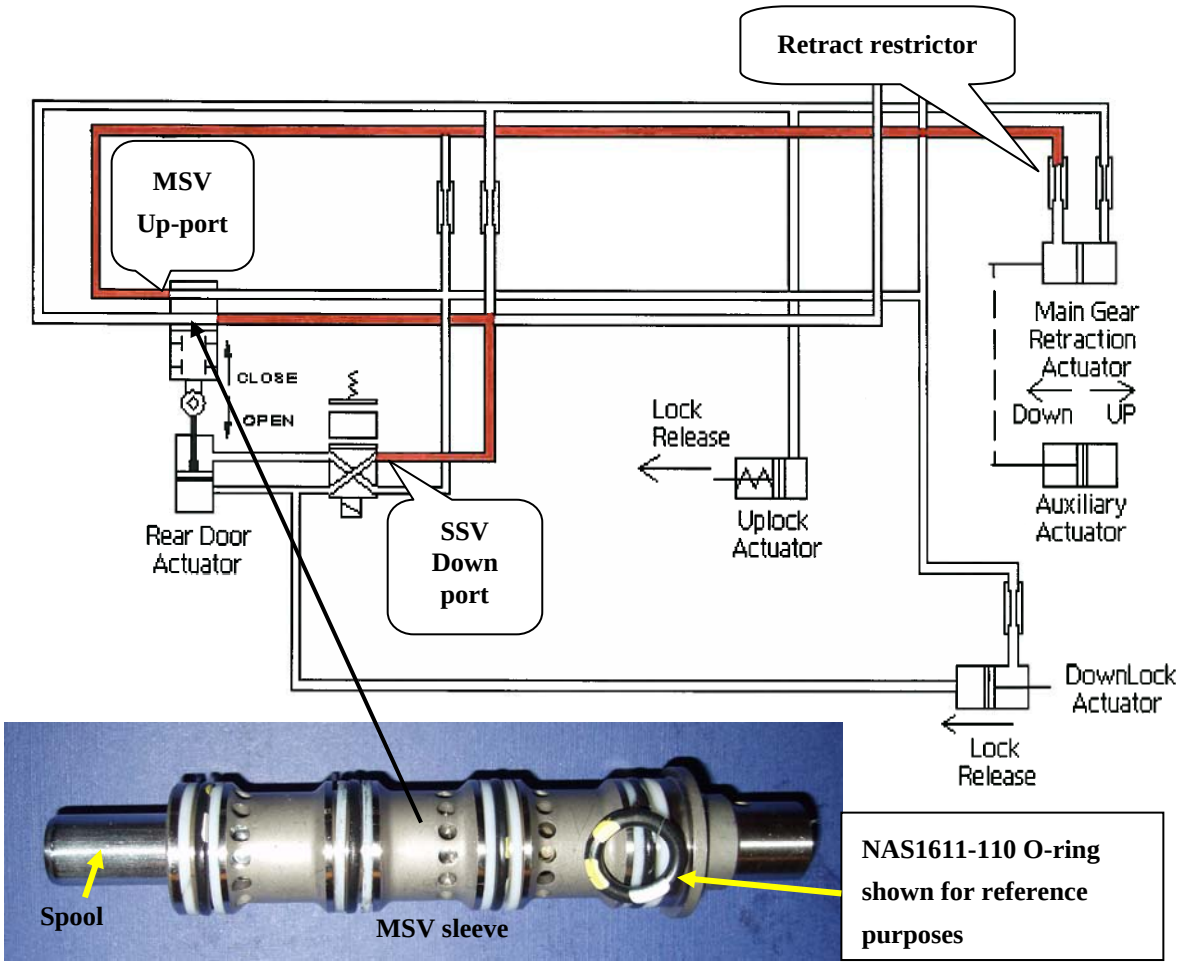
Left:
The filter element is damaged but still in place behind the o-ring.
Right:
Collapsed filter element and damaged o-ring.
Below:
Collapsed filter element migrated into the SSV port drill bore.

1.12.8 Main Landing Gear hydraulic system review

A review of the aircraft hydraulic system concluded that the rogue O-ring could not travel from the SSV to its final location in the Retract Port Restrictor of the right MLG Retraction/Extension Actuator. This conclusion was supported by a detailed analysis of the other valves, in-line restrictors and fittings in the system between these two components.

The analysis showed that while some of the hydraulic tubes would allow free passage of a rogue O-ring, other of the valve components, such as the Mechanical Sequence Valve (MSV) were of such a design that the O-ring could not pass through.

The review of the hydraulic system revealed that the rogue O-ring from the SSV down port was able to travel between the SSV and the MSV and between the MSV and the Retract Port Restrictor installed on the MLG Retraction/Extension Actuator. This is shown on the following drawing by **red** colored lines. The sleeve was removed from the MSV. It was determined that the diameters of the sleeve holes at the up and down ports were less than the diameter of the NAS1611-110 O-ring. Furthermore the space inside the sleeve is minimized by the moveable spool operated by the Rear Door Actuator (illustrated below).



1.12.9 Trouble shooting and maintenance actions

The operator grounded its DHC-8 fleet on 11th September 2007. This action was taken because the operator suffered from two accidents where MLG Retraction/Extension Actuators were involved. The aircraft was released as airworthy by the Civil Aviation Authorities and the first flight with LN-RDI after grounding was a test flight performed on 15th October 2007.

According to the technical documentation, the following discrepancies were reported and handled in the period from 15th to 24th October 2007, which is showed on the following transcript of the maintenance records:

Discrepancy reported on 15th October 2007:	Corrective action:
On first retraction of landing gear right door and unsafe light stayed on much longer than left side.	*Right MLG door Solenoid Sequence Valve (installed in right MLG wheel well) replaced with serviceable valve, taken from same location from A/C Reg.: LN-RDB.* Part removed: Solenoid Sequence Valve P/N: 48302-3 S/N: FAH-0083 Date: 16.10.2007 Part installed: Solenoid Sequence Valve P/N: 48302-3 S/N: FAH-0200 Date: 16.10.2007

Discrepancies reported on 16th October 2007:	Corrective actions:
1) During gear retraction, right gear door 5 sec. slower than left gear door and nose door. *2) At level flight (4000') gear down selected. Yellow gear door caution light right gear door and red LDG unsafe light, also transit light in gear handle on, visual check confirmed with indication after app 5 min flight 3 green LDG lights on LDG selector panel, also checked with LDG alternate extension gear green light in floor. After shut down right gear indication red.*	*1) Function test of landing gear performed acc. to AMM 32-31-00-720-801 found within limit.* *2) Found target for right MLG down lock prox sensor loose. Target replaced and test performed acc. AMM 32-31-00-720-801.*

Discrepancy reported on 17th October 2007:	Corrective action:
Functional test flight 4 x recycling of LDG performed. First time gear light right main stayed on for 5 sec. longer than nose and left main door. Other cycles all normal.	*Aircraft connected to ground hyd. cart. Multiple retraction extension functions completed IAW AMM 32-31-00 and alternate system function IAW AMM 32-34-00 no defects evident all indications correct # 2 hyd. System bleeding IAW AMM 29-10-00. Ground cart removed.*

Discrepancy reported on 20th October 2007:	Corrective actions:
Right gear doors closing 5-7 sec. later than other doors.	*Right MLG door actuator replaced acc. AMM 32-31-26-000-801.* Part removed: Door Actuator, P/N: 46830-5, S/N: MAL-0307, Date: 21.10.2007 Part installed: Door Actuator, P/N: 46830-5, S/N: MAL-0095, Date: 21.10.2007 *Right Mechanical Sequence Valve replaced acc. AMM 32-31-36-04.* Part removed: Mechanical Sequence Valve, P/N: 48303-103, S/N: FAH-0107, Date: 22.10.2007 Part installed: Mechanical Sequence Valve, P/N: 48303-7, S/N: FAH-0345, Date: 22.10.2007

Discrepancy reported on 22nd October 2007:	Corrective action:
Right MLG retraction slow.	*Alternate extension manifold filter checked ok, filter installed and alternate extension check performed.*

Discrepancies reported on 24th October 2007:	Corrective actions:
1) Test flight performed right MLG is very slow to extend more than 60 sec. perhaps 2 min. *2) Right MLG door closing 5-7 sec. later than other doors.*	*1) Right MLG MSV rigging checked, air bled from # 2 hyd system, 20 gear swings carried out and system bled no further defects evident.* *2) MLG Retraction Extension Actuator replaced.* Part removed: MLG Retraction Extension Actuator P/N: 46550-9 S/N: MAL-0117 Date: 24.10.2007 Part installed: MLG Retraction Extension Actuator P/N: 46550-9 S/N: MAL-0074 Date: 24.10.2007

Since the last maintenance action performed on 24th October 2007 until the accident occurred on 27th October 2007, the aircraft had completed a test flight on 25th October 2007 and 21 flight sectors without any reported discrepancies.

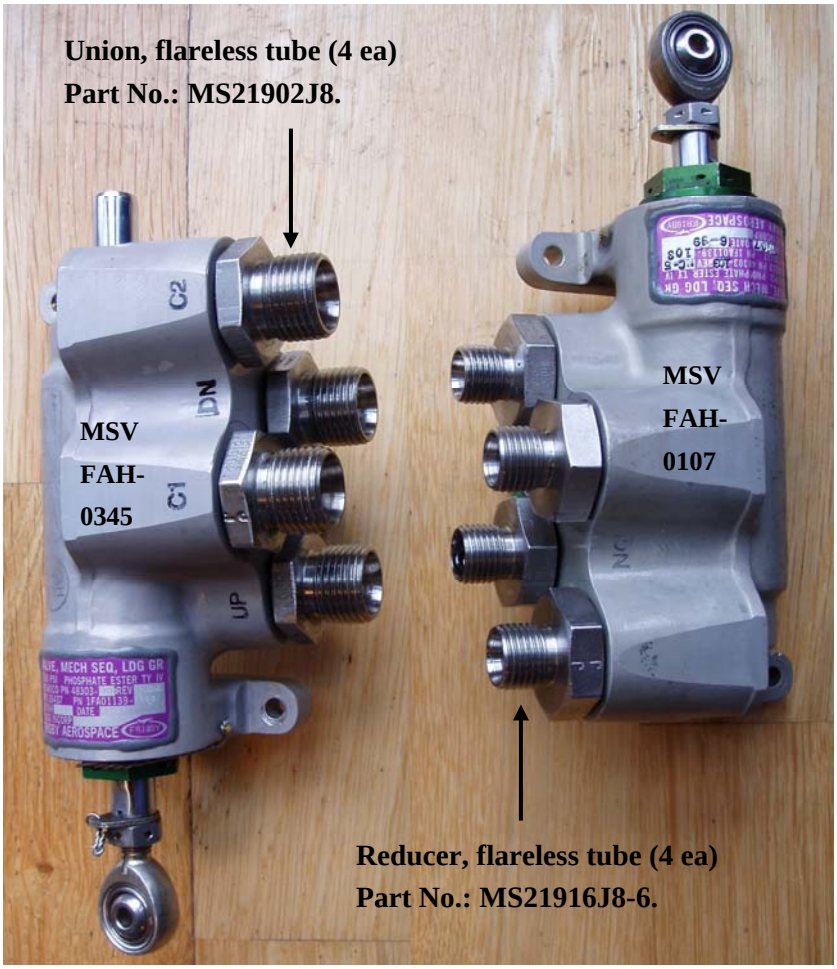
1.12.10 Mechanical Sequence Valve installation

The MSV S/N FAH-0345 that was installed on the aircraft right MLG at the time of the accident was removed from the aircraft and examined without it leading to any findings or remarks.
According to the operator maintenance and logistic records, the MSV was identified as NLG MSV P/N 48303-7 S/N FAH-0345. The Authorized Release Certificate following the MSV from stock also identified the valve as NLG MSV P/N 48303-7 S/N FAH-0345.

The MSV S/N FAH-0107 that was replaced on 22nd October 2007 was located and examined.
The MSV was found to be configured with unions different from these attached to MSV S/N FAH-0345. There were no other findings or remarks.
According to the operator technical and logistic documentation and the manufacturer aircraft S/N 4024 Serialization List, the MSV was identified as Valve Body P/N 48303-103 S/N FAH-0107.

Review of the Aircraft Illustrated Parts Catalog (IPC) revealed that the MSV Valve Body S/N FAH-0107 was reconfigured as a MSV P/N 48303-7 intended for installation in the nose Landing Gear wheel well. The four unions were described as Reducer, flareless tube P/N MS21916J8-6.
According to the aircraft records, the MSV Valve Body P/N 48303-103 S/N FAH-0107 had been installed on the aircraft since the aircraft was delivered from the manufacturer as new. The P/N 48303-103 was in the IPC defined as a MSV Valve Body without Unions/Reducers.

MSV S/N FAH-0345 compared to S/N FAH-0107 is shown on the following picture.
Note: The MSV FAH-0107 is shown as it was found by the investigation team in the storage system.



According to the maintenance records and the IPC, the replacement MSV, supplied from stock, was a NLG MSV P/N 48303-7 S/N FAH-0345 intended for installation in the NLG wheel well.

Interview with the involved maintenance personnel revealed that prior to installation into the right MLG wheel well; the supplied MSV was reconfigured by the maintenance personnel.
The Unions/Reducers were interchanged between the MSV's.
The Unions from MSV S/N FAH-0107, which were removed from the aircraft, were installed on the supplied MSV S/N FAH-0345 converting this MSV from a P/N 48303-7 to a P/N 48303-5, which was compatible with the installation requirements for the MLG wheel well.

The picture comparing the two valves shows that the Reducers from the MSV P/N 48303-7 S/N FAH-345, supplied from stock, was installed on the MSV Valve Body P/N 48303-103 S/N FAH-0107, which was removed from the aircraft on 22nd October 2007.

The NLG MSV P/N 48303-7 S/N FAH-0345 was identified and approved by the attached Authorized Release Certificate issued by the landing gear manufacturer on May 17th 2006.

No approved reconfiguration procedure was found in the Aircraft Maintenance Manual (AMM) or in any other approved aircraft maintenance documents.

NLG MSV P/N 48303-7 S/N FAH-0345 Authorized Release Certificate shown below.

1. Approving National Aviation Authority/Country: Transport Canada	2. **AUTHORIZED RELEASE CERTIFICATE** TCCA 24-0078				3. Form Tracking Number: **155203**	
4. Approved Organization Name and Address: Goodrich Aerospace Ltd. Goodrich Landing Gear Division 1400 South Service Road West Oakville, Ontario, Canada L6L 5Y7					5. Work Order/Contract/Invoice Number: P.O. 2AHJ5600926 W.O. No. 94302 / 203964	
6. Item:	7. Description:	8. Part Number:	9. Eligibility:	10. Quantity:	11. Serial/Batch Number:	12. Status/Work:
1	VALVE, MECHANICAL SEQUENCE	48303-7	X	1	FAH0345	INSPECTED

"EASA Part-145.Certificate No. EASA.145.7043"

13. Remarks:
TSN: 3280.51 CSN: 5622
WARRANTY EXCHANGE UNIT REPLACES SERIAL NUMBER: FAH0187
VACUUM TEST CARRIED OUT AT GOODRICH AS PER ENGINEERING INSTRUCTIONS. THE UNIT WAS REPAIRED BY THE VENDOR FRISBY AEROSPACE, LLC ON GOODRICH P.O. 20060018 OW LINE 25. INSPECTED AT GOODRICH.

14. Certifies the items identified above were manufactured in conformity to: ☐ Approved design data and are in a condition for safe operation. ☐ Non-approved design data specified in Block 13.		19. ☒ CAR 571.10 Maintenance Release ☒ Other regulations specified in Block 13 Certifies that unless otherwise specified in Block 13, the work identified in Block 12 and described in Block 13 was accomplished in accordance CAR 571	
15. Authorized Signature:	16. Certificate/Approval ref No.:	20. Authorized Signature: GOODRICH FINAL PRODUCT ACCEPTANCE MC 32	21. Certificate/Approval ref No.: TCA.AMO 3-66
17. Name (Typed or Printed):	18. Date :	22. Name (Typed or Printed): K Greenway	23. Date : MAY 17 2006

User/Installer Responsibilities

1. This document does not constitute authority to install the part.
2. Where the installer works in accordance with the national regulations of an airworthiness authority other than the authority specified in Block 1, the installer must ensure that his/her airworthiness authority accepts products or maintenance from the airworthiness authority specified in Block 1.
3. Statements 14 and 19 do not constitute installation certification. In all cases, the aircraft technical record must contain an installation certification issued in accordance with the national regulations of the state of registry, before the aircraft may be flown.

1.12.11 Mechanical Sequence Valve Identification and Registration

1.12.11.1 General

The manufacturer's documentation adhered to Air Transport Association of America (ATA) Specification 100 – Specification for Manufacturers Technical Data.
Among other texts the ATA document chapter 2-4. Aircraft Illustrated Parts Catalog. Section 2-4-0. Policy writes in general:

"A) The Illustrated Parts Catalog is intended for use in the identification and requisition of replaceable aircraft parts and units. It is a companion document to the Aircraft Maintenance Manual and shall contain all parts information for which maintenance practices coverage has been provided."

"B) It shall also contain all those individual line-replaceable units such as light bulbs, sockets, lenses, caps, seals, bearings, screens, screws, filters, electrical connectors, circuit cards, relays, pulleys, fittings, brackets, external lines and all components and/or parts where maintenance practices allow replacement of the components or parts rather than replacement of the next higher assembly."

"C) If a specific part is to be locally manufactured from raw (bulk) stock such as cut lengths of conduit, bonded braid, upholstery cloth, gasket material, rubber extrusion, etc., it shall be clearly stated."

1.12.11.2 Manufacturer's parts documentation

At the time of delivery of the aircraft, a Serialization List by ATA chapter was compiled by the aircraft manufacturer for the operator of the DHC-8 aircraft S/N 4024.

Extract from the aircraft S/N 4024 Serialization list regarding ATA chapter 32 is shown following.

A. ATA chapter.
B. P/N.
C. Description.
D. Life time component.
E. Manufacturing date (life limit according to).
F. Serial (serialized component).
G. Interchangeable.
H. Replaceable.
I. S/N.
J. Verified.
K. Location on aircraft.

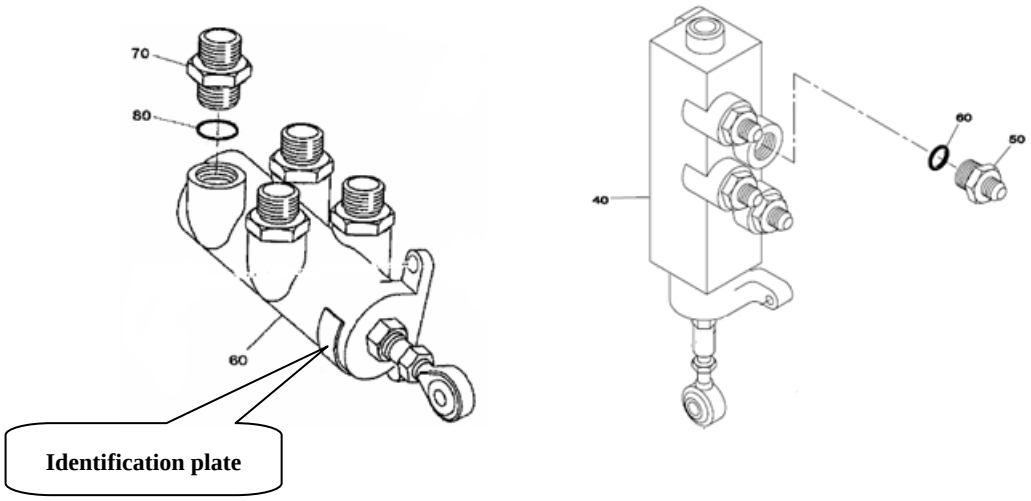
A	B	C	D	E	F	G	H	I	J	K
32-31-11	46551-1	Retraction Actuator, Cylinder	T	Cycle Life	X	X		M1367	M	L Nacelle
32-31-11	46551-1	Retraction Actuator, Cylinder	T	Cycle Life	X	X		MF9900522	M	R Nacelle
32-31-11	46570-1	Retraction Actuator, Piston	T	Cycle Life	X	X		CT0037	M	L Nacelle
32-31-11	46570-1	Retraction Actuator, Piston	T	Cycle Life	X	X		LE0039	M	R Nacelle
32-31-11	46572-3	Retraction Actuator, Gland	T	Cycle Life	X	X		SD0042	M	L Nacelle
32-31-11	46572-3	Retraction Actuator, Gland	T	Cycle Life	X	X		BC1040	M	R Nacelle
32-31-16	46600-5	MLG Lock Actuator Assembly	X	Cycle Life	X	X		MAL0068	M	Left Main Landing Gear
32-31-16	46600-5	MLG Lock Actuator Assembly	X	Cycle Life	X	X		MAL0071	M	Right Main Landing Gear
32-31-21	46500-3	Uplock Assy, MLG	T	Cycle Life	X	X		MAL-NLG/0009/99		L Nacelle
32-31-21	46500-3	Uplock Assy, MLG	T	Cycle Life	X	X		MAL-NLG/0019/99		R Nacelle
32-31-26	46830-1	Door Actuator Assy, MLG	T	Cycle Life	X	X		0044		L Nacelle
32-31-26	46830-1	Door Actuator Assy, MLG	T	Cycle Life	X	X		MAL0048	5/7	R Nacelle
32-31-36	48303-103	Mechanical Sequence Valve			X	X		0106		L Nacelle
32-31-36	48303-103	Mechanical Sequence Valve			X	X		0107		R Nacelle
32-31-41	48302-3	Solenoid Sequence Valve (MLG)			X	X		FAH075	V	L Nacelle
32-31-41	48302-3	Solenoid Sequence Valve (MLG)			X	X		FAH0082	V	R Nacelle
32-31-46	47500-3	Retraction Actuator Assy, NLG	T	Cycle Life	X	X		MAL0035		Nose Gear Bay
32-31-51	47400-1	Lock Actuator Assy, NLG	T	Cycle Life	X	X		MAL0034		Nose Gear Bay
32-31-56	47830-1	Door Actuator Assy, NLG	T	Cycle Life	X	X		0032	20/3	Nose Gear Bay
32-31-66	48303-7	Mechanical Sequence Valve			X	X		FAH0086	9/2	Nose gear Bay

According to the list ATA number 32-31-36 MSV Valve Body P/N 48303-103 was installed in both MLG wheel wells and ATA number 32-31-66 MSV P/N 48303-7 was installed in the NLG wheel well during delivery of the aircraft.

Compared to a life limited component, like the ATA 32-31-46 Retraction Actuator Assy, NLG, which had a cycle life limit, the list indicates (D and E blank) the MSV's as components life on condition.

No Component Maintenance Manual (CMM) for the MSV was available in the maintenance system.

Review of the IPC revealed the following information about the MSV's:
The IPC describes some items as "*item not illustrated*". Item 10 mentioned in the list is such an item.



32-31-36-01 MLG Doors Mechanical Sequence Valve

Figure Item	Part Number	Description
10	48303-5	Valve, Mechanical Sequence
60	48303-103	Valve, Body
70	MS21902J8	Union, Flareless Tube
80	NAS1612-8A	O-Ring

32-31-66-01 NLG Doors Mechanical Sequence Valve

Figure Item	Part Number	Description
10	48303-7	Valve, Mechanical Sequence
40	48303-103	Valve, Body
50	MS21916J8-6	Reducer, Flareless Tube
60	NAS1612-8A	O-Ring

The identification plates fitted to the MSV's describe the valves as MSV Valve Body P/N 48303-103 regardless of the type of Unions/Reducers that were installed.

The following pictures show the identification plates fitted to the MSV S/N FAH-345 and FAH-0107.

1.12.11.3 Information given by the operators computerized data support systems

The operators Maintenance Management Information System (MMIS) and its subsystems handle actions related maintenance and configuration control.

According to the operator, the registration of components into the data support system at the time when the DHC-8 aircraft were introduced was based on the Aircraft Serialization List compiled by the manufacturer.

When the data was transferred in 2006 from the origin data support system to the system used at the time of the accident, the operator decided that there was no reason to verify that the basic data in the origin system was correct, only that a fully accurate transfer of data into the new data support system was accomplished.

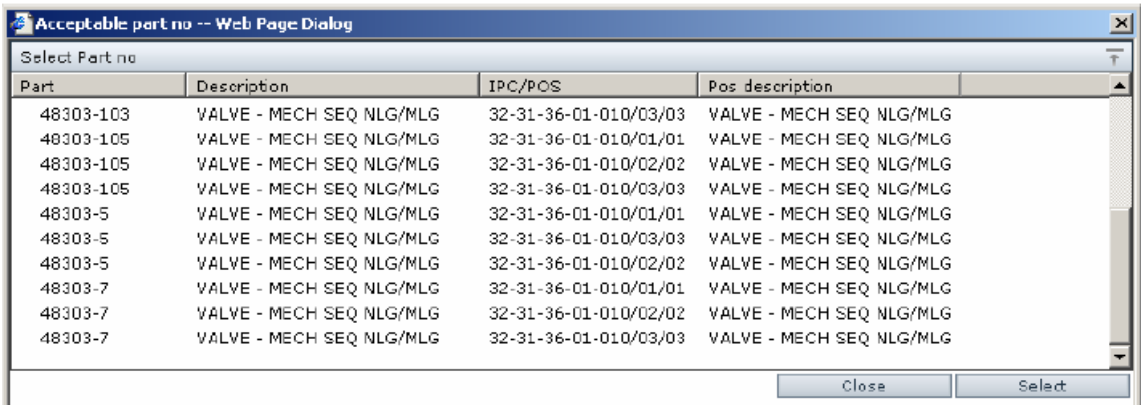
In the data system it was found that the MSV P/N 48303-103, -5 and -7 was registered as interchangeable parts that could be installed in the positions NLG/MLG.

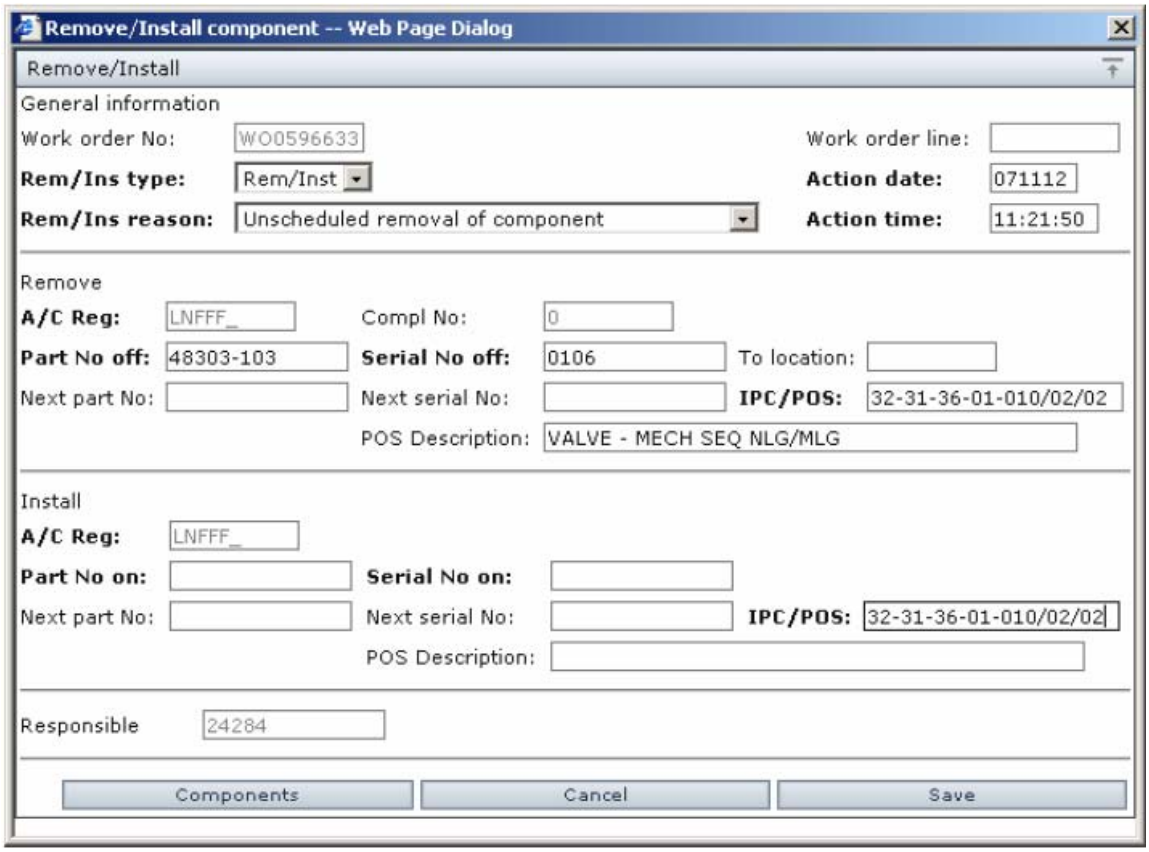
Position 01 = NLG position.

Position 02 = MLG left position.

Position 03 = MLG right position.

An extract from the operator data system is shown following (P/N 48303-105 is not in production).





It appeared on the extract from the data system that on 12th November 2007 (post the accident) P/N 48303-103 S/N 0106 (FAH-0106) was removed from the aircraft POS 02.
It is shown that the position description is both NLG and MLG.

The following data lists from the operator shows the MSV Installed Serial Numbers selected as P/N 48303-103, -5 and -7 was made available for review on 5th November 2007.

According to the list, MSV Valve Body P/N 48303-103 was registered as installed on the mentioned aircraft in both NLG (01) and MLG (02/03) positions.

According to the list MLG MSV P/N 48303-5 was registered as installed on the mentioned aircraft in MLG positions except S/N FAH-0152 that was registered as installed in the NLG position.

According to the list NLG MSV P/N 48303-7 was registered as installed on the mentioned aircraft in NLG position except S/N FAH-0345 that was registered as installed in the MLG right position on the accident aircraft at the time of the accident.

The lists are shown below.

MSV Valve Body P/N 48303-103.

Selected Part: **48303-103**

Installed Serial Numbers

Ins Part	Ins Serial	A/C Reg	Inst Pos IPC	POS	NH Part	NH Serial	NH Syst. Part	NH Syst. Serial	Installed
48303-103	0100	LN-RDQ	32-31-36-01-010	01	Q400	4008	Q400	4008	2000-02-27
48303-103	0106	LNFFF_	32-31-36-01-010	02	Q400	4024	Q400	4024	2000-09-22
48303-103	0109	LN-RDG	32-31-36-01-010	02	Q400	4022	Q400	4022	2000-09-05
48303-103	FAH0039	LN-RDF	32-31-36-01-010	03	Q400	4021	Q400	4021	2000-08-03
48303-103	FAH0042	LN-RDD	32-31-36-01-010	02	Q400	4009	Q400	4009	2001-02-05
48303-103	FAH0044	LN-RDD	32-31-36-01-010	03	Q400	4009	Q400	4009	2001-02-05
48303-103	FAH0058	LNEEE	32-31-36-01-010	01	Q400	4035	Q400	4035	2001-02-04
48303-103	FAH0070	LN-RDF	32-31-36-01-010	02	Q400	4021	Q400	4021	2000-08-03
48303-103	FAH0088	LN-RDC	32-31-36-01-010	01	Q400	4019	Q400	4019	2000-06-06
48303-103	FAH0089	LN-RDG	32-31-36-01-010	03	Q400	4022	Q400	4022	2000-09-05
48303-103	FAH0090	LN-RDD	32-31-36-01-010	01	Q400	4009	Q400	4009	2001-02-05
48303-103	FAH0092	LN-RDE	32-31-36-01-010	01	Q400	4020	Q400	4020	2002-10-31
48303-103	FAH0098	OYDDD	32-31-36-01-010	02	Q400	4025	Q400	4025	2000-10-06
48303-103	FAH0099	LN-RDA	32-31-36-01-010	01	Q400	4013	Q400	4013	2000-03-23
48303-103	FAH0108	OYDDD	32-31-36-01-010	03	Q400	4025	Q400	4025	2000-10-06
48303-103	FAH0110	LN-RDH	32-31-36-01-010	03	Q400	4023	Q400	4023	2000-08-21
48303-103	FAH0111	LN-RDH	32-31-36-01-010	02	Q400	4023	Q400	4023	2000-08-21
48303-103	FAH0117	LN-RDP	32-31-36-01-010	01	Q400	4012	Q400	4012	2000-01-17
48303-103	FAH0118	OY-KCD	32-31-36-01-010	03	Q400	4054	Q400	4054	2003-01-12
48303-103	FAH0123	LN-RDO	32-31-36-01-010	01	Q400	4036	Q400	4036	2001-02-02
48303-103	FAH0125	LN-RDR	32-31-36-01-010	01	Q400	4034	Q400	4034	2001-03-07
48303-103	FAH0140	LN-RDO	32-31-36-01-010	02	Q400	4036	Q400	4036	2001-02-02
48303-103	FAH0144	LN-RDM	32-31-36-01-010	01	Q400	4033	Q400	4033	2001-03-14
48303-103	FAH0165	LN-RDR	32-31-36-01-010	02	Q400	4034	Q400	4034	2001-03-07
48303-103	FAH0169	LN-RDO	32-31-36-01-010	03	Q400	4036	Q400	4036	2001-02-02
48303-103	FAH0174	LNEEE	32-31-36-01-010	02	Q400	4035	Q400	4035	2001-02-04

MLG MSV P/N 48303-05

Selected Part: **48303-5**

Installed Serial Numbers

Ins Part	Ins Serial	A/C Reg	Inst Pos IPC	POS	NH Part	NH Serial	NH Syst. Part	NH Syst. Serial	Installed
48303-5	0028	LN-RDL	32-31-36-01-010	03	Q400	4011	Q400	4011	2001-09-06
48303-5	0164	LN-RDJ	32-31-36-01-010	02	Q400	4010	Q400	4010	2003-02-10
48303-5	066	LN-RDL	32-31-36-01-010	02	Q400	4011	Q400	4011	2001-09-06
48303-5	DUMFAH0131	OY-KCH	32-31-36-01-010	03	Q400	4064	Q400	4064	2002-06-26
48303-5	DUMFAH0171	OY-KCH	32-31-36-01-010	02	Q400	4064	Q400	4064	2002-06-26
48303-5	FAH0149	OY-KCE	32-31-36-01-010	02	Q400	4057	Q400	4057	2002-06-06
48303-5	FAH0152	LN-RDJ	32-31-36-01-010	01	Q400	4010	Q400	4010	2003-10-23
48303-5	FAH0164	LN-RDM	32-31-36-01-010	03	Q400	4033	Q400	4033	2001-03-14
48303-5	FAH0170	OY-KCE	32-31-36-01-010	03	Q400	4057	Q400	4057	2002-06-06
48303-5	FAH0176	LN-RDR	32-31-36-01-010	03	Q400	4034	Q400	4034	2001-03-07
48303-5	FAH0195	LN-RDT	32-31-36-01-010	03	Q400	4038	Q400	4038	2001-05-14
48303-5	FAH0200	LN-RDT	32-31-36-01-010	02	Q400	4038	Q400	4038	2001-05-14
48303-5	FAH0217	OY-KCD	32-31-36-01-010	02	Q400	4054	Q400	4054	2007-10-04
48303-5	FAH0224	OY-KCG	32-31-36-01-010	02	Q400	4063	Q400	4063	2002-06-27
48303-5	FAH0242	OY-KCF	32-31-36-01-010	02	Q400	4062	Q400	4062	2002-06-19
48303-5	FAH137	OY-KCG	32-31-36-01-010	03	Q400	4063	Q400	4063	2002-06-27

NLG MSV P/N 48303-07.

Selected Part: **48303-7**

Installed Serial Numbers

Ins Part	Ins Serial	A/C Reg	Inst Pos IPC	POS	NH Part	NH Serial	NH Syst. Part	NH Syst. Serial	Installed
48303-7	0025	LN-RDG	32-31-36-01-010	01	Q400	4022	Q400	4022	2000-09-05
48303-7	0052	LN-RDL	32-31-36-01-010	01	Q400	4011	Q400	4011	2001-09-06
48303-7	0183	OY-KCE	32-31-36-01-010	01	Q400	4057	Q400	4057	2002-06-06
48303-7	0258	LNFFF_	32-31-36-01-010	01	Q400	4024	Q400	4024	2005-08-08
48303-7	0270	OY-KCG	32-31-36-01-010	01	Q400	4063	Q400	4063	2002-06-27
48303-7	DUMFAH0250	OY-KCH	32-31-36-01-010	01	Q400	4064	Q400	4064	2002-06-26
48303-7	FAH0016	LN-RDF	32-31-36-01-010	01	Q400	4021	Q400	4021	2000-08-03
48303-7	FAH0028	LN-RDH	32-31-36-01-010	01	Q400	4023	Q400	4023	2000-08-21
48303-7	FAH0162	OY-KCF	32-31-36-01-010	01	Q400	4062	Q400	4062	2002-06-19
48303-7	FAH0185	LN-RDT	32-31-36-01-010	01	Q400	4038	Q400	4038	2001-05-14
48303-7	FAH0274	OY-KCD	32-31-36-01-010	01	Q400	4054	Q400	4054	2002-03-20
48303-7	FAH0345	LNFFF_	32-31-36-01-010	03	Q400	4024	Q400	4024	2007-10-22

Review of the spare part handling data system revealed that there were two MSV's on stock in Copenhagen on the 20th October 2007. Both valves on stock were NLG MSV P/N 48303-7.
The data system also revealed that MSV's replaced by the maintenance personnel was returned to the stock system as MSV Valve Body P/N 48303-103.
The Logistics Tag concerning the MSV replacement on 22nd October 2007 was examined. It was found that the P/N out was at first written as P/N 48303-7 but, this P/N was afterwards deleted and rewritten as P/N 48303-103.

The maintenance personnel explained that they used the identification plate fitted to the MSV as reference when they fulfilled the paperwork following the replaced valve back to the stock system.

The data system showed P/N 48303-5 / -7 out-going from stock and P/N 48303-103 as replaced part returned to the stock system.
The Authorized Release Certificate issued by the Landing Gear manufacturer following the MSV's identified the valves as P/N 48303-5 or -7 despite P/N 48303-103 was printed on the identification plates fitted to the valves. The identification of the valves could be verified via the S/N that was printed both in the certificate and on the valve.

1.12.12 Mechanical Sequence Valve reconfiguration

Regarding the MSV reconfiguration, the involved maintenance personnel were interviewed and the work process was identified.
The maintenance organization and the maintenance supervisor were of the opinion that the MSV's were interchangeable as it appeared from the operator data system. The maintenance personnel were told to change the configuration of the delivered NLG MSV to fit into the MLG position.
Rgarding replacement of the Unions fitted to the MSV Valve Body P/N 48303-103, the maintenance organization found no information in the Aircraft Maintenance Manual.
However, the organization did find information in the IPC indicating that the Union (item 70) and the O-ring (item 80) could be replaced if necessary indicating that standard maintenance practices allow replacement of fittings, gaskets and O-rings rather than replacement of the assembly.

The maintenance organization was of the opinion that the MSV Unions and the O-rings underneath them were such line-replaceable parts and therefore the decision and action to change the Unions on the NLG MSV S/N FAH-0345 was approved in accordance to standard maintenance practices.

The maintenance personnel informed the AIB that the MSV S/N FAH-0107 was removed from the aircraft by another shift. They were told to interchange the Unions between the removed MSV and a new MSV that was delivered from stock and placed on a table in the hangar.
The maintenance personnel were not involved in the trouble shooting process on the aircraft.
The AIB was told by the mechanic that removed the Unions from the old MSV that they were dirty. Before installation on the new MSV S/N FAH-0345, the Unions were cleaned. It was the opinion of the mechanic that if an O-ring was hidden inside one of the Unions, it would have been observed. The mechanic that removed the Unions was not DHC-8 type rated as a mechanic. However, a company DHC-8 course was completed. The mechanic had no MSV inspection procedures available but, it was strongly expressed to the AIB that work always was done in a meticulous way and that before installation, parts were always inspected. The Unions were inspected and it was expressed that no O-ring were hidden inside any of them.
The four Unions were of the same type and size therefore the mechanic fitted the Unions to the MSV in random order.

To illustrate that it was possible for an O-ring NAS1611-110 to be transferred via the Unions, the AIB placed an O-ring inside the Union as shown in the pictures below.

Union, Flareless Tube P/N MS21902J8 and O-ring P/N NAS1611-110 is shown in comparison.

The O-ring is shown placed inside the Union illustration purposes only.

1.13 Medical and pathological information

No further information.

1.14 Fire

According to a security video recording there was some sparks and smoke originating from the aft fuselage as the aircraft made contact with the runway surface, but there was no fire.

1.15 Survival aspects

As mentioned in Section 1.12.1, the right engine was shut down by the flight crew before landing to minimize the risk of propeller blade or blade debris separation and penetration into the cabin area fuselage. Four propeller blades were damaged while skidding on the runway asphalt (following picture), but no debris separations from the engine or the non powered propeller occurred and the fuselage surrounding the cabin area was undamaged.

When the aircraft came to rest on taxiway C area the first cabin door (Left Forward) was opened at 1453:13 hrs and the first crew member was outside the aircraft at 1453:15 hrs. The crew member took position to the left of the door, assisting the passengers out of the aircraft and guided the passengers away from the aircraft. The left aft cabin door was opened a second later and the passengers were directed in the same direction away from the aircraft. The two right cabin doors were not used during the evacuation.

The first fire fighters arrived at the scene at 1453:21 hrs.

Evacuation requirements written in JAR and FAR Sec. 25.803: "*It must be demonstrated that when the aircraft is at maximum seating capacity, the aircraft, including the crewmembers, can be evacuated to the ground under simulated conditions within 90 seconds"*.
The aircraft was evacuated in 50 seconds. The last person that left the aircraft was the first officer.

During the accident, the data from the FDR showed that the maximum vertical, lateral and longitudinal G forces were 1.30 G, -0.09 G and -0.48 G respectively.
The airframe did not exceed the certification requirements specified by Joint Aviation Regulation (JAR) and Federal Aviation Regulation (FAR) Sec. 25.561 (9 G forward, 3 G upward, 3 G sideward on the airframe and 4 G on the seats and their attachments). These requirements were established to ensure that under these loads each occupant has every reasonable chance of avoiding serious injury in a minor crash landing and also that heavy items in the passenger cabin do not become deformed in any manner that would impede subsequent rapid evacuation of the occupants.
Four of the seat meal tables next to the aisle were found deployed (i.e. meal serving position).
As mentioned in the Accident Report HCLJ510-000433 published by the AIB Denmark regarding an accident to another DHC-8 aircraft on 9th September 2007, the latch of the tables was found slack and easy

to move. The latch could rotate both to the left and to the right. All four latch pins was found moved towards the aisle and therefore the tables could have been released either by the person who left the window seat or who left the seat next to the aisle during the emergency evacuation of the aircraft.

1.16 Tests and research

No tests and research were done.

1.17 Organizational and management information

The maintenance organization was EASA Part-145 Category A approved.
For instance, the A class rating means; that the Part-145 approved maintenance organization may carry out maintenance on aircraft and any component (including engines/APU's) only whilst such components are fitted to the aircraft.

1.18 Additional information

In this report there are references to:
The AIB Denmark Report HCLJ510-000433 regarding the accident to Bombardier DHC-8-400 registration LN-RDK at Aalborg Airport (EKYT) Denmark on 9th September 2007.

The report was published in 2009 and is available on http://www.aib.dk

1.19 Useful or effective investigation techniques

No new techniques were used during this investigation.

2. Analysis

2.1 Flight crew

The flight crew was properly licensed.

2.2 The aircraft

The aircraft had a valid certificate of airworthiness. The aircraft maintenance records were in compliance with the established maintenance program.
The aircraft was within the mass and balance limitations.

2.3 The Quick Reference Handbook (QRH)

During the final approach and landing, continuous GPWS warnings sounded. The AIB considers continuous warnings to be a mental stress factor increasing flight crew workload.

The AIB found, analysing the information from the CVR, that the Emergency Landing checklist was not performed by the flight crew. This is based on the fact that if the checklist was performed the GPWS circuit breakers would have been pulled in order to avoid continuous GPWS warnings. The Alternate Landing Gear Extension checklist did not contain this information.

The AIB finds it appropriate that the Alternate Landing Gear Extension checklist, in case of not solving an unsafe gear situation, contains information and/or references to the Emergency Landing checklist as guidance to the flight crew.
There are no certification requirements for the checklists (manufacturers and/or operators) to refer to other relevant checklists. However, it is the opinion of the AIB that helpful information and/or references might improve flight safety despite that minimum requirement is fulfilled.
For that reason, it is the opinion of the AIB that a more appropriate checklist structure could have contributed to a reduction of a high flight crew workload.

The above mentioned issues were also issues in the AIB investigation of the DHC-8 accident at Aalborg Airport on September 9th 2007 (report HCLJ510-000433).

2.4 Weather

The weather at the time of the accident was VMC and did not influence the sequence of events.

2.5 Navigation aids

At the time of the accident, all navigation aids were functioning without any remarks and did not influence the sequence of events.

2.6 Communication

At 14:07:38 hrs the commander informed Approach that the landing would be an Emergency Landing. The flight crew was in radio contact with ATC using the normal routine frequencies until 14:20:09 hrs. At that time on request from the first officer, the flight was assigned its unique controller, Kastrup Final (119.100 MHz). The flight remained on that frequency (119.100 MHz) through the remainder of the flight.

The AIB found that the flight crew was very busy in the above mentioned period. For that reason, some communication from Copenhagen Approach was missed by the flight crew.

The AIB is of the opinion that the flight crew, ATC and the airport Rescue and Fire Fighting Service had the understanding that a mayday call in some way was declared by the flight crew.

The communication between the flight crew and ATC did not influence the sequence of events.

2.7 Fire

There was no fire.

2.8 Survival aspects

In general, lessons learned from the accident in Aalborg seemed to assist the crew in handling the emergency (aircraft and passengers).

The right engine was shut down by the flight crew before landing to minimize the risk of propeller blade or blade debris separation and penetration into the fuselage surrounding the cabin area.
No debris separated from the non powered propeller.
In relation to survival/injury aspects the AIB found the decision to shut down the right engine was appropriate in this situation.

The latches securing the seat meal tables in the stowed position were found to be slack and easy to rotate. The AIB found seat meal tables released which could be influential on the evacuation of the aircraft. Passengers seated next to the window could find it difficult to leave the seat row if the tables were in released position.

The above mentioned issue was also an issue in the AIB investigation of the DHC-8 accident at Aalborg Airport on September 9th 2007 (report HCLJ510-000433).

The preparations that were done by the crew lead the evacuation of the aircraft to be optimum.

The accident was survivable.

2.9 Right Main Landing Gear (MLG) stuck

At the place of the accident, the MLG was found to be released from the up-lock hook but stuck in almost up position. It was impossible to extend the right MLG further down without dismantling the MLG Retraction/Extension Actuator from the MLG yoke cross beam.
When the actuator was replaced with an actuator taken from another aircraft the operational function of the MLG system was found to be normal as per design specifications.

A detailed examination of the MLG Retraction/Extension Actuator found that the Retract Port Restrictor was blocked by a rogue O-ring. This blockage in the single line hydraulic system caused the actuator to be hydraulically locked.
The hydraulic lock of the actuator caused the MLG to be stuck and impossible to extend into landing configuration.

The investigation reveled that the port restrictors on the actuator had no protection against contamination in the hydraulic line system. Any contamination caused by released parts from the components within the MLG hydraulic system or foreign objects introduced during maintenance could block one of the restrictors and cause the actuator to be hydraulically locked.

2.10 Origin, transfer and travelling of the rogue O-ring

The rogue O-ring found in the Retract Port Restrictor was found to be a P/N NAS1611-110 and it was determined that the only component in the right MLG system that incorporated this type of O-ring was the right MLG Solenoid Sequence Valve (SSV).
The SSV S/N FAH-0200 installed in the right wheel well was examined. It was found that all the O-rings NAS1611-110 were in place in the ports of the valve.
The aircraft technical records showed that the valve recently was replaced. The investigation tracked down the replaced valve that was found to be SSV S/N FAH-0083.

Examination of the SSV FAH-0083 that was replaced on 16th October 2007 revealed that the filter element and the NAS1611-110 O-ring were not present in the down port of the SSV as it should be.
Although it could not be determined with any degree of certainty that the origin of the O-ring found in the Retract Port Restrictor was from the SSV FAH-0083, the conclusion of the AIB is in the light of the fact that the investigation found no other possibilities that the origin of the O-ring was from the SSV FAH-0083.

During the investigation, the AIB revealed that filter element collapse during normal operation of the Landing Gear was not uncommon. The investigation also revealed that when the filter element collapses, the O-ring located adjacent to the filter element looses compression. This situation gave the O-ring the possibility to move out of its position and migrate into the Landing Gear hydraulic system. Therefore, the AIB is of the opinion that the SSV down port and up port filter elements may not withstand normal Landing Gear hydraulic operational pressure fluctuations and may collapse.

Since the test flight of LN-RDI on 15th October 2007 until the accident occurred a sequence of discrepancies regarding the function of the right MLG were reported.
The AIB can not exclude or conclude that these technical problems were related to the O-ring that was found inside the Retract Port Restrictor of the MLG Retraction/Extension Actuator.
The O-ring that had travelled inside the hydraulic lines could have restricted the hydraulic fluid flow more or less during MLG operations.
It must be added that the aircraft manufacturer had no previous knowledge of specific details that may arise as a result of an O-ring dislodging after the port filter element collapsed.

Looking at the design and the function of the valves contained within the landing gear hydraulic system it is evident that the discrepancies mentioned during the test flight and the trouble shooting period, are symptomatic of issues related to one or more of these valves. Therefore, the AIB found it natural to suspect and replace a valve as part of trouble shooting before looking into other areas of the hydraulic system.

There was no reason to inspect the ports of the valve SSV FAH-0083 that was replaced, which probably explains why no one involved in the handling of the valve observed and/or reported that the filter element and the O-ring were missing from the down port of the valve.
The AIB can not exclude or conclude that the accident could have been prevented if the trouble shooters had found the filter element and the O-ring missing when they replaced the SSV FAH-0083 on 16th October 2007.

On 24th October 2007 during a test flight, it was reported that the right MLG was very slow to extend and that the MLG doors were late to close. The AIB can not exclude or conclude that this problem was caused by the O-ring travelling inside the hydraulic lines reducing the hydraulic fluid flow. This is based on the fact that the maintenance action in this case was to replace the MLG Retraction/Extension Actuator.

Since the above mentioned maintenance action was performed on 24th October 2007 until the accident on 27th October 2007 the aircraft had completed a test flight on 25th October 2007 and 21 flight sectors without any reported discrepancies. In this period the O-ring was somewhere inside the hydraulic line between the MSV and the MLG Retraction/Extension Actuator.

Examination of the valves, in-line restrictors, fittings and lines revealed that space available to the size of the NAS1611-110 O-ring was limited.
The O-ring was able to travel inside the hydraulic lines between the SSV and the Mechanical Sequence Valve (MSV), as well as inside the hydraulic lines between the MSV and the Retract Port Restrictor of the MLG Retraction/Extension Actuator.
The MSV and the other parts of the system were of such a design that the O-ring could not pass through. It is unknown to the AIB when the filter and the O-ring migrated from the SSV that was replaced on 16th October and migrated into the hydraulic system. The fact that the O-ring was missing in the down port of the removed valve and that the MLG was reported to operate slowly from time to time strongly indicates that the system was affected by the travelling O-ring in the hydraulic lines of the system.

The AIB found it impossible for the released O-ring to pass through the MSV positioned in the hydraulic line between the SSV and the MLG Retraction/Extension Actuator Retract Port Restrictor. However, the MSV was replaced on 22nd October 2007 which caused the investigation to concentrate on a possible way of transferring the O-ring from one side of the valve to the other side of the valve.
It was found that the new MSV supplied was a NLG MSV P/N 48303-7 S/N FAH-0345 having Reducers installed to fit the NLG. These Reducers were interchanged with the Unions taken from the MSV Valve Body P/N 48303-103 S/N FAH-0107 that was removed from the right MLG.

The AIB is of the opinion that, the O-ring was transferred while trapped inside one of these Unions.
The AIB found that this was the only way the O-ring could be transferred from one side of the MSV to the other side of the MSV given the possibility to travel between the MSV and the MLG Retraction/Extension Actuator Retract Port Restrictor.
The Unions were identical which made it unimportant in which position they were installed on the new MSV. The Unions were installed in random order on the new MSV. The rogue O-ring was transferred because the Union in which the O-ring was trapped coincidently was installed on the MSV port connected to the MLG Retraction/Extension Actuator.

2.11 Maintenance documentation, procedures and support system

The AIB found that no Component Maintenance Manual was available to the maintenance personnel.
No maintenance procedures regarding reconfiguration or replacement of the Reducers/Unions or the O-rings underneath them were found in the manufacturers Aircraft Maintenance Manual or other maintenance documents.
However, replacement of the mentioned O-rings could be necessary if leaking and replacement of a Union could be necessary for instance if the Union was damaged on the treads connecting the Union to the MLG hydraulic system line.
The Illustrated Parts Catalog (IPC) showed that the Reducers/Unions and the O-rings underneath them were replaceable parts.
In general, the ATA 100 policy document defines fittings and gaskets/O-rings as line-replaceable units.

The MSV installed on the aircraft on 22nd October 2007 was identified as MSV Valve Body P/N 48303-103 given by the identification plate fitted to the valve. The Unions P/N MS21902J8, connecting the valve to the MLG hydraulic system, were correct as specified in the IPC. This combination could in the IPC be identified as P/N 48303-5 and as such in accordance to the design specifications.
However, the reconfigured NLG MSV installed on the aircraft was no longer approved by an Authorized Release Certificate (ARC).
The AIB is of the opinion that the EASA Part-145 Category A maintenance organization would be allowed to replace a Union or the O-rings underneath the Unions as line-replaceable units in accordance to standard maintenance practices but, this is not comparable to reconfiguration of a valve that is approved by a ARC.

The AIB found that the aircraft at the time of delivery from the manufacturer was registered to have MSV P/N 48303-103 installed in both left and right MLG positions which according to the IPC were the valve bodies. This indicates that the Reducers/Unions were interchangeable and therefore the configuration of the MSV depended on these.
The AIB viewpoint of the MSV Valve Body P/N 48303-103 installation is that the aircraft manufacturer accepted the MSV Valve Body P/N 48303-103 as a MLG MSV installation. In this case, the Unions were used to connect the -103 valve into the MLG hydraulic system.
It is a fact that the MSV Valve Body P/N 48303-103 was used by the manufacturer both in the MLG and NLG systems.

This viewpoint could be identified in the IPC leading maintenance organizations to the interpretation that the MSV Valve Body P/N 48303-103 could be replaced using the old Unions/Reducers to connect the -103 valve into the MLG or NLG hydraulic system.

The operators computerized data support system showed that the MSV P/N 48303-103, -5 and -7 were interchangeable and that MSV Valve Body P/N 48303-103 was installed on several aircrafts within the fleet in both the MLG and the NLG positions.
Because the operators computerized data support system was based on the serialization lists from the aircraft manufacturer the AIB can not exclude or conclude, that the reason for the operator data system to show the MSV P/N 48303-103, -5 and -7 as interchangeable was the serialization list showing -103 as MLG MSV.
However, despite the serialization list was misleading regarding the MSV Valve Body P/N 48303-103 installation the operators computerized data support system was not recognized by the approved data shown in the IPC.
The AIB also found that the maintenance personnel that replaced the MSV's returned the replaced valves as P/N 48303-103. The AIB is of the opinion that this was done because the maintenance personnel referred to the identification plate fitted to the valve.
The AIB is of the opinion, that the information regarding the MSVs with or without Unions/Reducers that were available to the maintenance personnel, as a unified whole was unclear, not easily seen through and misleading to the maintenance personnel. The information sources were the aircraft manufacturer serialization list, operator computerized data support system, the IPC, the documentation following the MSV and the identification plate fitted to the MSV.

The AIB is also of the opinion that the maintenance organization system had some weaknesses in relation to reveal problems as mentioned above. The organisation accepted the manufacturer data at delivery of the aircraft as they were. The organisation never questioned the fact that the serialization list differed from the IPC in relation to part number installation position. The organisation accepted that the data support system gave no information or warning if a dash number not suitable in the actual position was registered into the system. The maintenance personnel returned the MSV P/N 48303-103 S/N FAH-0107 configured as an NLG MSV P/N 48303-07 to the system without any reaction from the data system or persons within the organisation.
The AIB finds it unsuitable that the maintenance personnel were able to identify and return valves with P/N's different from the P/N's that really were installed without any reaction from the data system or persons within the organisation.

2.12 Human factors

The mechanic that did the reconfiguration had no MSV inspection procedures available but, it was strongly expressed to the AIB that work was done in a meticulous way and that before installation, parts were always inspected.
The Unions were inspected and it was expressed that no O-ring were hidden inside any of them.
It was the opinion of the mechanic that if an O-ring was hidden inside one of the Unions, it would have been observed.

However, it was not observed that the O-ring was trapped inside the Union.
The AIB can not exclude that a thorough inspection of the Unions according to a defined inspection procedure might have led to a finding of the rogue O-ring. But any inspection done by humans is related to human factors and not a guarantee of any findings.
It was proven that the O-ring could be trapped inside the Unions, and it was difficult to observe that fact. Furthermore there was no reason for the mechanic to anticipate that a foreign object was present in the Unions because the human was not mentally prepared to find anything.
Furthermore, the mechanic was told to do the reconfiguration and was not involved in the trouble shooting on the MLG. Probably, the conception of the work was that it was routine work and for that reason, a foreign object present in any of the Unions was not anticipated.

It appeared that the maintenance organization and therefore the supervisor were of the opinion that the MSV's were interchangeable. The maintenance organization was also of the opinion, based on the ATA 100 policy regarding line-replaceable parts, that reconfiguration of a MSV was comparable to replacement of one or more Unions on a component still fitted in the aircraft in connection with repair.
The AIB is of the opinion that this is not the case. Reconfiguration of an ARC approved component can not be compared with repair of components fitted in the aircraft according to the Part-145 Category A approval.
The maintenance personnel followed the maintenance practices and the information that were available to them when they decided to interchange the Unions between the two MSV's.

The supervisor had the following information available:

1. MLG MSV Valve Body P/N 48303-103 was installed in the aircraft since new. This MSV was in the IPC identified as the next lower component from MSV P/N 48303-5 which means a clean MSV body without Unions.
2. The maintenance organization was of the opinion that they could order a MSV Valve Body P/N 48303-103 from stock, install Unions and then install the MSV in the aircraft because they found this was what the manufacturer did according to the serialization list.
3. All MSV's were identified as P/N 48303-103 by the identification plates fitted to the MSV's.
4. The IPC shows the Unions/Reducers and the O-rings underneath them as replaceable parts.
5. The ATA 100 policy defines fittings and O-rings in general as line-replaceable parts.
6. The operator computerized data support system based on the aircraft manufacturer serialization list shows the MSV P/N 48303-103, P/N 48303-5 and P/N 48303-7 as interchangeable parts.

The MSV removed from the aircraft was a P/N 48303-103 but, on the table it would appear as a P/N 48303-5. When the Unions were removed the MSV would appear as the P/N 48303-103.
When the supervisor found that only two NLG MSV's P/N 48303-7 on stock and given the information above, there was no doubt in his mind that he could interchange the Unions/Reducers between the valves. Furthermore the MSV, when installed in the aircraft, fulfilled the design specifications.
Therefore the AIB is of the opinion that the technical information regarding the MSVs with or without Unions/Reducers that were available to the maintenance personnel, as a unified whole was unclear, not easily seen through and misleading to the maintenance personnel. The information sources were the

aircraft manufacturer serialization list, operator computerized data support system, the IPC, the documentation following the MSV and the identification plate fitted to the MSV.
The AIB point of view is in relation to human factors that the maintenance personnel were mislead to reconfigure an ARC approved component. The AIB found no procedures available to reconfigure the MSV's.
The sources of the misleading information mentioned above were both the aircraft manufacturer and the operator maintenance organization.

2.13 MLG Retraction/Extension Actuator hydraulic lock

The MLG Retraction/Extension Actuator hydraulic systems was a single line system and the port restrictors fitted to retract and extend ports of the MLG Retraction/Extension Actuator had no protection (in-line filter) against hydraulic fluid contamination. During the investigation, the aircraft manufacturer introduced a modification that incorporated an in-line filter to be installed in the line connected to the retract port restrictor of the Main Landing Gear Retraction/Extension Actuator.
The AIB is of the opinion that this type of in-line filter would have prevented this specific accident if installed.
At a given time after the replacement of the actuator on 24th October 2007, the rogue O-ring ended up inside the Floating Valve of the Retract Port Restrictor of the newly installed actuator.
During retraction of the MLG, the O-ring passed through the flow relief holes in the Floating Valve which caused the retraction time to be increased.
During extension of the MLG the O-ring was blocking the small orifice in the Floating Valve reducing the hydraulic fluid flow and increasing the extension time of the MLG.
Inside the Retract Port Restrictor, due to movement of the Floating Valve, the O-ring was successively damaged and finally cut into three larger parts and one smaller part.
At a given time, a part of the O-ring was almost punched through the small orifice hole of the Floating Valve inside the Retract Port Restrictor by the MLG extension fluid flow. This caused the orifice to be blocked.
The MLG Retraction/Extension Actuator was then hydraulically locked which caused the right MLG to be stuck in the almost up position. In this situation, it was impossible to move the right MLG.

3. Conclusions

3.1 Findings

The findings are drawn from the factual information and the analysis.

The findings contain topics that exclude subjects as a factor to the accident.

The findings contain topics of valuable information regarding flight safety without being a factor to the accident.

The findings contain topics about the factors established in the investigation.

1. The flight crew was properly licensed.

2. The weather at the time of the accident was VMC and did not influence the sequence of events.

3. The navigation aids were functioning and did not influence the sequence of events.

4. The commander informed Approach that the landing would be an Emergency Landing.

5. The flight was assigned its unique controller, Final (119.100 MHz) on request by the first officer.

6. The communication between the flight crew and ATC did not influence the sequence of events.

7. The Aircraft had a valid airworthiness certificate and the maintenance records were verified to be in compliance with the established maintenance program.

8. The mass and balance was within the limitations.

9. The Alternate Landing Gear Extension checklist was adequate as long the flight crew tried to extend the MLG. The Alternate Landing Gear Extension checklist did not refer to the Emergency Landing checklist as guidance to the flight crew. The Emergency Landing checklist was not performed by the flight crew which caused continuous GPWS warnings during the remaining flight.

10. The decision to shut down the right engine was appropriate in the emergency landing situation. No debris separated from the non powered propeller.

11. Seat meal tables could accidentally be released making evacuation of the aircraft difficult to some passengers.

12. The preparations that were done by the crew lead the evacuation of the aircraft to be optimum. The evacuation of the aircraft was done in 50 seconds.

13. The accident was survivable.

14. The filter element placed in the ports of the Solenoid Sequence Valves could collapse during normal operation. The SSV down port and up port filter elements may not withstand normal Landing Gear hydraulic operational pressure fluctuations and may collapse. The O-ring P/N NAS1611-110 located adjacent to the SSV port filter element could migrate into the Landing Gear hydraulic system when the filter element collapses.

15. At a given time before the 16th October 2007 the SSV down port filter element collapsed and the O-ring located adjacent to the filter element migrated into the hydraulic line that among other parts connected the SSV to the MSV.

16. The filter element and the O-ring were not present in the down port of the SSV S/N FAH-0083 that was removed from the aircraft on 16th October 2007 as part of the trouble shooting. The SSV was not examined until after the accident.
Remains of the filter element were not found in the MLG hydraulic system between the SSV and the MLG Retraction/Extension Actuator.
The function of the right MLG may have been affected by the O-ring travelling inside the hydraulic line between the SSV and the MSV.

17. The MSV was of such a design that it was impossible for the travelling O-ring to pass through the MSV positioned in the hydraulic line between the SSV and the MLG Retraction/Extension Actuator Retract Port Restrictor.

18. The operator maintenance organization only had NLG MSV's on stock. Therefore the MSV supplied from stock on 22nd October 2007 was a NLG MSV P/N 48303-7 having Reducers installed to fit the NLG.

19. The information, as a unified whole given by both the aircraft manufacturer and the operator computerized data support system was unclear, not easily seen through and misleading to the maintenance personnel; misleading the maintenance personnel to reconfigure the delivered ARC approved NLG MSV P/N 48303-7 S/N FAH-345 to fit the MLG MSV. There were no procedures available to reconfigure the MSV.

20. The rogue O-ring was transferred from the SSV side of the hydraulic line to the Actuator side of the hydraulic line while trapped inside a Union when the Unions from the removed MSV Valve Body P/N 48303-103 were transferred and reused on the NLG MSV P/N 48303-7 to fit the MLG hydraulic system.

21. It was not observed that the O-ring was trapped inside one of the reused Unions. The circumstances were human factor related. A thorough inspection of the Unions according to a defined inspection procedure might have led to a finding of the rogue O-ring, but the maintenance personnel had no procedures available.

22. The O-ring travelled inside the hydraulic line between the MSV and the MLG Retraction/Extension Actuator Retract Port Restrictor from 22nd October 2007 - when the MSV was replaced - until 27th October 2007.

23. The MLG Retraction/Extension Actuator hydraulic systems was a single line system and the port restrictors fitted to retract and extend ports of the MLG Retraction/Extension Actuator had no protection (in-line filter) against hydraulic fluid contamination.

24. At a given time after replacement of the MLG Retraction/Extension Actuator on 24th October 2007 during retraction of the MLG the O-ring passed through the flow relief holes in the floating valve of the MLG Retraction/Extension Actuator Retract Port Restrictor. The O-ring was damaged and cut into several pieces while trapped inside the restrictor.

25. On the accident flight on 27th October 2007 during extension of the Landing Gear the right MLG extension fluid flow had enough flow to force a part of the damaged O-ring through the small orifice hole of the floating valve in the Retract Port Restrictor blocking off the hydraulic fluid flow.

26. The right MLG Retraction/Extension Actuator was hydraulically locked by the blocked Retract Port Restrictor which caused the right MLG to be stuck in the almost up position. In this situation it was impossible to extend the right MLG.

3.2 Factors

The factors contain topics about the factors established in the investigation. These include both the immediate factors and the deep seated factors that arose from the whole system within which the operation was performed.

1. The filter element placed in the ports of the Solenoid Sequence Valves could collapse during normal operation. The SSV down port and up port filter elements may not withstand normal Landing Gear hydraulic operational pressure fluctuations and may collapse. The O-ring P/N NAS1611-110 located adjacent to the SSV port filter element could migrate into the Landing Gear hydraulic system when the filter element collapses.

2. At a given time before the 16th October 2007 the SSV down port filter element collapsed and the O-ring located adjacent to the filter element migrated into the hydraulic line that among other parts connected the SSV to the MSV.

3. The operator maintenance organization only had NLG MSV's on stock. Therefore the MSV supplied from stock on 22nd October 2007 was a NLG MSV P/N 48303-7 S/N FAH-0345 having Reducers installed to fit the NLG.

4. The information, as a unified whole given by both the aircraft manufacturer and the operator computerized data support system was unclear, not easily seen through and misleading to the maintenance personnel; misleading the maintenance personnel to reconfigure the delivered ARC approved NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG MSV. There were no procedures available to reconfigure the MSV.

5 The rogue O-ring was transferred from the SSV side of the hydraulic line to the Actuator side of the hydraulic line while trapped inside a Union when the Unions from the removed MSV Valve Body P/N 48303-103 S/N FAH-0107 were reused on the NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG.

6. It was not observed that the O-ring was trapped inside one of the reused Unions. The circumstances were human factor related. A thorough inspection of the Unions according to a defined inspection procedure might have led to a finding of the rogue O-ring, but the maintenance personnel had no procedures available.

7. The MLG Retraction/Extension Actuator hydraulic systems was a single line system and the port restrictors fitted to retract and extend ports of the MLG Retraction/Extension Actuator had no protection (in-line filter) against hydraulic fluid contamination.

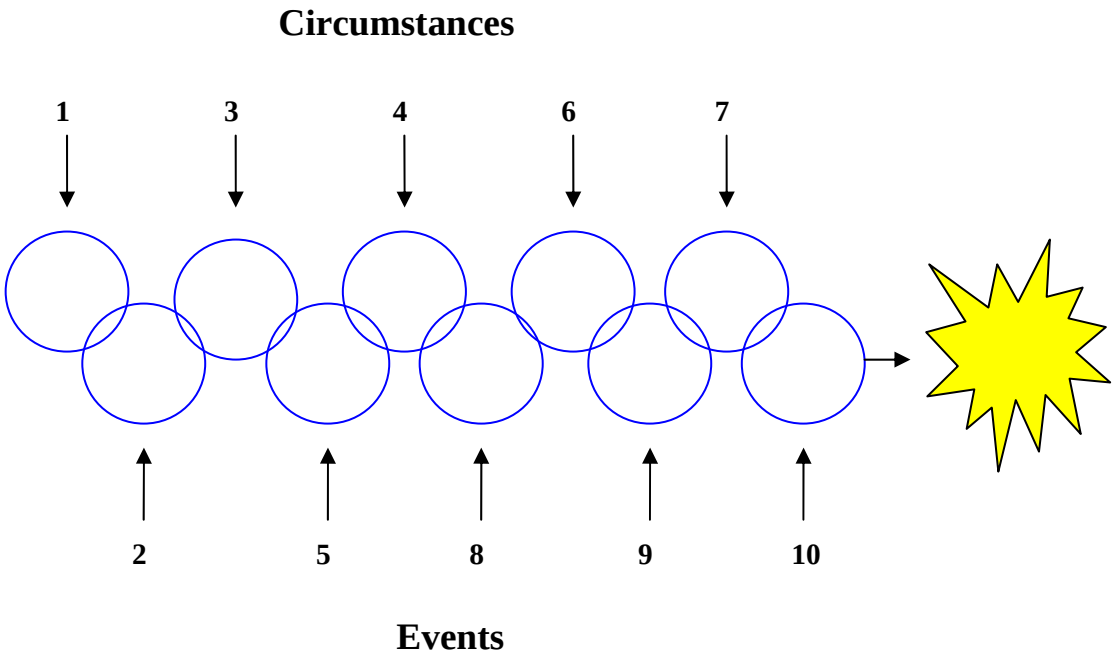
8. At a given time after replacement of the MLG Retraction/Extension Actuator on 24th October 2007 during retraction of the MLG the O-ring passed through the flow relief holes in the floating valve of the MLG Retraction/Extension Actuator Retract Port Restrictor. The O-ring was damaged and cut into several pieces while trapped inside the restrictor.

9. On the accident flight on 27th October 2007 during extension of the Landing Gear the right MLG extension fluid flow had enough flow to force a part of the damaged O-ring through the small orifice hole of the floating valve in the Retract Port Restrictor blocking off the hydraulic fluid flow.

10. The MLG Retraction/Extension Actuator was hydraulically locked by the blocked Retract Port Restrictor which caused the right MLG to be stuck in the almost up position. In this situation it was impossible to extend the right MLG.

The 10 factors established in the investigation are shown below as the chain of circumstances and events leading to the accident.
If the chain was broken by removing one of the chain-links (circumstance or event) in the chain leading to the accident this accident would not have occurred. For instance with reference to item number 3; if the operator had the MLG MSV P/N 48303-5 on stock this accident would not have occurred.

The numbers pointing at the chain refer to the number of the factors divided into circumstances and events.



Summary
The summary contains findings and factors that was established in the investigation.

The Solenoid Sequence Valve (SSV) down port and up port filter elements may not withstand normal Landing Gear hydraulic operational pressure fluctuations and may collapse. At a given time prior to the accident, the SSV down port filter element collapsed and the O-ring located adjacent to the filter element migrated into the hydraulic line.

The Mechanical Sequence Valve (MSV) was of such a design that it was impossible for the O-ring to pass through the MSV on its way from the SSV down port to the MLG Retraction/Extension Actuator Retract Port Restrictor. However, the MSV was replaced on 22nd October 2007.
The operator maintenance organization had only Nose Landing Gear (NLG) MSV's on stock. Therefore, the MSV supplied from stock on 22nd October 2007 was a NLG MSV P/N 48303-7 S/N FAH-0345 having Reducers installed to fit the NLG.
The information, as a unified whole given by both the aircraft manufacturer and the operator computerized data system was unclear, not easily seen through and misleading to the maintenance personnel; misleading the maintenance personnel to reconfigure the delivered Authorized Release Certificate approved NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG MSV. There were no procedures available for reconfiguring the MSV.
For that reason by a maintenance action, the rogue O-ring was transferred from the SSV side of the hydraulic line to the Actuator side of the hydraulic line while trapped inside a Union when the Unions from the removed MSV Valve Body P/N 48303-103 S/N FAH-0107 were reused on the NLG MSV P/N 48303-7 S/N FAH-0345 to fit the MLG.
It was not observed that the O-ring was trapped inside one of the reused Unions. The circumstances were human factor related. A thorough inspection of the Unions according to a defined inspection procedure might have led to a finding of the rogue O-ring, but the maintenance personnel had no procedures available.

The Main Landing Gear (MLG) Retraction/Extension Actuator had no protection (in-line filter) against hydraulic fluid contamination.
At a given time during retraction of the MLG, the O-ring was able to enter the Retract Port Restrictor of the Actuator. While trapped inside the restrictor, the O-ring was damaged and cut into several pieces.

On the accident flight on 27th October 2007 during extension of the Landing Gear, the right MLG extension fluid flow had enough flow to force a part of the damaged O-ring through the small orifice hole in the floating valve in the Retract Port Restrictor which blocked off the hydraulic fluid flow.
The MLG Retraction/Extension Actuator was hydraulically locked by the blocked Retract Port Restrictor, which caused the right MLG to be stuck in the almost up position. In this situation, it was not possible to extend the right MLG.

4. Safety Recommendations

4.1 Safety initiatives taken during the investigation.

Early in the investigation the following safety initiatives were issued by the aircraft manufacturer:

- **Service Bulletin No. 84-32-54 issued on 22nd November 2007.**
  Subject: Landing Gear – Solenoid Sequence Valve (SSV) – Inspection of Filter and Introduction of new Configuration – Modsum 4-126410.
  (The Service Bulletin document is enclosed as appendix E).

- **Modification Summary Package No. IS4Q3200033 issued November 2007.**
  Title: In-line Filter Installation, MLG Actuator, Retract Hose Assy.
  (The Modification Summary Package document is enclosed as appendix F).

4.2 Safety recommendations

As a result of the investigation on this accident, the Accident Investigation Board, Denmark makes the following recommendations to the European Aviation Safety Agency (EASA):

- During the investigation the aircraft manufacturer introduced a modification that incorporated an in-line filter. The in-line filter protects the retract port of the Main Landing Gear Retraction/Extension Actuator. The in-line filter would have prevented the accident to DHC-8-402 LN-RDI in Copenhagen.
  However the scope of the AIB is flight safety aspects as a unified whole therefore:
  It is recommended to review if an in-line filter to protect the extend port of the Main Landing Gear Retraction/Extension Actuator is necessary. It is also recommended to review the design of the single line Main Landing Gear hydraulic system in order to prevent hydraulic locking of the Main Landing Gear system. The review should include a possible in-line filter blockage.
  REK-01-2010

- The investigation revealed that the information available to the maintenance personnel as a unified whole was unclear, not easily seen through and misleading to the maintenance personnel. The AIB understand that it is possible to review these topics separate (for instance the Illustrated Parts Catalog) and finds it sufficient to fulfil the requirements. However in respect to general flight safety aspects the AIB finds it important to review the above mentioned information in its unified whole therefore:
  It is recommended to review the information that was available to the maintenance personnel in its unified whole to avoid misunderstandings of the definitions of aircraft components and/or aircraft parts as described. The information sources were the aircraft manufacturer serialization list, operator computerized data support system, the IPC, the documentation following the MSV and the identification plate fitted to the MSV.
  REK-02-2010

4.3 Aircraft manufacturer comments to the safety recommendations

During the hearing process, the aircraft manufacturer offered the following comments to the safety recommendations:

- The aircraft manufacturer and the Retraction/Extension Actuator Vendor have developed a modification that will introduce a filter in both the extension and retraction restrictor ports of the main landing gear retraction/extension actuator. The Vendor modification will be available the first quarter of 2010. The new Retraction/Extension Actuator will be identified as P/N 46550-17.

- The aircraft manufacturer will revise the Illustrated Parts Catalog and identify the differences between a NLG Mechanical Sequence Valve and a MLG Mechanical Sequence Valve.

5. Appendices

Appendix A Flight history – timetable

Appendix B Alternate Landing Gear Extension checklist (page 14.1)
Emergency Landing checklist (page 8.1 – 8.2)

Appendix C Aerodrome map EKCH

Appendix D Retract Port Restrictor examination report

Appendix E Service Bulletin No. 84-32-54

Appendix F Modification Summary Package No. IS4Q3200033

Appendix A

Flight history - timetable

Appendix A

Flight history - timetable

The timetable is based on a summary of events from FDR, CVR, radar, security camera, ATC communication and interview.

A.1 1230 – 1345 hrs. The departure from ENBR and initial approach at EKCH

The flight departed Bergen, Flesland (ENBR) on the 27 October 2007 at 1230/1236 hrs (ATD Off Block/Airborne). The scheduled time of departure (STD) was 1210 hrs. The planned destination was Copenhagen, Kastrup (EKCH). The first officer was the pilot flying. The Landing Gear was selected up at 1236:48 hrs and the Landing Gear was retracted at 1236:53 hrs with normal indication. Flaps Up was selected at 1237:31 hrs and Flaps was Up at 1237:37 hrs while the aircraft was climbing through 2460 ft Pressure Altitude (PA). The Autopilot was engaged at 1238:01 hrs while the aircraft was climbing through 3180 ft PA. The flight reached the cruising flight level (FL250) at 1255:40 hrs. The flight started the descent inbound EKCH at 1327:39 hrs.

The flight crew contacted Copenhagen Approach (119.800 MHz) and was informed that they could expect an ILS approach to runway 04L. The flight was cleared to descent to 4000 feet and was instructed to contact Kastrup Final on the frequency 119.100 MHz. Kastrup Final cleared the flight to descent to 3000 feet. The preceding aircraft on final to runway 04L was a “heavy” aircraft. Final asked the flight crew if they could accept to land on runway 04R. The commander accepted the change of runway to runway 04R. Final then changed the approach clearance to runway 04R instead of 04L. The flight crew was instructed to contact Kastrup Tower on the frequency 119.350 MHz. At first contact with Kastrup Tower the flight was cleared to land on runway 04R.

A.2 1345 – 1347 hrs. The first approach and the go-around at EKCH

The first officer called for Flaps 5° and Landing Gear Down.
The commander selected Flaps 5° at 1345:54 hrs and the Landing Gear was selected down at 1345:59 hrs. Flaps 5 were set at 1346:00 hrs while the aircraft was descending through 1245 ft RA. The Landing Gear indication was: Nose Landing Gear Down, Left Main Landing Gear (MLG) Down and Right MLG in Transit (1346:04 hrs). The automatic altitude call “1000” was issued at 1346:10 hrs. The commander initiated a go around at 1346:15 hrs. The power was increased at 1346:25 hrs while the aircraft was at 800 ft MSL. The Landing Gear was selected Up at 1346:31 hrs and the Landing Gear was Up at 1346:36 hrs with normal indication while the aircraft was climbing through 873 ft RA The commander informed Kastrup Tower about the Landing Gear problem and that they were making a go around (1346:45 hrs). The flight was cleared to climb straight ahead to 3000 feet MSL. Kastrup Tower asked if they were ready for a new approach or if they needed to solve the problem. The commander replied that they needed to solve the problem. The Flaps were selected Up at 1347:24 hrs and the Flaps were Up at 1347:32 hrs while the aircraft was climbing through 1385 ft RA.

A.3 1347 - 1351 hrs. Recognising a Right MLG problem

The cabin attendant (CA2) contacted the commander via interphone and told him that a passenger had observed that the Right MLG did only extend to half of its normal travel (1347:55 hrs).

The flight was instructed to contact Copenhagen Approach on the frequency 118.450 MHz (1348:15 hrs).

The commander informed Approach that the flight was going around due to a Landing Gear problem. The commander asked Approach for radar vectoring around the area for some time in order to solve the Landing Gear problem. Approach acknowledged and asked the commander about the requested altitude. The commander requested the cruise altitude 3000 ft MSL. Approach cleared the flight to 3000 ft on QNH 1026 and instructed the flight to turn right to a heading of 170°. Approach provided radar vectoring for the flight around the Copenhagen Area (1348:45 hrs).

The aircraft reached and maintained 3000 ft. MSL at 1349:22 hrs.

The cabin attendant (CA2) contacted the commander via interphone and suggested that the passenger could report his observations direct to the commander. The passenger was a ATPL pilot employed by another operator. The passenger reported that the Right MLG had only extended to approximately 30° [of the 90°] and that it at present time was completely retracted (1350:40 hrs).

The first officer called for flaps 5 and the commander selected flaps 5 at 1351:02 hrs. Flaps 5 were set at 1351:10 hrs.

A.4 1351 hrs. The second Landing Gear Down selection

The commander decided to select the Landing Gear down. The Landing Gear was selected Down at 1351:11 hrs and the Landing Gear indication was: Nose Landing Gear Down, Left MLG Down and Right MLG in Transit (1351:16 hrs).

A.5 1351 – 1358 hrs. The Alternate Landing Gear Extension procedure (first attempt)

The commander decided to retract the Landing Gear and then follow the Alternate Landing Gear Extension procedure. The Landing Gear was selected Up at 1351:23 hrs and the Landing Gear indication was Up at 1351:28 hrs with normal indication.

The commander made radio contact with the technical department. He explained that the Right MLG would not extend correctly. The commander asked if he should use the Alternate Landing Gear Extension procedure. A decision was made to use the Alternate Landing Gear Extension procedure (1352:00 hrs).

The commander went through different Landing Gear procedures using the Quick Reference Handbook (QRH) trying to find the appropriate procedure (1352:52 hrs). The commander found the Alternate Landing Gear Extension procedure and followed the procedure using the QRH. The commander went through the items “Landing Considerations” and “Airspeed”. The commander located the Landing Gear

Inhibit switch after some time (25 to 35 seconds). The Landing Gear Inhibit switch was selected to Inhibit at 1355:01 hrs triggering a warning bell. The Landing Gear was selected Down at 1355:15 hrs and the Landing Gear Alternate Release Door was opened. The Main Gear Release handle was pulled at 1355:44 hrs.

Approach instructed the flight to turn right to heading 250° and the commander acknowledged (1356:12 hrs).

The Landing Gear indication was: Nose Landing Gear Down, Left MLG Down and Right MLG in Transit (1356:48 hrs). The commander tried manually to pump the Landing Gear down but without any success (1356:54 hrs).

After completion of the procedure the commander asked the cabin attendant (CA2) to report the position of the Right MLG (1358:57 hrs).

A.6 1358 - 1412 hrs. Preparing for the Emergency Landing

The first officer informed Approach that they needed more time “around 15 to 20 minutes” and Approach acknowledged (1359:13 hrs).

The cabin attendant (CA2) informed the commander that the Left MLG was down and that the Right MLG was in the Up position (1359:27 hrs). The cabin attendant (CA2) suggested that the commander informed the passengers about the situation (1359:35 hrs). The commander informed the cabin attendant (CA2) that they should expect an Emergency Landing in about 20 to 25 minutes (1400:02 hrs).

The commander decided to contact the technical department prior to the passenger briefing (1400:27 hrs). The commander informed the technical department that the Alternate Landing Gear Extension procedure was unsuccessful and that the Right MLG was now in the Up position. The technical department suggested the commander to check if the Landing Gear Alternate Extension Door was fully open. The commander could confirm that the door was fully open.

Approach instructed the flight to turn left to a heading of 070° and the first officer acknowledged (1401:22 hrs).

The first officer suggested that the commander made a passenger briefing as the passengers probably were getting a bit anxious. The commander made a passenger briefing. He informed the passengers that the crew would prepare the flight for an Emergency Landing. He also instructed the passenger to pay attention to the instruction given by the cabin attendants (1401:52 hrs).

The technical department was informed that the Right MLG was not down and locked. They were also informed that several attempts were made without any success and that they would make an Emergency Landing (1402:52 hrs). The technical department was informed that the flight not yet had declared an emergency but they would shortly.

The flight crew instructed the cabin attendant (CA2) to move passengers away from the propeller area and they informed the cabin crew to begin preparing the passengers for an Emergency Landing (1403:24 hrs). “Able bodies” were already located, and were about to be instructed and re-seated. The “able bodies” were crew members employed by the same operator and one crew member employed by another operator.

The flight crew checked the cockpit for any loose objects at 1405:38 hrs.

Approach instructed the flight to turn right to a heading of 250°. The commander acknowledged and informed Approach that the landing would be an Emergency Landing. Approach informed the commander that the landing would be on runway 04R (1407:38 hrs). Approach asked when time permitting how many souls was on board and the amount of fuel on board. The commander answered that there was 40 passengers and 4 crew members on board and about 1300 kg of fuel [at that present time] (1408:09 hrs).

Approach instructed the flight to begin the right turn to heading 250° and the commander acknowledged (1408:15 hrs).

The flight crew informed the cabin attendants that they needed to use more fuel before the landing and that the cabin attendants had plenty of time to prepare the passengers for the landing (1408:19 hrs).

The commander informed Approach that the Right MLG was confirmed not to be down. Approach acknowledged. The commander added that he believed the aircraft would depart the runway to the right during the landing roll (1408:38 hrs).

The Approach asked the commander to report when he would start the inbound flight. The commander replied that it would take half an hour as they needed to use more fuel (1409:10 hrs).

The commander made a passenger briefing explaining that the landing would be an Emergency Landing and the landing was expected in about half an hour. He explained that the Right Engine would be shutdown before the landing and that the Left Engine would be shutdown after the landing. He informed the passengers located near the propeller area would be moved away from the propeller area. The commander instructed the passengers to pay attention to the cabin attendant briefing (1410:23 hrs).

Approach asked the first officer to confirm the amount of fuel on board was 1,300 kg and to state the numbers of persons on board. The first officer replied that they were expecting the fuel onboard upon landing would be around 800 kg that there were 40 passengers and 4 crew members on board. The first officer added that among the 40 passengers were two infants [0 to 2 years old children] and that all the passengers were mobile (1410:35 hrs).

The commander contacted the technical department and explained that the landing would be an Emergency Landing. He informed technical department that the Right MLG did not extend when selected down (1412:40 hrs).

A.7 1412 - 1417 hrs. The technical department and troubleshooting

The cabin attendant (CA2) informed the first officer that a passenger reported that the Right MLG wheel was only half way extended (1412:51 hrs). [Only half of the wheel was visible from the passenger cabin].

The commander informed the technical department that the Right MLG wheel was only half way extended and they would try manually to pump the Landing Gear down. The technical department agreed (1412:59 hrs).

The technical department made a suggestion. The flight crew should not select Landing Gear Up. They should close the Landing Gear Alternate Extension Door for about 20 seconds and then open the door again and start to manually pump the Landing Gear down (1414:03 hrs).

Approach instructed the flight to turn right to a heading of 270° and the flight crew acknowledged (1414:36 hrs).

The commander asked the cabin attendant (CA2) if she could see whether or not the Landing Gear was moving downwards. The cabin attendant (CA1) informed the commander that "nothing was extended" on the right side except for the Landing Gear Doors [only the right aft MLG doors were open] (1415:53 hrs).

The flight crew discussed weather or not it would be possible to extend the Right MLG and they agreed that it did not seem likely (1416:51 hrs).

The commander contacted the technical department and informed them that he had followed the suggested procedure and that the Right MLG remained in the up position. The commander decided that he would inspect the Right MLG from the passenger cabin. The technical department suggested to close the Landing Gear Alternate Extension Door and "make some movements" with the aircraft (1417:22 hrs). The commander left the cockpit while the first officer communicated with the technical department.

A.8 1417 – 1420 hrs. The flight was assigned it own radio communication frequency

Approach instructed the flight to turn right to a heading of 070° (1418:39 hrs). Approach repeated the instruction without any reply from the crew (1418:53 hrs). Approach then asked the crew to confirm that they could read his transmission (1419:23 hrs). The first officer replied and informed Approach that he was a little busy right now. He also informed Approach to expect the aircraft to depart the runway to the right during the landing. The first officer also informed Approach that there was no change in the situation and that they would shutdown the Right Engine before landing. The first officer asked if he could get a different radio communication frequency (1418:49 hrs). Approach asked the flight to "stand by short". Copenhagen Approach instructed the first officer to contact Kastrup Final on the frequency 119.100 MHz (1420:09 hrs).

The first officer made radio contact with Final and was informed that the flight was the only flight on the frequency (1420:20 hrs). The first officer expressed that it was much better as there was a lot of radio

communication on the previous frequency. The flight remained on that frequency throughout the remainder of the flight.

A.9 1420 – 1422 hrs. "Flight Crew Procedural Considerations"

The commander returned to the cockpit. He informed technical department that the forward Right Landing Gear Doors were closed. The technical department suggested that the commander pulled the Main Gear Release Handle. The commander was of the opinion that it would not have any effect but he did pull the handle anyway. (1420:56 hrs).

The flight crew went through the new "Flight Crew Procedural Considerations" covering an unsafe Landing Gear condition. The operator information, which was sent out from the operator fleet office, suggested that they could shutdown the Right Engine in flight and then shutdown the Left Engine after the landing. The Left Engine could be operated in reverse power in order to maintain directional control while the aircraft was on the runway (1422:12 hrs).

A.10 1422 - 1423 hrs. The technical department and troubleshooting

The technical department contacted the flight and asked if the Right MLG Doors were fully opened. The commander replied that the aft Landing Gear Doors were fully opened and the forward Landing Gear Doors were closed. The commander informed technical department that he could see half of the Right MLG Wheel. The technical department informed the commander that the forward Landing Gear Doors were linked to the MLG and they would follow the Landing Gear movement. The commander asked for the reason why the Right MLG did not extend but the technical department could not give any reason. The commander informed the technical department that the landing would be on runway 04R. The technical department informed the commander that they still were working on a solution to the problem. The commander replied that he did not have that much fuel left (1423:42 hrs).

A.11 1423 - 1423 hrs. Preparing the approach pattern

At the same time as the commander was in contact with technical department the first officer was in contact with Final. Final informed the first officer that his intention was to "base" the flight east of the field. Final asked the first officer to report ready for the inbound turn around "time 40" [1440 hrs]. The first officer acknowledged (1423:50 hrs).

A.12 1423 – 1426 hrs. The cabin attendant briefing of passengers

The cabin attendant started a passenger briefing at 1425:26 hrs.
After the general passenger briefing the passengers were briefed individually.

A.13 1426 hrs. The technical department and troubleshooting

The technical department asked the commander if he at any time had tried to recycle the Landing Gear. The commander replied that the Landing Gear had been recycled twice already (1426:31 hrs).

A.14 1426 – 1428 hrs. Dangerous goods and numbers of passengers

Final asked the first officer to confirm that there were no dangerous goods onboard. The first officer replied that there were no dangerous goods onboard and that there were no handicapped passengers or wheel chair passengers on board. He informed Final that among the 40 passengers was two infants [0 to 2 years old children] and four crewmembers (1427:03 hrs). Final acknowledged the information.

A.15 1428 – 1430 hrs. Preparing the Emergency Landing

The flight crew went through the tasks and procedures before the Emergency Landing (1428:36 hrs).

The cabin attendant (CA1) informed the commander that the Emergency Landing briefing was completed. The commander suggested that he could enter the passenger cabin in case the passengers had any questions. The cabin attendant (CA1) asked if she could enter the cockpit and the commander accepted.

The first officer briefed the cabin attendant (CA1). The first officer explained that the aircraft would drop the right wing during the landing and that she should expect the passenger evacuation through the left cabin doors. He also explained that the Right Engine would be shutdown during flight to avoid propeller debris entering the passenger cabin during the landing [roll]. He explained that both engines would be shutdown after landing (1429:23 hrs).

The commander entered the passenger cabin at approximately 1430 hrs.

A.16 1430 – 1436 hrs. The technical department and troubleshooting

The technical department made radio contact with the first officer at 1431:35 hrs. They suggested that he reverted to Normal Landing Gear Extension. At the same time Final made a radio call instructing the flight to turn left to heading 220° for downwind. The first officer asked the technical department to “stand by” while he made radio contact with Final. The first officer asked Final to repeat the message.
Final instructed the first officer to turn left to a heading of 220° for a long down wind for runway 04R. The first officer explained that he was in radio contact with the technical department as well and that he was listening in now. Final expressed that it was “no problem” and asked the first officer to confirm that they would be ready at “time 40” [1440 hrs]. The first officer asked Final to stand by.

The technical department suggested that the Landing Gear Handle should remain in down position and that and the Landing Gear Alternate Extension door should be closed and the Landing Gear Alternate Release Door should be closed and the Landing Gear Inhibit switch should be set to Normal. The first officer followed the instruction and was informed by the technical department to wait for about 3 to 4 minutes as it could take some time getting the Landing Gear down. The technical department informed the flight crew that at a previous incident it took two minutes to get the MLG down and locked [another operator] (1432:10 hrs).

The technical department was in phone contact with the aircraft manufacture. They suggested that the aircraft manufacturer could contact the commander direct by using a cell phone. The attempt was unsuccessful.

The flight crew tried once more to pump the Landing Gear down. At this time they were getting concerned about the remaining amount of fuel (1435:54 hrs).

A.17 1436 – 1442 hrs. Initializing the approach and continuing troubleshooting

Final instructed the flight to turn right to a heading of 270° and to report ready for the approach (1436:50 hrs). The flight crew acknowledged. At the same time the flight crew was trying to extend the Landing Gear using the Alternate Landing Gear Extension procedure with the Landing Gear Lever in Down position.

The first officer informed Final that the flight was ready for the approach (1439:45 hrs).

Final instructed the flight to turn right heading 070° and cleared the flight for the ILS approach to runway 04R (1439:49 hrs).

Final asked the flight if the crew “had a moment” and the flight crew acknowledged (1440:47 hrs).

The technical department suggested that the flight crew restored the landing gear system back to normal, and then selected the Landing Gear Up (1440:49 hrs).

Final asked if the crew had any special request he could forward to the fire chief, and the commander informed Final, that the aircraft would depart the runway to the right. The commander asked Final if they could “make a 360” and Final approved (1441:16 hrs).

The Landing Gear was selected Up at 1441:39 hrs and the Landing Gear indication was Up at 1441:44 hrs with normal indications. The technical department suggested that the Landing Gear should remain in the Up position for about 15 to 20 seconds and then the Landing Gear should be selected down again (1442:11 hrs).

The commander asked the technical department if he should select the Landing Gear down again. The technical department suggested that the Landing Gear could be selected down again (1442:27 hrs).

The Landing Gear was selected Down at 1442:47 hrs and the Landing Gear indication was: Nose Landing Gear Down, Left MLG Down and Right MLG in Transit (1442:52 hrs).

The flight crew considered trying the Alternate Landing Gear Extension procedure again but choosing not to; instead they decided to continue the approach (1442:59 hrs).

A.18 1442 – 1446 hrs. The initial approach and Engine Shot Down In Flight

The flight crew made an approach briefing and completed the Approach Checklist (1444:17 hrs) [The Approach Checklist contained the remaining items before landing]. The commander informed Final that they were "coming in for the approach". Final asked the flight to report when established [on the ILS]. The commander informed the cabin attendants to expect landing in 5 minutes (1444:32 hrs).

The first officer suggested to shutdown the right engine in due time to ensure a stabilized approach and he also suggested at least a 10 miles final approach (1444:58 hrs). The commander agreed.

The commander informed the passengers to expect landing within 4 to 5 minutes (1445:41 hrs).

The first officer started the Engine Shutdown (In Flight) procedure of the Right Engine. The commander confirmed that the first officer was about to shutdown the Right Engine [engine #2]. The Right Engine Power Lever was set to Flight Idle at 1446:04 hrs. At the same time the Torque dropped from 32.0 units to -0.4 units. The Propeller maintained 1018.0 RPM. The first officer announced that he would shut down the Right Engine (1446:26 hrs). The commander confirmed that the first officer was about to shutdown the Right Engine [engine #2]. The Right Engine Condition Level was set to Fuel Off at 1446:35 hrs. At the same time the Propeller dropped from 1018.0 RPM to 122.0 RPM and the warning bells sounded. The commander noted that the engine was shutting down and that the propeller was feathered (1446:46 hrs).

A.19 1446 – 1452 hrs. The final approach and continuous warnings

Final cleared the flight to land and informed the crew that the wind was from 100 degree at 3 knots (1447:08 hrs). The commander informed Final that the Right Engine had been shutdown.

Flaps 15 were selected at 1447:36 hrs and they were set at 1447:52 hrs. At the same time (1447:36 hrs) continuous Landing Gear Warning started to sound. The warning continued though the remaining flight.

The flight started the descent and approach from 3000 ft at 1448:28 hrs.

Final asked the commander if they would land at the threshold or further down the runway. The commander asked "where it was best". Final informed the commander that the fire brigade was at taxiway B3 [505 meter after threshold 04R] and on runway 30. Final contacted the fire brigade and returned to the commander suggesting touch down abeam taxiway B3 (1448:56 hrs). Final informed the flight that the wind direction was 090 degrees at 3 knots, and that they were cleared to land.

Flaps 35 were selected at 1450:02 hrs and they were set at 1450:10 hrs. The radio altimeter (RA) indicated 1528 feet and the Calibrated Air Speed (CAS) was 140 knots (decreasing).

The commander instructed the passengers to brace for impact at 1451:13 hrs while the aircraft was passing through approximately 800 feet RA. Thereafter the cabin attendants repeated the command to brace for impact continuously until the aircraft came to a full stop.

Final cleared the flight to land and informed the flight that the wind direction was 090° at two knots (1451:29 hrs).

The Auto Pilot was disengaged at 1451:36 hrs while the aircraft was descending through 551 ft RA. The CAS was 118 knots.

The Ground Proximity Warning System (GPWS) started issuing warnings "Too Low Gear" when the aircraft passed 531 ft RA. The GPWS continued issuing warnings with shorter and shorter intervals during the remaining flight (1451:39 hrs).

After the aircraft passed 532 ft RA and just prior to touch down the CAS was decreasing from 118 knots to 111 knots. [The Vref with flaps at 35° and a landing weight of 23 tons was 109 knots].

A.20 1452 – 1453 hrs. The landing

The aircraft left MLG touched down on runway 04R abeam taxiway B3 at 1452:31 hrs.
The left Inboard and Outboard spoilers were extended at 1452:31 hrs (and they were retracted at 1452:50 hrs).
After touch-down on the left MLG the left Engine was selected to reverse and the power was increased from 2.5 units to 30-32 units torque (1452:35 hrs). At the same time the Nose Landing Gear made contact with the runway. The aircraft followed the runway centreline from 1452:31 hrs until the final ground roll at 1452:51 hrs. The aircraft right propeller and aft fuselage made contact with the runway surface at 1452:38 hrs. The right Wingtip made contact with the runway at 14:52:46 hrs. The aircraft started to turn to the right at 1452:51 hrs and as it departed the runway it damaged two runway edge lights. The Nose Wheel suffered some damage during this turn to the right. The right Nose Wheel Tyre deflated during the turn. The maximum vertical acceleration of 1.30 G occurred at 1452:52 hrs (the latitude G was -0.09 and the longitude G was -0.48 at that time). The left Engine Condition Lever was set to Fuel Off position at 1452:53 hrs. The aircraft departed the runway to the right and came to rest at the taxiway C area on a heading of 115° and with a bank angle of 14.2° to the right (1452:58 hrs). The taxiway C area surface was approximately 60 meters width area covered with asphalt. The Left Engine was out of reverse at 1453:00 hrs.

(There was no indication from the FDR data of MLG Weight On Wheels (WOW). The spoilers did not extend during landing because of a missing WOW signal from the right MLG. The spoilers eliminate the lift on the wings to assist in maximum braking efficiency.)

As the aircraft came to rest the cabin attendants noted "a warm smell" however they did not observe any sparks, smoke or fire.

According to a security video recording there was some sparks and smoke originating from the aft fuselage as the aircraft made contact with the runway surface but there was no fire.

A.21 1453 – 1454 hrs. The evacuation

After the aircraft came to rest there were no sparks or fire visible on the video recording. The smoke originating from the aft fuselage disappeared within a few seconds and before the cabin doors were opened.

The final valid FDR data was recorded at 1453:00 hrs.

Final informed the flight that they could not see any fire from their position; however the information did not reach the crew, as the aircraft electrical power was switched off at that time (1453:10 hrs). [Neither the command to evacuate the aircraft nor the Evacuation Signal was recorded on the CVR].

While the commander was going through the "on ground emergency checklist" the first officer asked if he should command the start of the evacuation. The commander agreed and the first officer gave order to start the evacuation. [The exact time or wording could not be verified as no FDR/CVR data was available after time 1453:00 hrs].

The first cabin door (Left Forward) was opened at 1453:13 hrs and the first crew member was outside the aircraft at 1453:15 hrs. The crew member took position to the left of the door [the direction of flight], assisting the passengers out of the aircraft and guided the passengers away from the aircraft. The left aft cabin door was opened a second later and the passengers were directed in the same direction away from the aircraft. The commander went through the passenger cabin and exited the aircraft via the left aft cabin door. The last person to leave the aircraft was the first officer using the forward left cabin door (1454:03 hrs). The two right cabin doors were not used during the evacuation. The cabin attendants found the left cabin doors harder than usual to open. According to the security video at least one of the passengers did evacuate the aircraft carrying light hand luggage.

A.22 1453 – 1454 hrs. The fire fighters

The first fire fighters arrived at the scene at 1453:21 hrs followed by fire trucks 4 seconds later. There was no fire fighting required.

No fire-fighters entered the aircraft within the first minutes after the aircraft came to rest.

A.23 The Evacuation Signal System

The AIB investigators found the aircraft at the accident side with the Evacuation Signal System activated. The Evacuation Signal sounded successfully. The system was selected off by AIB investigators.

Appendix B

Alternate Landing Gear Extension checklist (page 14.1)
Emergency Landing checklist (page 8.1 – 8.2)

ALTERNATE LANDING GEAR EXTENSION
("LDG GEAR INOP" Caution Light and/or Gear Unsafe Indication confirmed)

Landing Considerations:

- Landing Gear cannot be retracted.
- Nosewheel steering will be inoperative.
- Airspeed ..... 185 KIAS (max)
- L/G Inhibit switch ..... Inhibit
- Landing Gear selector ..... Down
- Landing Gear Alternate Release door ..... Open
- Main Gear Release handle ..... Pull Fully Down
- Landing Gear Alternate Extension door ..... Open

Note: *IF LEFT and/or RIGHT green gear locked down Advisory Lights do not illuminate, insert Hydraulic Pump handle in socket and operate until LEFT and RIGHT green gear locked down Advisory Lights illuminate.*

- Nose Gear Release handle ..... Pull Fully Up

Note: *Leave Landing Gear Alternate Release and Extension Doors fully open and L/G Inhibit switch at Inhibit.*

- Gear-Locked-Down indicator ..... On/Check/Off
- Anti-Skid ..... Test

Note: *If **one** Main Gear remains unsafe after landing gear extension, **consider** Engine Shutdown according to Engine Failure /Fire/Shutdown checklist page 5.10 on affected side and/or reseating of passengers sitting in rows adjacent to propeller on affected side, due to risk of propeller debris entering the cabin at touchdown.*

After Landing:

As soon as possible after engine shutdown:

- Ground Locks ..... Install

EMERGENCY LANDING
(Both Engines Operating)

If possible ensure no passengers are seated in the plane of the propellers.

- GPWS CB (A1 & B1 - Avionics CB Panel)..... Pull
- Emergency Lights ..... On
- Auto/Man/Dump .....Dump
- ELT ..... On
- Shoulder Harness .....Lock
- FD DOOR LOCK..... Un-Lock

Landing Gear Extended:

- Proceed with normal approach.

Landing Considerations:

When aeroplane comes to a stop:

- Emerg Brake..... On
- Condition Levers..... Fuel Off
- T- Handles ..... Pull
- Battery Master..... Off
- Evacuate airplane

Landing Gear Retracted:

Landing Considerations:

- Flap.....35°
- Maintain V_{REF} until immediately prior to flare.
- DO NOT exceed 6° nose up during flare.
- Touch down with minimum speed and minimum rate of descent without stalling.

After ground contact:

- Condition Levers..... Fuel Off
- T- Handles ..... Pull
- Battery Master..... Off

When aeroplane comes to a stop:

- Evacuate aeroplane

(cont'd on next page)

EMERGENCY LANDING
(Both Engines Operating) (cont'd)

Ditching:

- Landing Gear ..... Up
- Condition Levers ..... Max
- Bleed Air 1 and 2 ..... Off
- Flap ..... 35°
- ELT ..... On

Landing Considerations:

- In rolling swell surface conditions attempt to ditch along and parallel to the crests as much into wind as swell line permits. In other water surface conditions land into wind.
- Maintain V_{REF} until immediately prior to flare.
- Commence flare to achieve zero vertical velocity immediately prior to water contact.
- Maintain pitch attitude of 10° nose up.
- Touch down with minimum speed and minimum rate of descent without stalling.
- A transient nose-up pitching motion may result following touchdown. Overcorrection of this tendency could result in porpoising or nosing in.

After water contact:

- Condition Levers ..... Fuel Off
- T- Handles ..... Pull
- Battery Master ..... Off

When aeroplane comes to a stop:

- Evacuate aeroplane

Note: *After completion of the ditching run, the aeroplane will float with one wing in the water. The upper portion of the right forward emergency exit and the airstair door should be used for evacuation. The airstair door ditching dam must be in place prior to opening the door.*

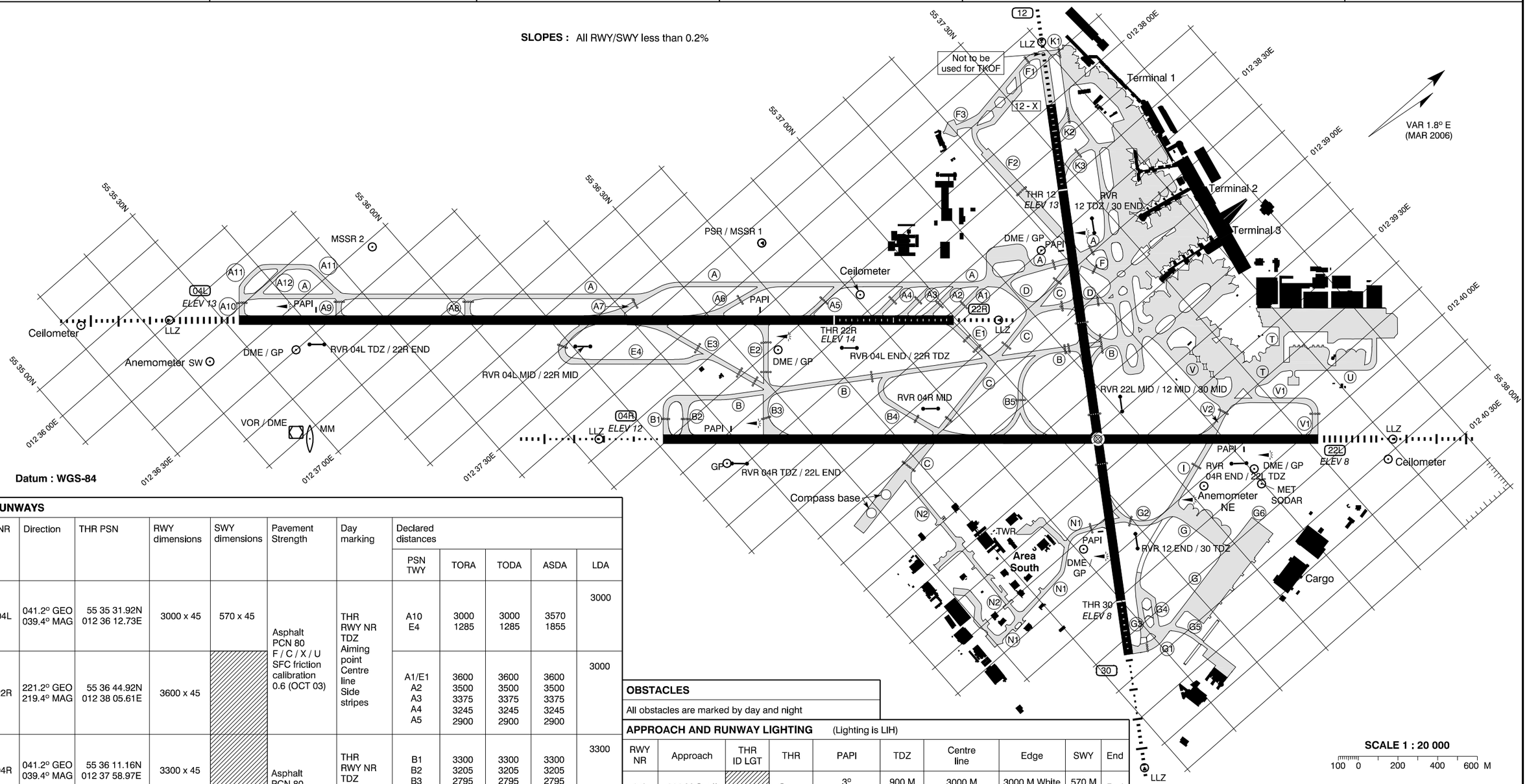
Warning: ***DO NOT*** *open the Aft Doors or the lower portion of the right forward emergency exit.*

Appendix C

Aerodrome map Copenhagen Airport Kastrup (EKCH)

AERODROME CHART - ICAO	ARP : 55 37 04.50N 012 39 21.50E INT RWY 04R / 22L - 12 / 30	AD ELEV : 17	ELEV in FT Dimensions / Distances In M	Copenhagen APP : 119.800 Kastrup TWR : 118.100 118.575 118.700 119.350 121.825 ATIS : 122.750 (ARR) 122.850 (DEP)	**AD 2 - EKCH** **ADC** **København / Kastrup**

SLOPES : All RWY/SWY less than 0.2%



Datum : WGS-84

RUNWAYS

NR	Direction	THR PSN	RWY dimensions	SWY dimensions	Pavement Strength	Day marking	Declared distances				
							PSN TWY	TORA	TODA	ASDA	LDA
04L	041.2° GEO 039.4° MAG	55 35 31.92N 012 36 12.73E	3000 x 45	570 x 45	Asphalt PCN 80 F / C / X / U SFC friction calibration 0.6 (OCT 03)	THR RWY NR TDZ Aiming point Centre line Side stripes	A10 E4	3000 1285	3000 1285	3570 1855	3000
22R	221.2° GEO 219.4° MAG	55 36 44.92N 012 38 05.61E	3600 x 45				A1/E1 A2 A3 A4 A5	3600 3500 3375 3245 2900	3600 3500 3375 3245 2900	3600 3500 3375 3245 2900	3000
04R	041.2° GEO 039.4° MAG	55 36 11.16N 012 37 58.97E	3300 x 45		Asphalt PCN 80 F / C / X / U SFC friction calibration 0.6 (OCT 03)	THR RWY NR TDZ Aiming point Centre line Side stripes	B1 B2 B3 B4/C	3300 3205 2795 1940	3300 3205 2795 1940	3300 3205 2795 1940	3300
22L	221.2° GEO 219.4° MAG	55 37 31.48N 012 40 03.29E	3300 x 45				V1 V2	3300 2770	3300 2770	3300 2770	3300
12	123.2° GEO 121.4° MAG	55 37 26.94N 012 38 20.82E	2800 x 45		Concrete + Asphalt PCN 80 F / C / X / U SFC friction calibration 0.6 (OCT 03)	THR RWY NR TDZ Aiming point Centre line Side stripes	12 - X K2 K3 D	2800 2695 2485 1800	2800 2695 2485 1800	2800 2695 2485 1800	2365
30	303.2° GEO 301.4° MAG	55 36 49.87N 012 40 01.01E	2365 x 45	300 x 45			G1	2365	2365	2665	2395 SWY incl.

OBSTACLES

All obstacles are marked by day and night

APPROACH AND RUNWAY LIGHTING (Lighting is LIH)

RWY NR	Approach	THR ID LGT	THR	PAPI	TDZ	Centre line	Edge	SWY	End
04L	900 M Cat II		Green	3° MEHT 61 FT	900 M White	3000 M 15 M	3000 M White 60 M	570 M Red	Red
22R	900 M White	FLG White	Green	3° MEHT 59 FT		3600 M 15 M	600 M Red 3000 M White 60 M		Red
04R	720 M White		Green	3° MEHT 57 FT		3300 M 15 M	3300 M White 30 M		Red
22L	900 M Cat II and III		Green	3° MEHT 60 FT	900 M White	3300 M 15 M	3300 M White 30 M		Red
12	900 M White	FLG White	Green	3° MEHT 49 FT			435 M Red 2365 M White 30 M		Red
30	900 M White		Green	3° MEHT 60 FT			270 M Red 2095 M White 30 M	300 M Red	Red

Secondary power supply : Yes, all RWY switch-over time 1 SEC at RVR below 800 M, otherwise MAX 15 SEC.

TAXIWAYS (Except TWY N1 and TWY N2)

Width :	23. G4 27.5.
Pavement :	Concrete or asphalt.
Strength :	PCN 80 / F / C / X / U.
Day marking :	Centre line, Side stripes (where deemed necessary), Holding positions.
Lighting :	Edge - blue; Centre line - green; Centre line on exit taxiways within ILS critical/sensitive areas and centre line within 60 M from RWY centre line - standard colour. Stop bars. RGL. Deicing TWY A and TWY B : Exit facility light.
Taxiing guidance system :	Sign boards.
Rapid exit taxiways :	A6, A7, B4 and E3

Changes : Editorial (TWR).

Appendix D

Retract Port Restrictor examination report

Examination of blocked back flow restrictor from main landing gear retract actuator

Requested by:	Accident Investigation Board, Denmark
Reported by:	Curt Christensen, FORCE Technology
Reviewed by:	Hans Peter Nielsen, FORCE Technology
Our ref.:	107-34859 CC/mal

6 November 2007

Materials and Environment

Introduction

FORCE Technology was requested to examine a back flow restrictor valve dismantled from a main landing gear retract actuator. The purpose of the examination is to establish the cause of the experienced blockage of the flow through the restrictor.

Each step in the examination was approved and witnessed by:

Accident Investigation Board Denmark.
Transportation Safety Board Canada.
The Operator of the accident aircraft.
The Aircraft Manufacturer.
The Landing Gear Manufacturer.

(Company and persons names blanked by
AIB Denmark according to the Danish
Air Navigation Act § 134 – 144.)

Results

The photos in Figure 1 show the restrictor (labelled SN 074) and its engraved marking. For reference throughout this document the restrictor ports are named S, system connection port, and A, actuator connection port, respectively.

Viewing down into the S port it was evident that the orifice hole was blocked, c.f. Figure 2. At higher magnification the blocking material appeared like black rubber as visualised in Figure 3.

The flow restrictor was x-rayed in axial and transverse directions using voltages ranging from 200 kV down to 25 kV. The x-ray images obtained at low voltages, Figures 4 and 5, did not reveal presence of any metallic particles or other x-ray absorbing material in the flow channels or orifices.

Disassembling the restrictor and removing the A port orifice allowed a view of the valve interior, c.f. Figure 6. A broken O-ring is partly emerging through one of the flow relief holes and the central orifice hole is blocked by a piece of O-ring material. In addition it appears that O-ring material is trapped between the valve cone and the housing thus blocking the flow relief holes. Forcing the valve cone out of the housing revealed 3 pieces of an O-ring, c.f. Figure 7. Together with a fourth piece that was easily plied free from the

central hole, they form an almost complete O-ring as seen in Figure 8 with only a small deficit in piece no. 4 (by the arrow in Figure 8). This deficit is accounted for by the small bit still residing in the orifice hole, c.f. Figure 9.

The O-ring surface shows signs of being in intimate contact with the valve cone thus producing circular punch cuts in the O-ring corresponding to the size and spacing of the flow relief holes in the valve cone. Figures 10 to 13 show examples of the punch cuttings, and squeeze and chewing marks in the O ring surfaces. Some of the punch cuts are more than halfway through the O-ring as illustrated in Figure 14. The striation patterns in the free ends of the O-ring pieces shown in Figure 15 are evidence of stepwise progressing punch cuts.

The dimensions of the O-ring as estimated in Figures 16 to 19 are:

Outer diameter:	between 13.52 and 13.91 mm (0.532 and 0.548 in)
Inner diameter:	8.68 mm (0.342 in)
Thickness:	2.86 mm (0.113 in)

The orifice dimensions as estimated from Figures 20 and 21 are:

S port orifice:	1.48 mm (0.058 in)
A port orifice:	2.56 mm (0.1 in)

The composition of the trapped O-ring (sample 1) was checked against a reference O-ring material (sample 2), by means of Fourier Transform Infra Red spectrometry. The obtained FTIR spectra are shown in Figure 22. The spectra are quite similar and correspond to EPDM rubber (ethylene diene monomer rubber) as normally required for use in fireproof hydraulic fluids.

Discussion

The function of the flow restrictor valve is illustrated by means of the cut-away views of a valve similar to the blocked valve, c.f. Figures 23 and 24. When pressure is applied through the A port (as during lowering of the landing gear) the floating valve cone is forced against the seal area and the flow through the restrictor is controlled by the smaller orifice. When pressure is supplied through the S port the valve cone travels away from the seal and opens up. The relief holes in the cone bypasses the smaller orifice and the flow is controlled by the large orifice in the A port end.

Figure 25 shows comparative sizes of the restrictor valve interior and captured O-ring. The O-ring cannot pass through either of the orifice holes. The only way it can end up where found is by travelling with the oil flow through the S port while the valve cone is open. It is not possible to determine whether the O-ring was intact but in our opinion, it arrived in one piece at least. As the valve cone closes the O-ring was caught between the valve cone and the housing. Consecutive opening and closing of the valve cone during retraction/extension of the main landing gear resulted in severe battering and chewing of the O-ring. It was partly punched through the flow relief holes in the cone and eventually some of the punch cuts resulted in division of the O-ring into 2 large and 2 small pieces. The stepwise growth of punch cuts is evidenced by the striation pattern visible in Figure 15. The smallest part of the divided O-ring was probably in the progress of being further subdivided when it made its way through one of the relief holes. Being captured in the cone interior between the two orifices the oil flow has caught the O-ring piece and forced it to block the orifice hole.

Analysis of the O-ring material showed the material to be EPDM rubber.

Conclusion

An O-ring has entered into the back flow restrictor valve through the port connecting to the hydraulic system.

Inside the valve it was caught between the floating valve cone and the seat/housing.

The valve cone has battered, chewed and punched the O-ring severely due to its back and forth travels during operation of the main landing gear.

Eventually, the O-ring broke up in pieces and one of the smaller lumps arrived into the valve cone interior through the flow relief holes where it finally was caught and lodged in the orifice to completely block the oil flow.

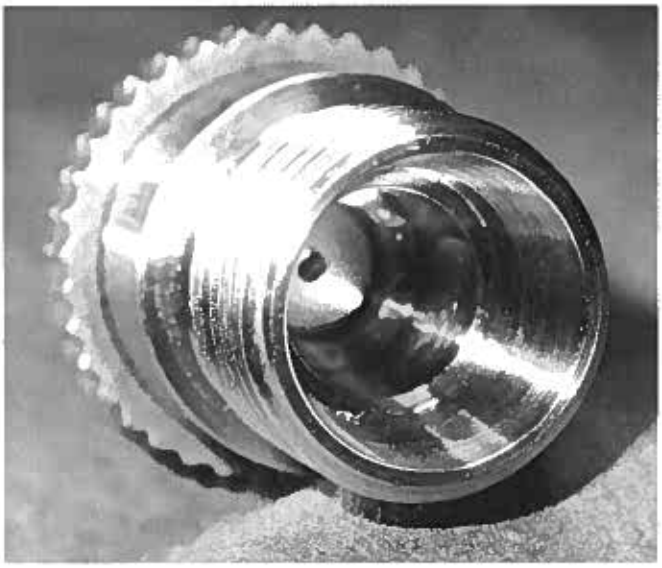
CORROSION & METALLURGY

Copy issued: 7/11-07
Sign.: HPN

Hans Peter Nielsen

Curt Christensen

Figure 1: External views of the blocked flow restrictor (labelled SN 074).



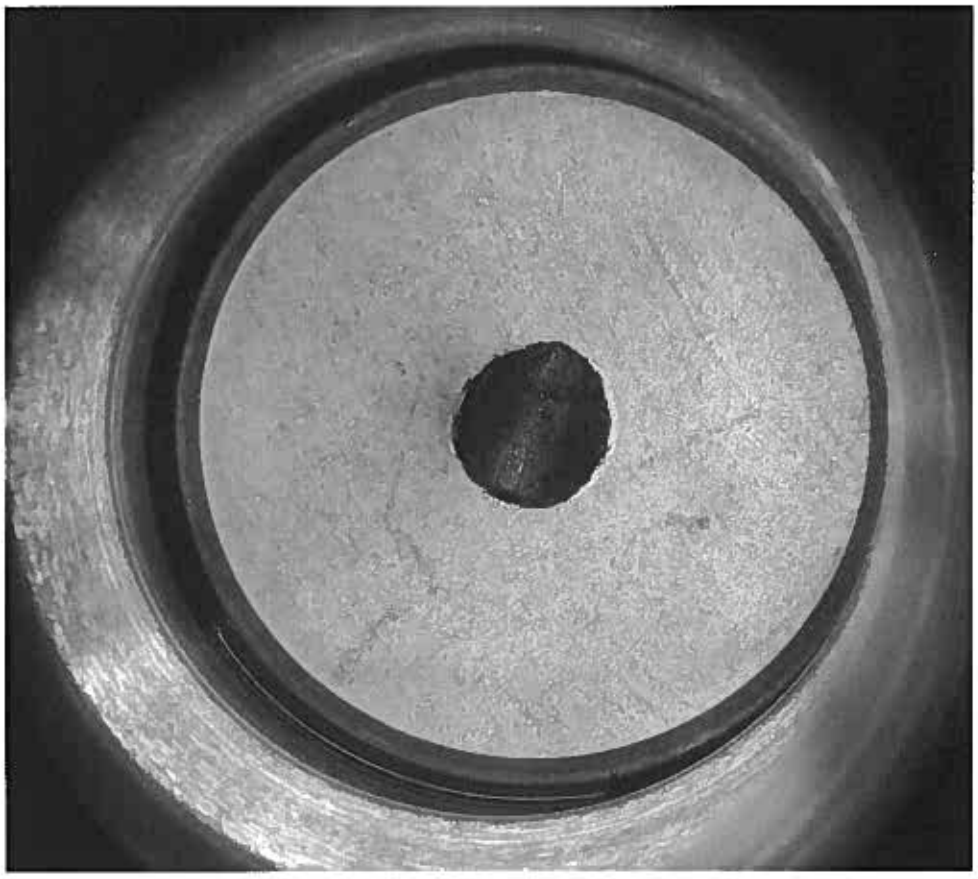


Figure 2: View down into the S port revealing the blocked orifice hole.

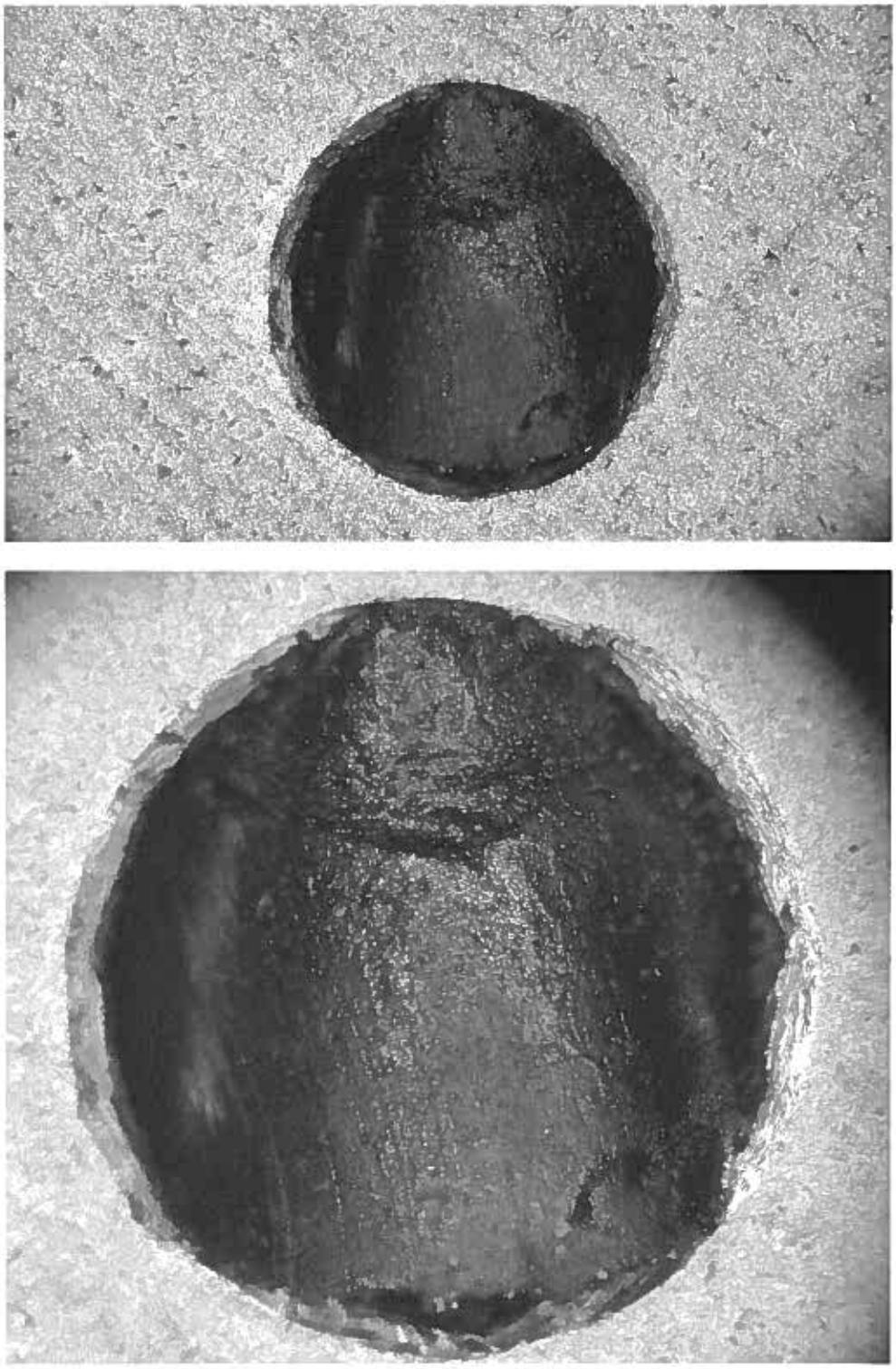


Figure 3: Higher magnifications of the blocked orifice hole as viewed through the S port.

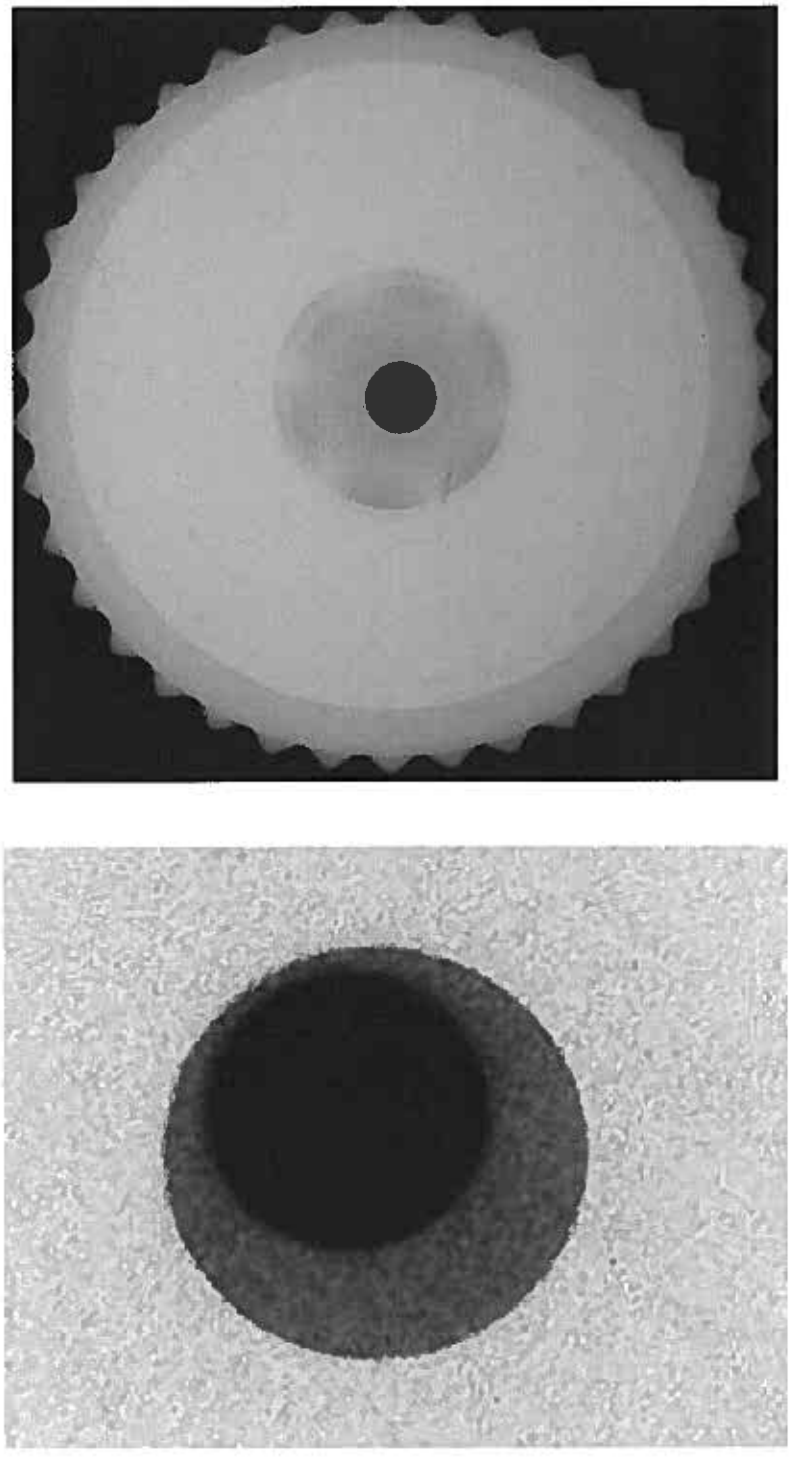


Figure 4: X-ray images of flow restrictor X-rayed in longitudinal direction from Port A. The lower image shows the two orifices at higher magnification.

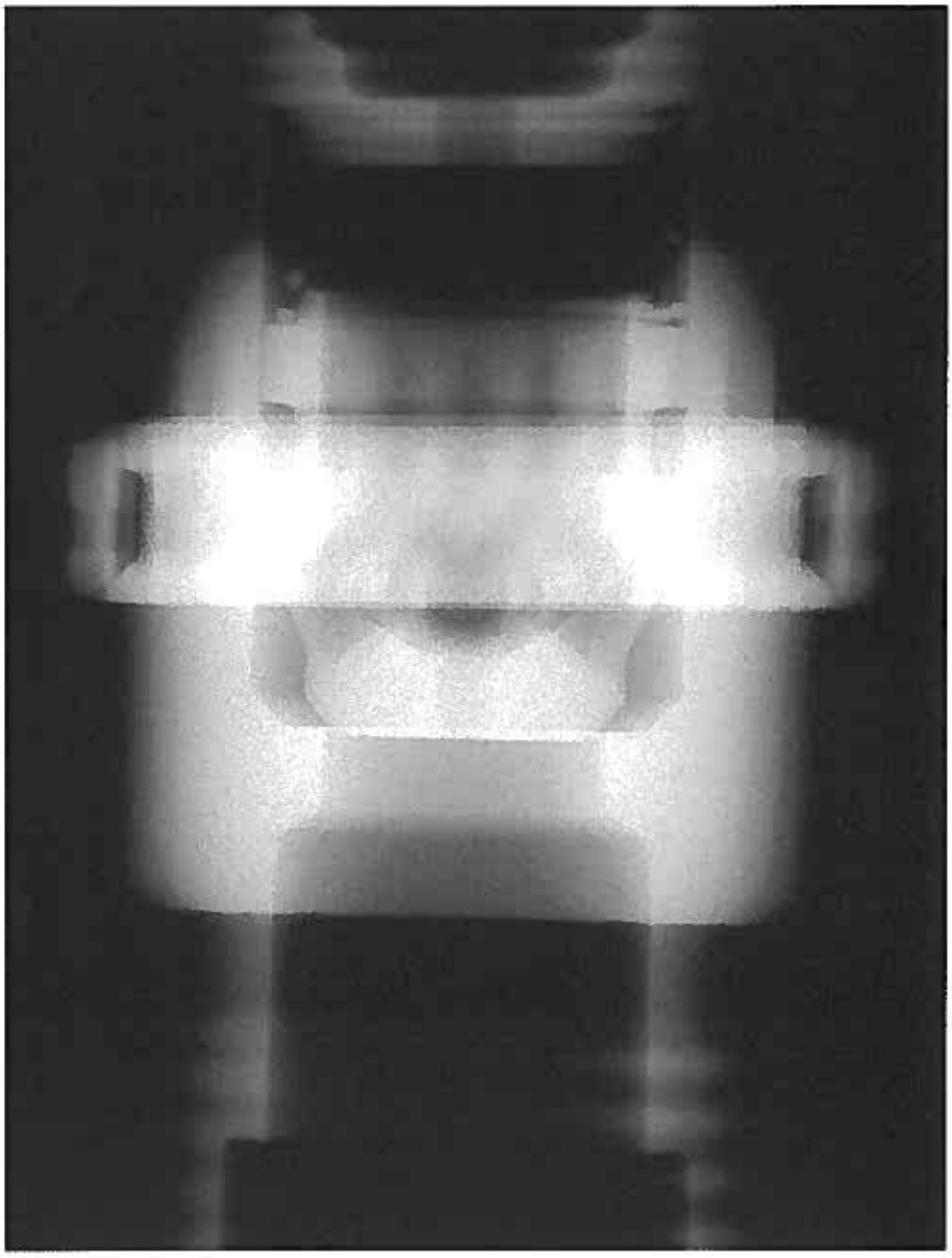


Figure 5: X-ray in transverse direction.

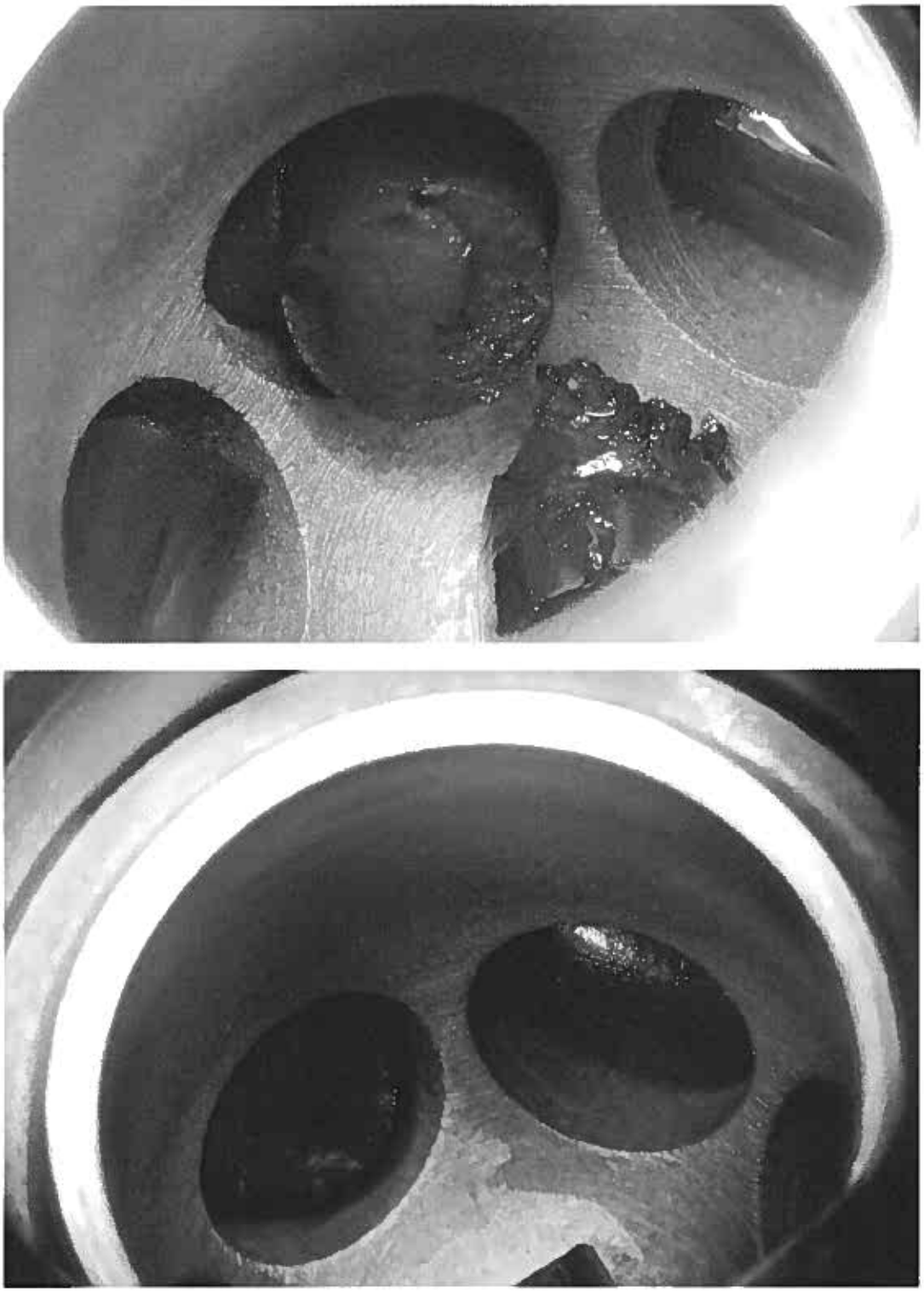


Figure 6: View from A port inside valve cone.

Figure 7: Retrieved parts of O-ring material trapped between cone and housing.

Figure 8: Reassemble of O-ring using all retrieved material except the small piece still residing in orifice hole. The arrow points to where the missing piece fits.

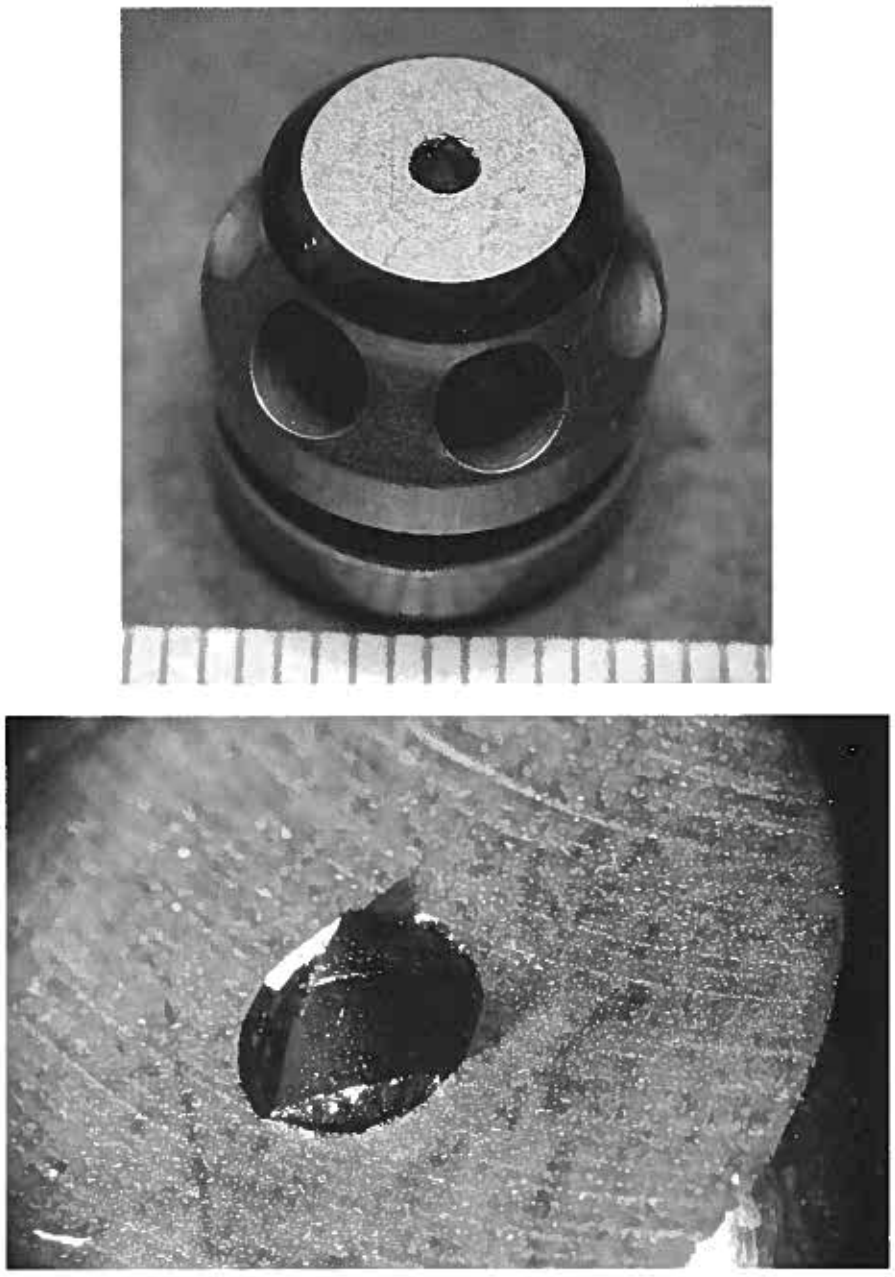


Figure 9: Missing piece of O-ring in Figure 8 still residing in orifice hole.

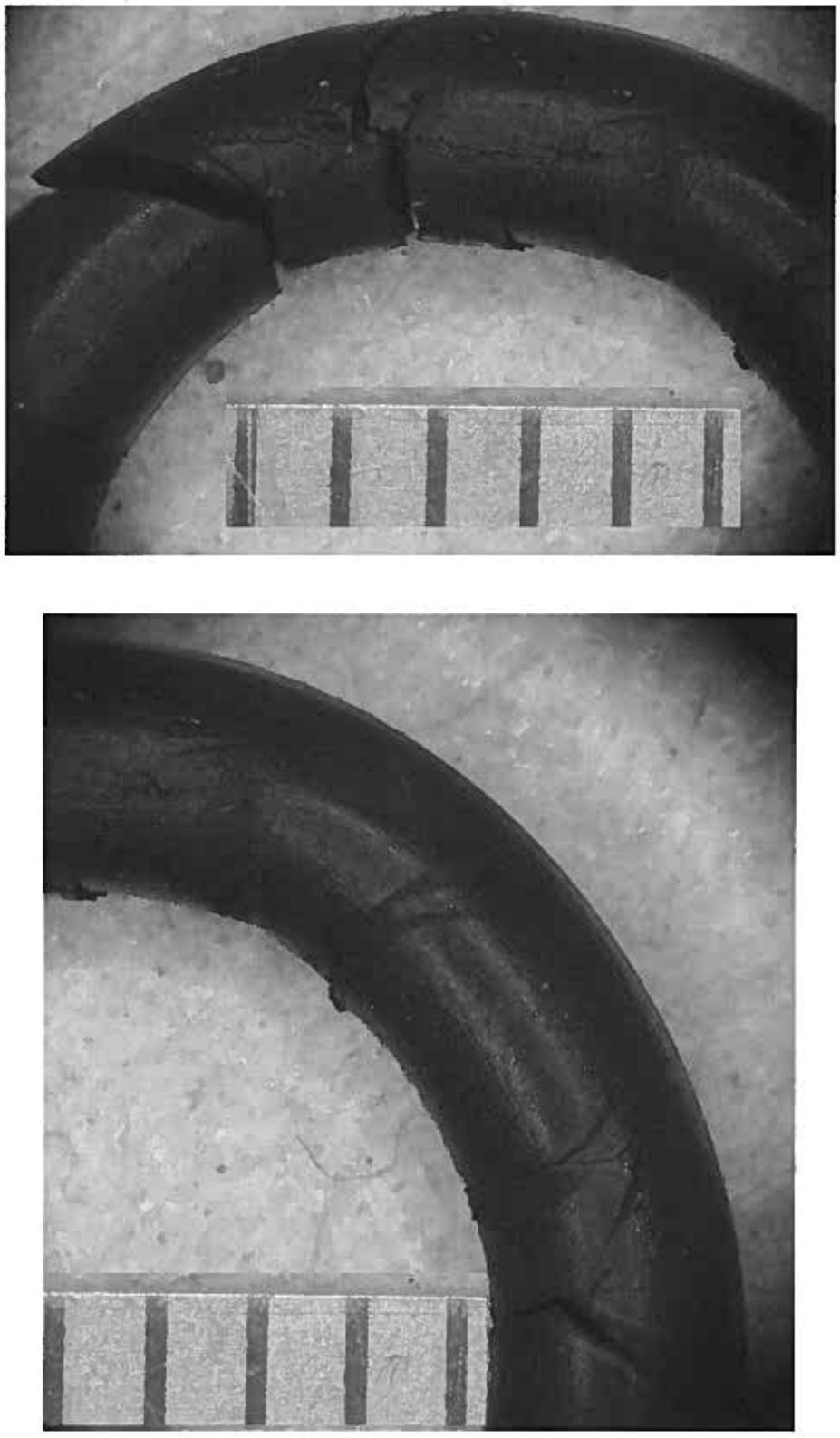


Figure 10: View of retrieved O-ring. Scale bar division is 1 mm.

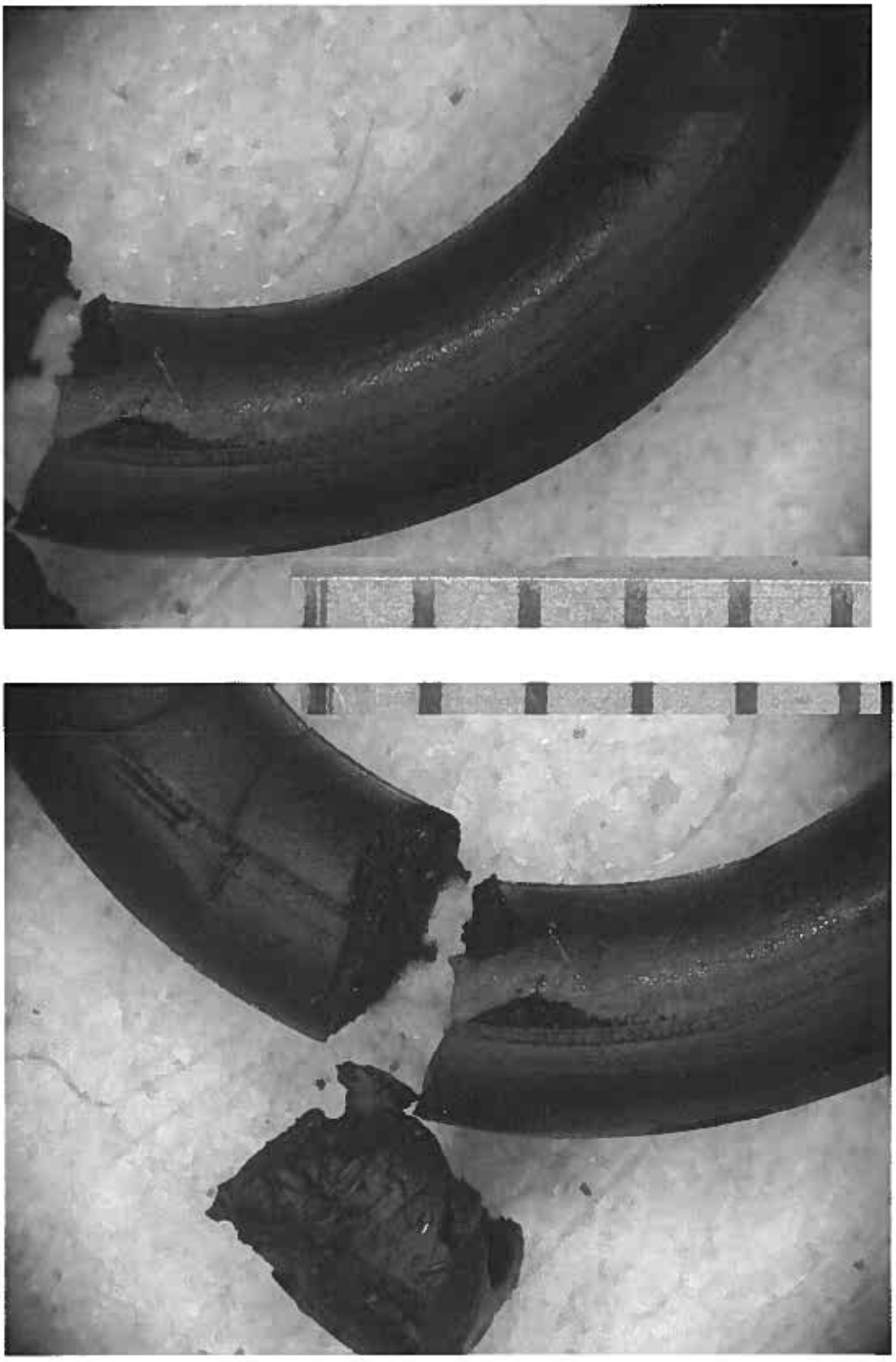


Figure 11: View of retrieved O-ring. Scale bar division is 1 mm.

Figure 12: View of retrieved O-ring. Scale bar division is 1 mm.

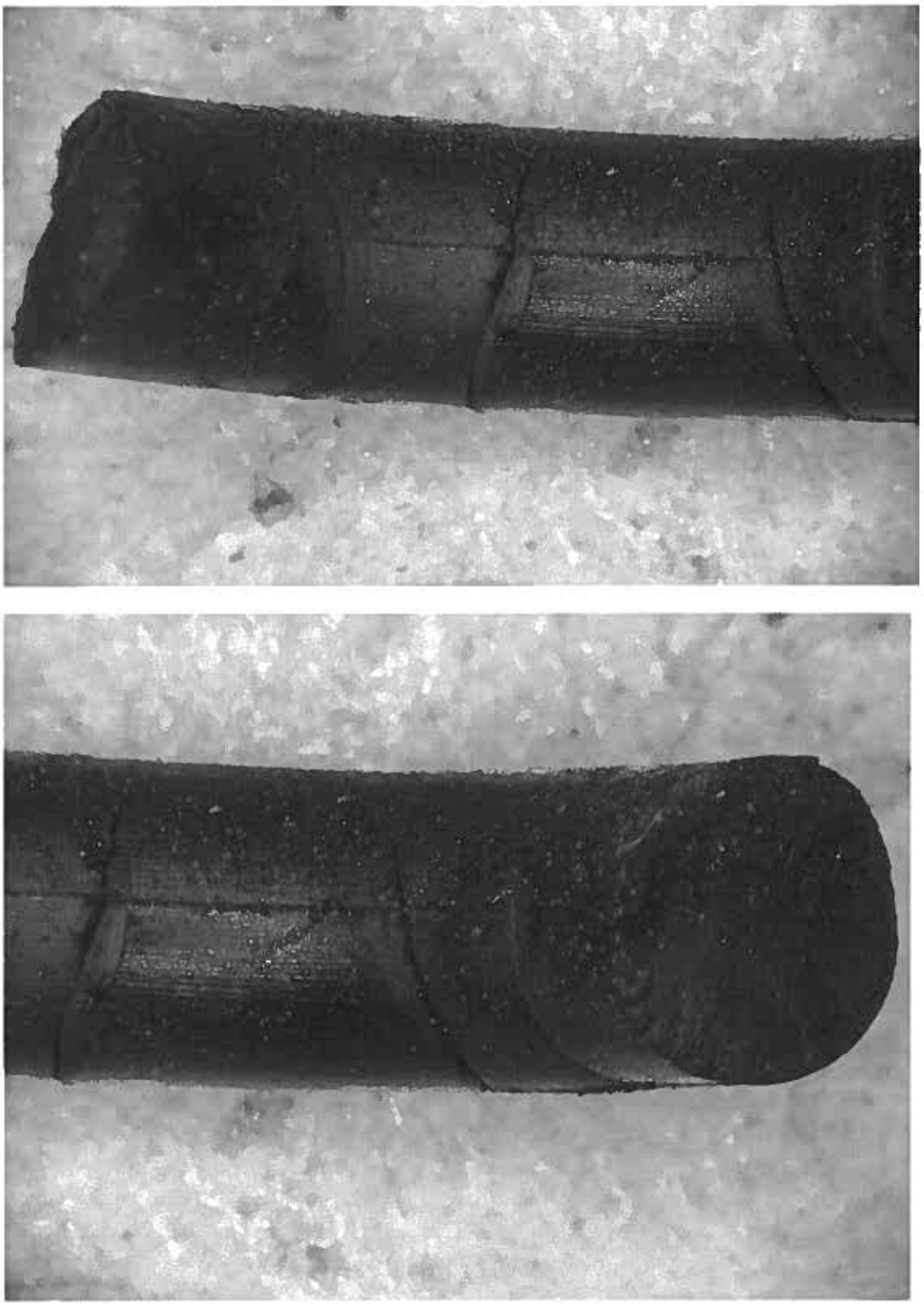


Figure 13: View of retrieved O-ring.

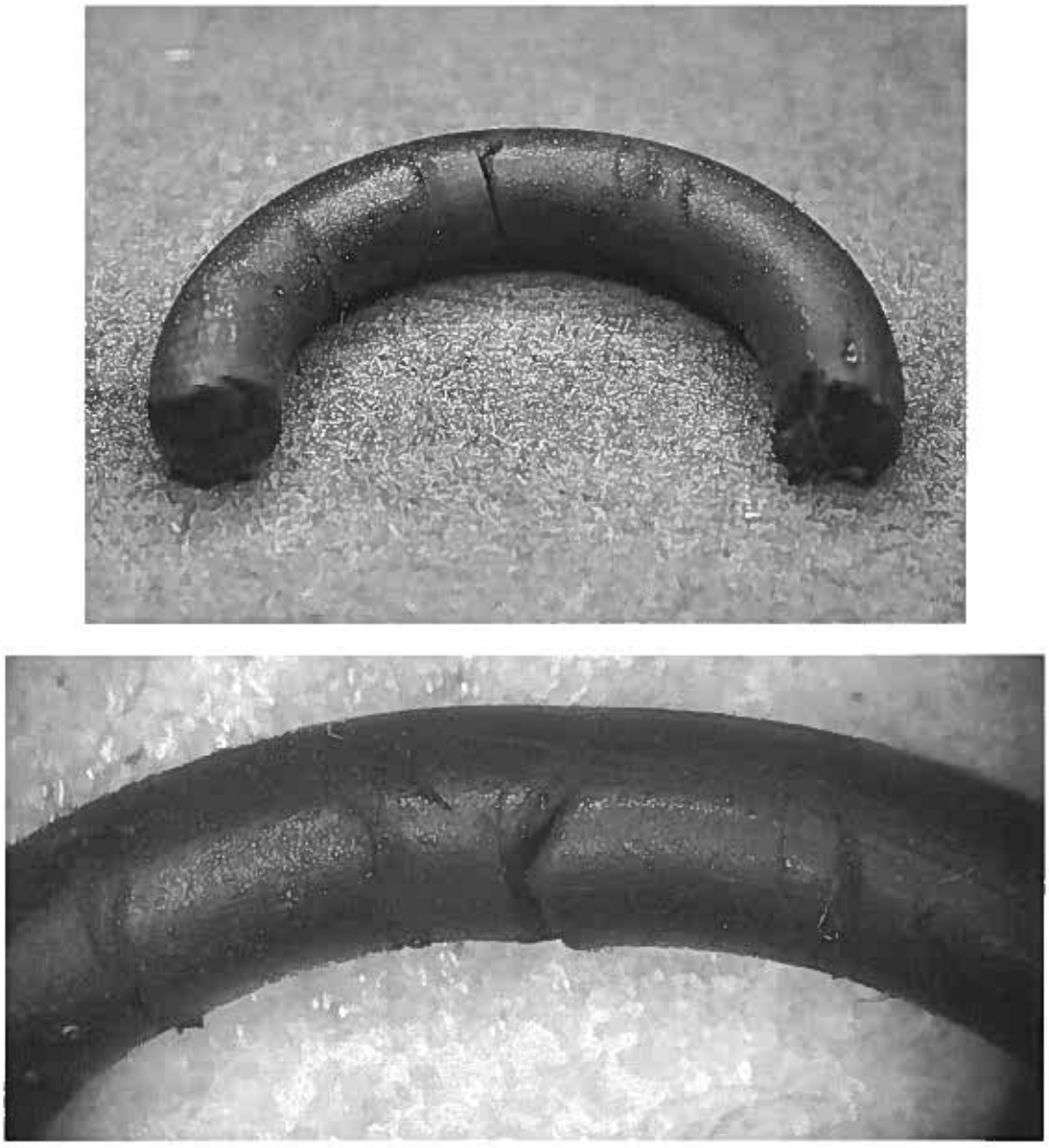


Figure 14: Illustration of punch cut depths in O-ring.

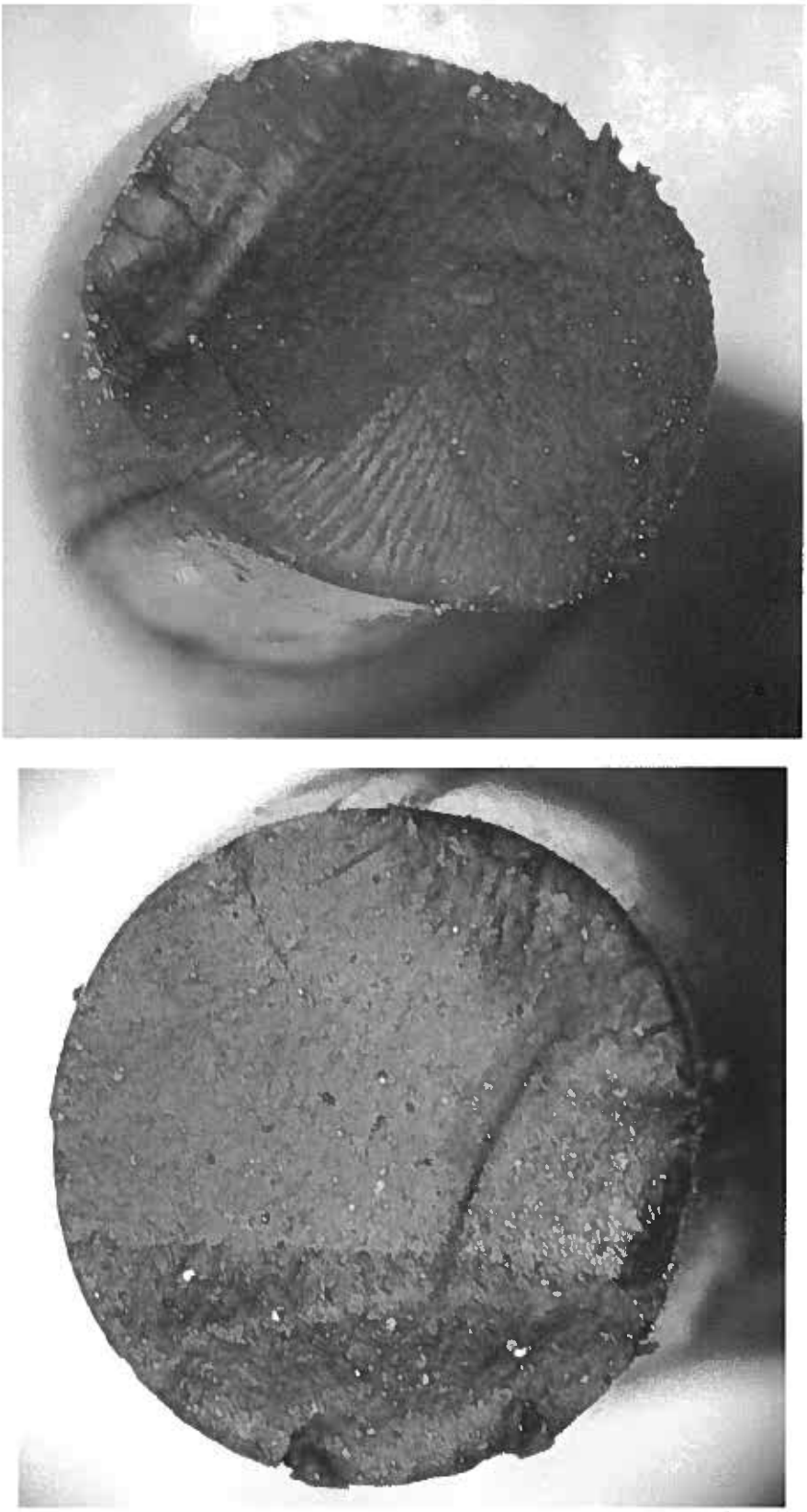


Figure 15: View of "free" ends of retrieved O-ring showing evidence of stepwise cutting.

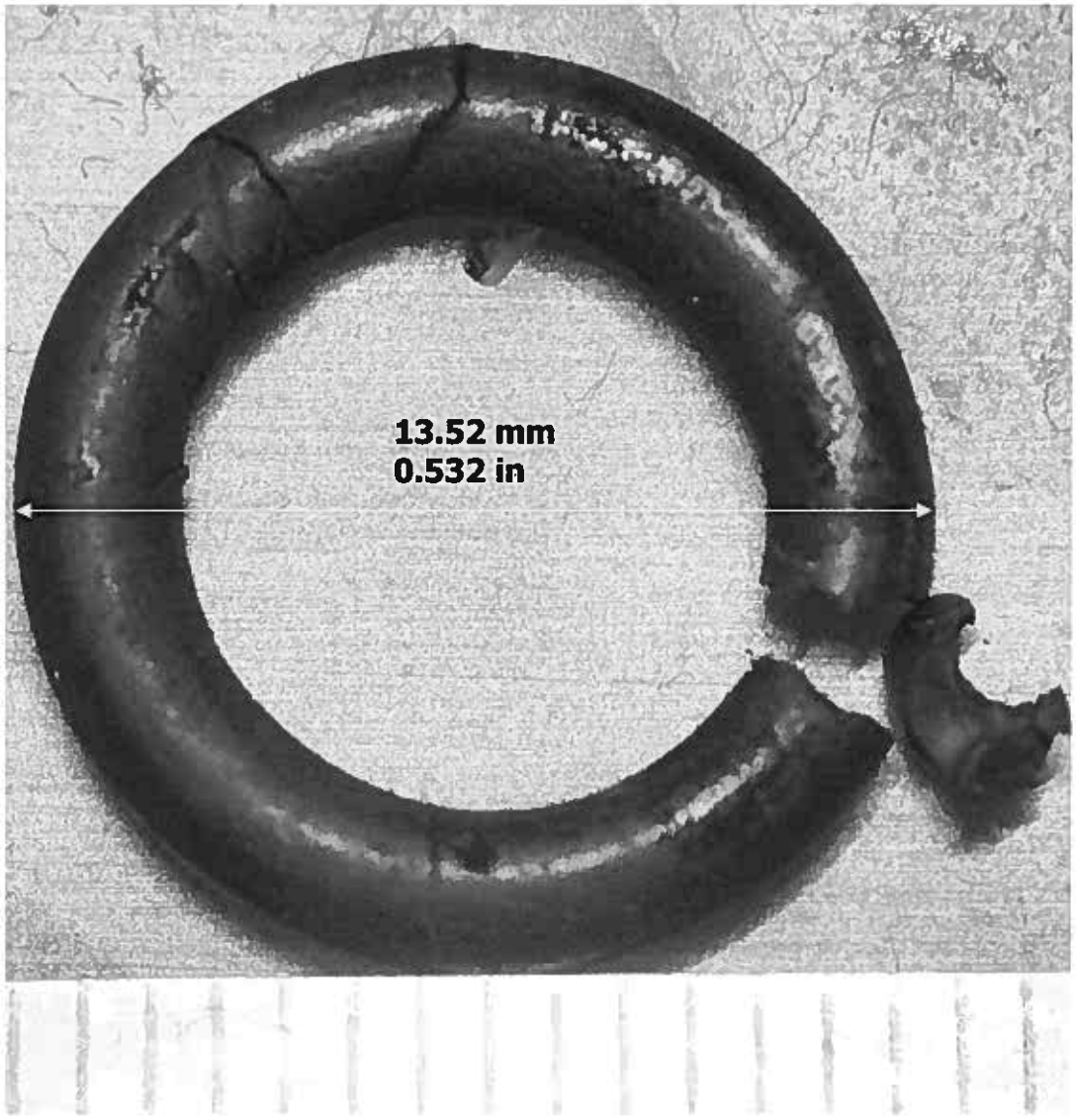


Figure 16: Reassembled O-ring. Estimation of outer diameter.

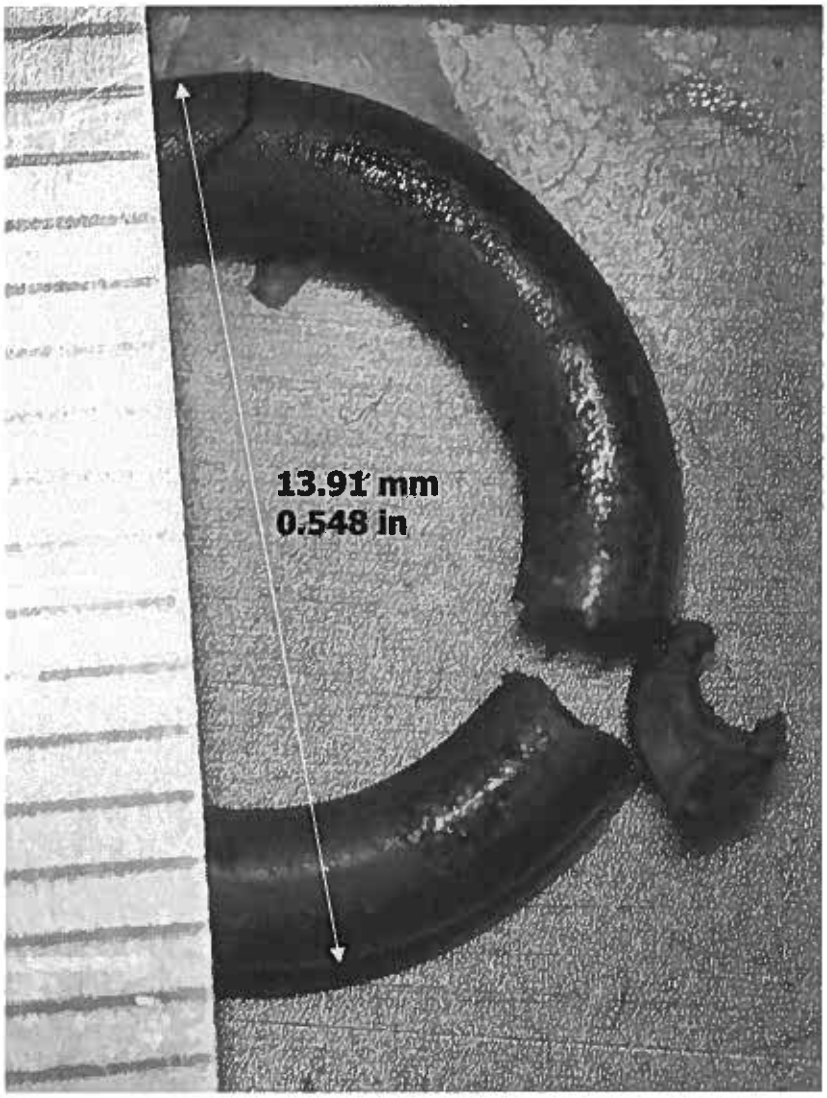


Figure 17: Reassembled O-ring. Estimation of outer diameter.

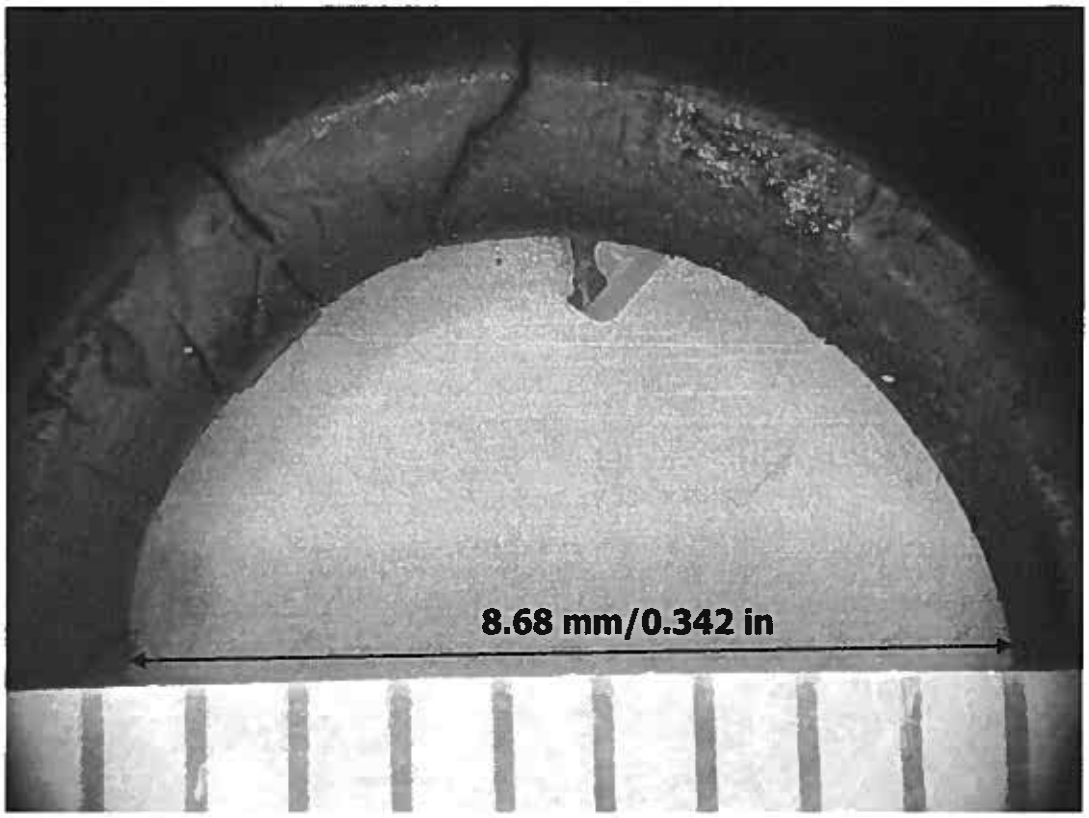


Figure 18: Reassembled O-ring. Estimation of inner diameter.

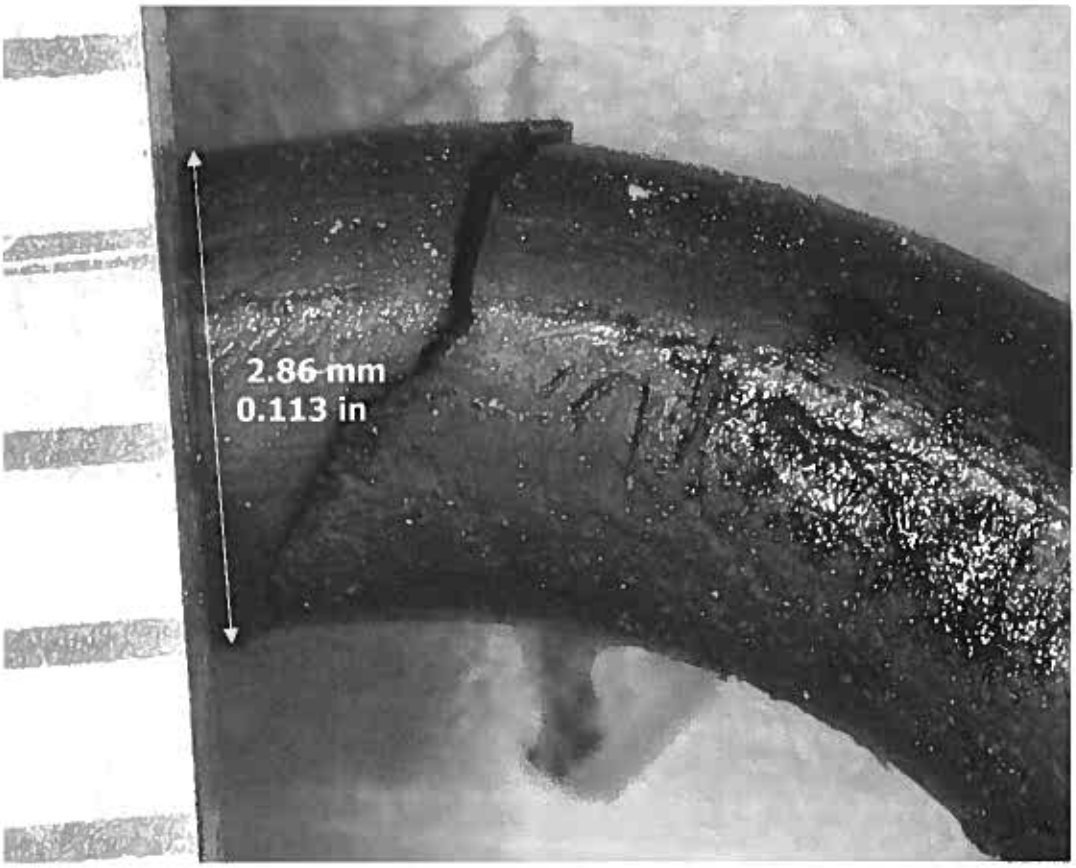


Figure 19: Reassembled O-ring. Estimation of O-ring thickness.

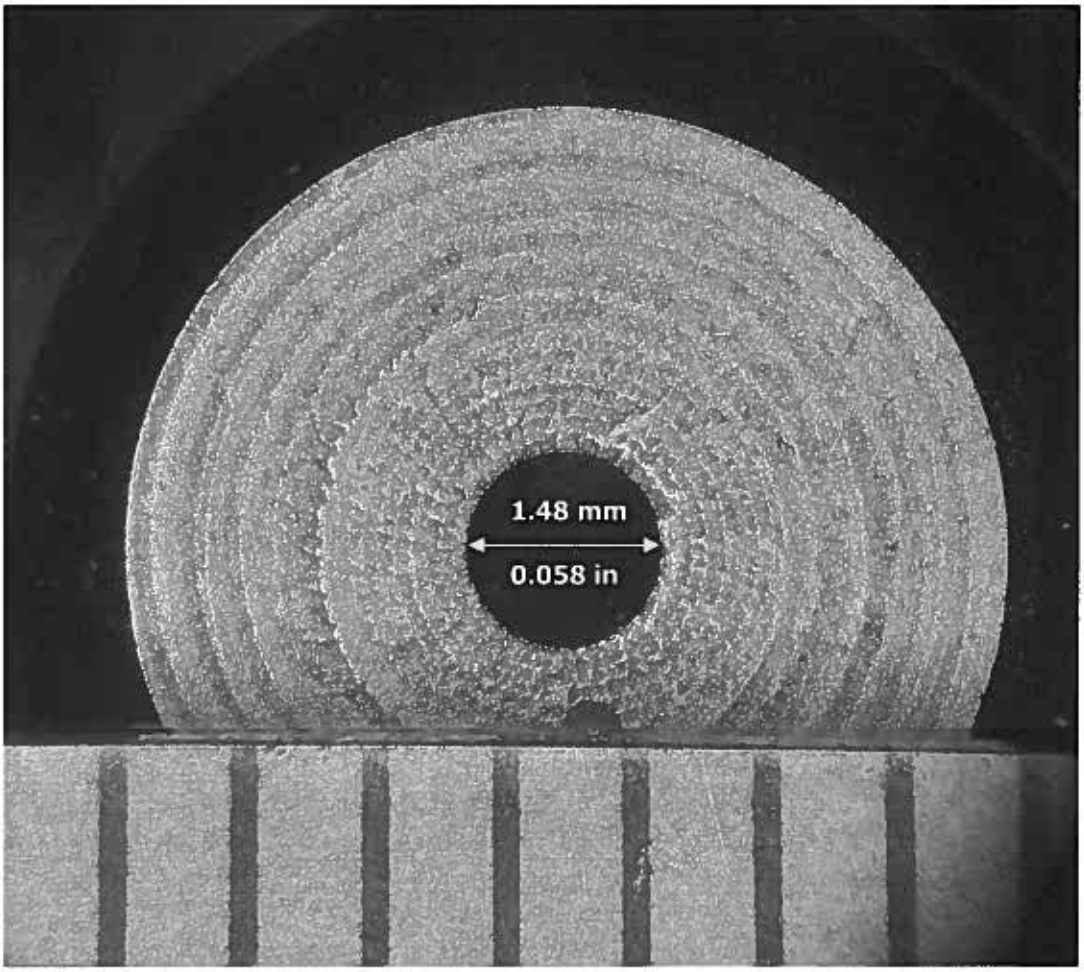


Figure 20: Estimation of valve cone orifice dimension.

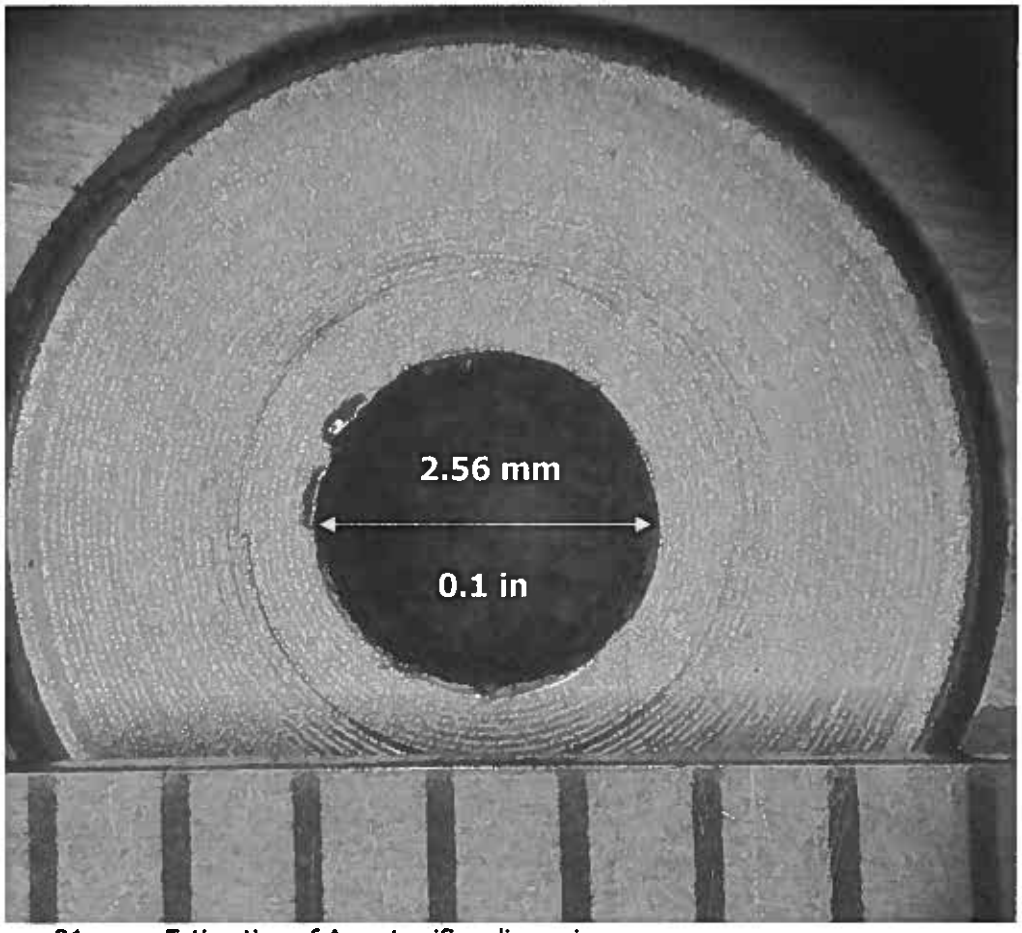
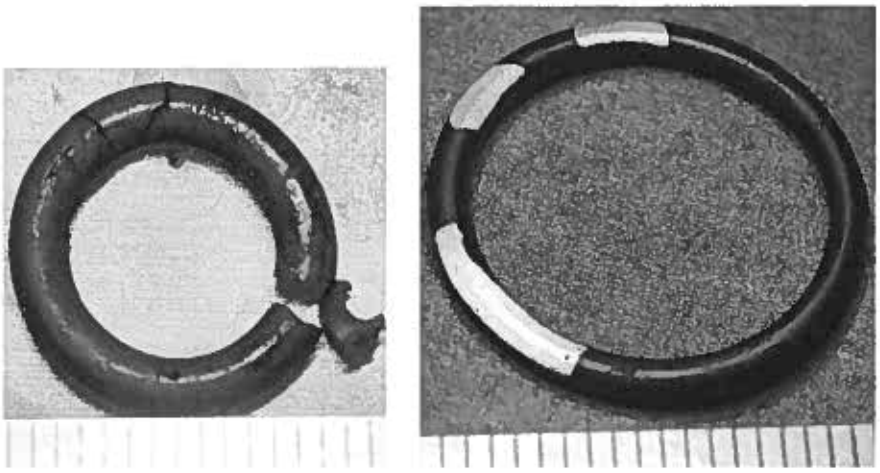


Figure 21: Estimation of A port orifice dimension.



Sample 1 Sample 2

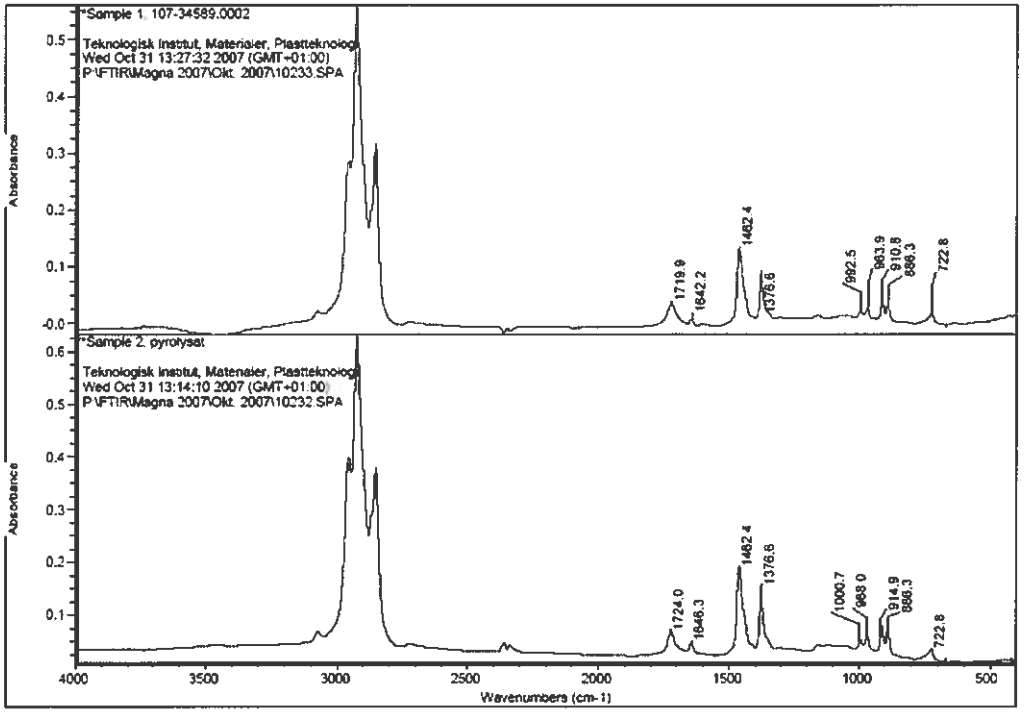


Figure 22: FTIR analyses of O-ring samples 1 and 2.

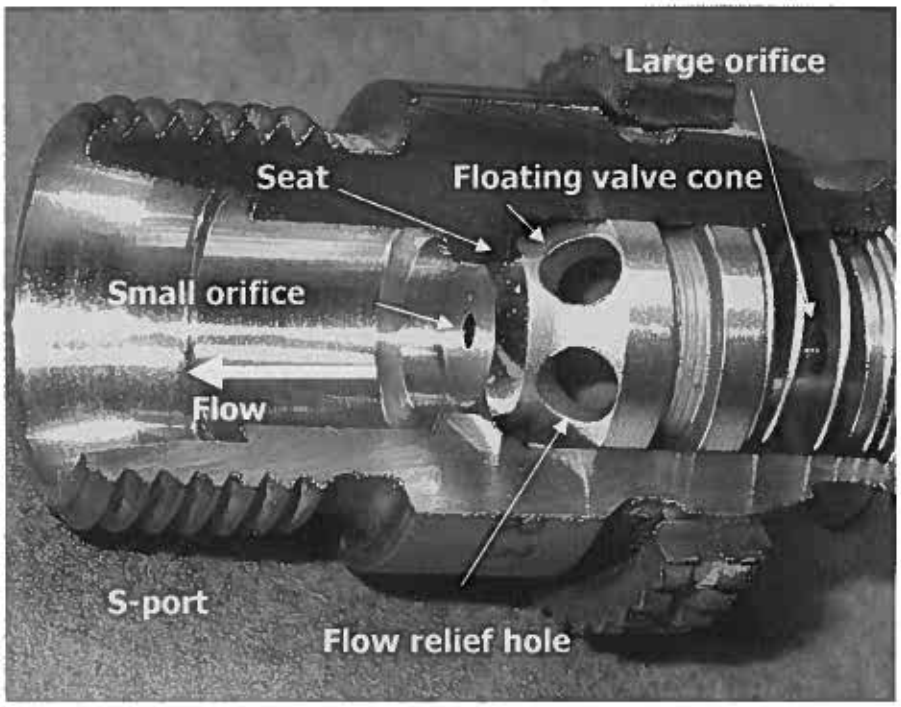


Figure 23: Cut-away view of back flow restrictor valve in closed position (during landing gear extension).

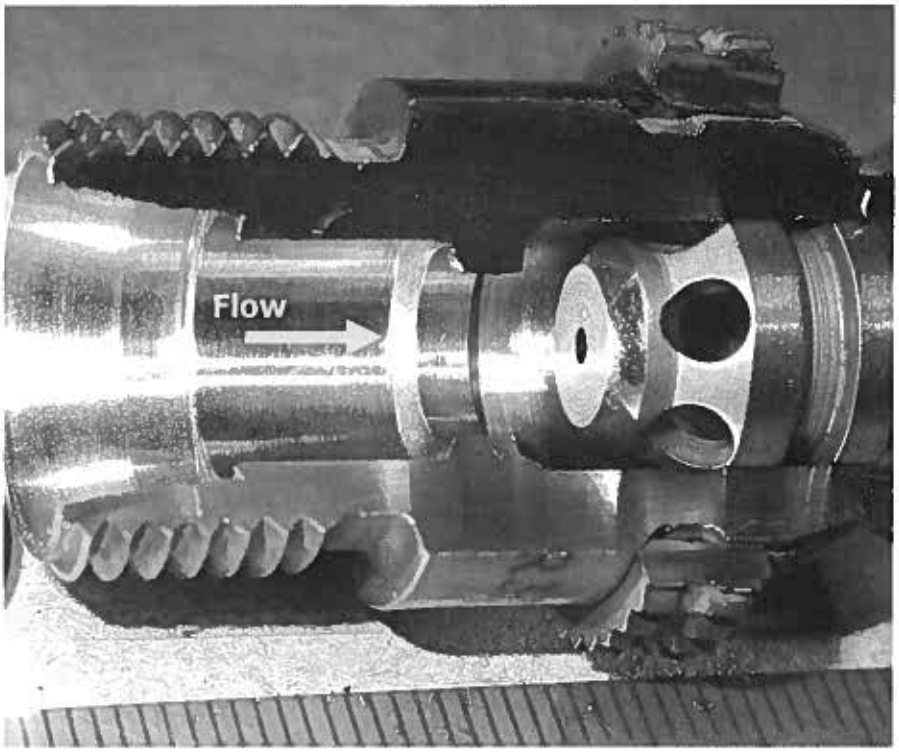


Figure 24: Cut-away view of back flow restrictor valve in open position (during landing gear retraction).

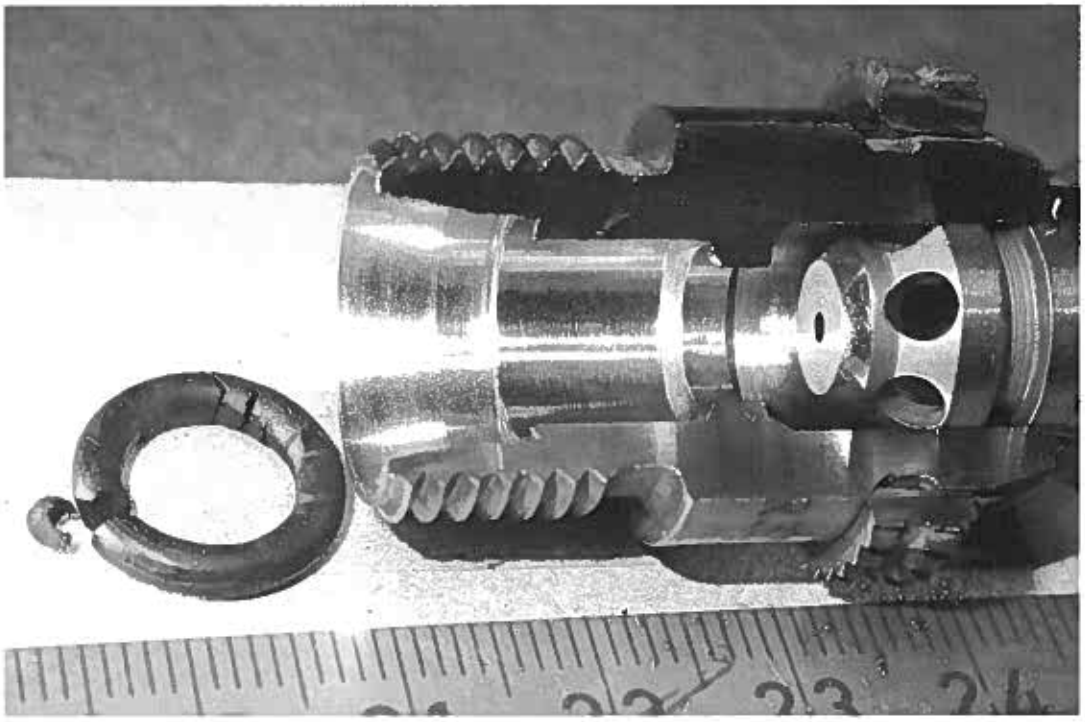


Figure 25: Comparative view of flow restrictor and O-ring.

Appendix E

Service Bulletin No. 84-32-54

BOMBARDIER

deHAVILLAND DASH 8

SERVICE BULLETIN

Customer Support

ATA SYSTEM: 3231 NUMBER: 84-32-54

SUBJECT: Landing Gear – Solenoid Sequence Valve (SSV) – Inspection of Filter and Introduction of new Configuration – ModSum 4-126410

1. PLANNING INFORMATION

A. Effectivity

Aircraft Affected:

In-Service: DHC-8 Aircraft Models 401 and 402 Serial Numbers 4001 thru 4229.
This Service Bulletin is recommended to be done concurrently with In-Service-Engineering ModSum IS4Q3200033.

NOTE: The instructions in this Service Bulletin are only applicable to the systems and parts installed at the time of delivery on the aircraft or as changed by Bombardier Aerospace Service Bulletin(s). Before you do this bulletin, examine all STC or equivalent action changes to make sure this bulletin can be completed.

Spares Affected:

None

B. Reason

Refer to enclosed Goodrich Service Bulletin 48302-32-58.

C. Description

The procedures in this service bulletin give the instructions to do the tasks that follow:

- the aircraft is jacked up
- the existing solenoid sequence valves are removed and inspected
- an operational test of the landing gear is done
- the aircraft is lowered
- close out.

D. Compliance

Bombardier Inc. recommends incorporation of ModSum 4-126410 at the earliest opportunity unless otherwise directed by the operator's airworthiness authority.

E. Approval

The technical content of this service bulletin has been approved under the authority of the Transport Canada Civil Aviation (TCCA) Design Approval Organization No: DAO #93-Q-02.

F. Manpower

It will take an estimated 3.5 man-hours to complete this service bulletin. The breakdown of the man-hours is shown in the table that follows:

TASK	MAN-HOURS
Job Set-Up	0.50
Procedure	2.00
Test / RTS	0.50
Close-Out	0.50

G. Material - Price and Availability

Refer to enclosed Goodrich Service Bulletin 48302-32-58.

H. Tooling – Price and Availability

None

I. Weight and Balance

None

J. Electrical Load Data

Not affected

K. Publications Affected

Dash 8 Illustrated Parts Catalogue ..... PSM 1–84–4

ModSums Manual ..... PSM 1–84–12

L. References

The initial issue of this service bulletin was prepared to the engineering drawings and related data that follows:

ModSum 4Q126410 Rev. 'A'

ModSum 4–126410 Rev. 'A'

PCA 41887 Revision –– (for internal reference only)

2. MATERIAL INFORMATION

A. Parts Required Per Aircraft

Refer to enclosed Goodrich Service Bulletin 48302–32–58.

NOTE: This service bulletin is self–contained (illustrated). No drawings will be supplied.

B. Parts Required to Modify Spares

None

C. Special Tools and Equipment Required

None

D. Existing Parts Accountability

None

3. ACCOMPLISHMENT INSTRUCTIONS

A. Job Set-Up

(1) Remove all electrical power from aircraft.

(2) Jack the aircraft. Refer to Maintenance Manual Task 07-10-00-582-801.

B. Procedure

(1) Remove Solenoid Sequence Valve (SSV) from the right and left hand nacelle near the MLG door mechanisms. Refer to Maintenance Manual Task 32-31-41-000-801.

(2) Remove Solenoid Sequence Valve (SSV) from the nose landing gear. Refer to Maintenance Manual Task 32-31-71-000-801.

(3) Do the special inspection of the Solenoid Sequence Valves has described in enclosed Goodrich Service Bulletin 48302-32-58.

(4) Install Solenoid Sequence Valve (SSV) to the right and left hand nacelle. Refer to Maintenance Manual Task 32-31-41-400-801.

(5) Install Solenoid Sequence Valve (SSV) to the nose landing gear. Refer to Maintenance Manual Task 32-31-71-400-801.

C. Close Out

(1) Remove all tools and equipment from the work area.

(2) Do an operational test of the landing gear primary extension and retraction system. Refer to Maintenance Manual Task 32-31-00-710-801.

(3) Lower the aircraft and remove all the jacks. Refer to Maintenance Manual Task 07-10-00-582-801.

(4) On incorporation of this ModSum, make an entry that conforms to local regulatory requirements in the applicable logbook(s). Enter component serial numbers if applicable. Enter this ModSum number only after complete and functional incorporation of all work defined in this service bulletin.

GOODRICH

SERVICE BULLETIN

DASH 8 Q400 – SOLENOID SEQUENCE VALVE (SSV) –
INSPECTION OF FILTER/INTRODUCTION OF NEW CONFIGURATION

SECTION I - PLANNING INFORMATION

1. **EFFECTIVITY**

   Solenoid Sequence Valve PN 48302-3 SN FAH0001 through FAH0687

2. **REASON**

   There is potential for existing filter failure and possible packing liberation at the SSV UP and DN ports.

   A new SSV configuration is introduced with a new design filter fitting.

3. **DESCRIPTION**

   The unions are removed from the UP and DN port on the SSV and the existing filter in the port is inspected in-situ (without removal). SSVs with damaged (distorted) but complete filters are reworked. SSVs with incomplete filters require no further action and are returned for repair.

4. **COMPLIANCE**

   Goodrich Landing Gear in concurrence with the aircraft manufacturer, recommends accomplishment of this service bulletin at operator's earliest convenience.

5. **APPROVAL**

   This bulletin is Transport Canada approved by Mr. M. Perrella, DE#3, Design Approval Organisation DAO # 94-0-01.

6. **MANPOWER**

   Approximately 1.0 man-hour is required to incorporate this service bulletin.

7. **MATERIAL COST AND AVAILABILITY**

   Filter fittings PN FA151274-001 are available free of charge from:

   Goodrich Landing Gear,
   1400 South Service Rd,
   Oakville, Ontario,
   Canada L6L 5Y7

   Tele: 1-905-827-7777
   Fax: 1-905-825-1583

   Attention: Spares Department

8. **TOOLING**

   NA

9. **WEIGHT AND BALANCE**

   NA

Goodrich Landing Gear Division
Goodrich Aerospace Canada Ltd.

10. ELECTRICAL LOAD DATA

NA

11. REFERENCES

NA

12. OTHER PUBLICATIONS AFFECTED

N/A

SECTION II - ACCOMPLISHMENT INSTRUCTIONS

1. Disassembly (Ref. Fig. 1)

A. Cut lockwire, remove and discard union MS21902J6 and packing NAS1612-6 at UP and DN ports on SSV.

2. Inspection (Ref. Fig. 1)

A. Inspect SSV filter and packing in each port for any evidence of missing material.

B. If inspection reveals severe damage to filter and/or packing (missing material) or filter and/or packing not present, return SSV to Goodrich Landing Gear for repair (Ref. Section I, Paragraph 7).

NOTE: Refer to BA documentation for aircraft system flushing instructions.

C. If inspection reveals no damage or only slight damage but no missing material from filter or packing:

(1) Remove complete filter and packing from UP and DN port on SSV and make sure area is clean.

NOTE: Complete filters may have damage (distortion) but must have no missing material.

3. Assembly (Ref. Fig. 1)

A. Lubricate new packing NAS1612-6 and new filter fitting FA151274-001 threads with Skydrol. Install packing on filter fitting.

B. Install filter fitting with packing in UP and DN port on SSV.

C. Torque filter fitting to 160 – 180 lbf.in. and safety with lockwire.

4. Reidentification (Ref. Fig. 1)

CAUTION: DO NOT LETTER STAMP NAMEPLATE ON SSV. THIS CAN DAMAGE THE SSV.

A. For SN FAH001 through FAH0643.

(1) Vibropeen 'B' in the MODS INCORP field on nameplate.

(2) Rubber stamp SB 32-58 at a suitable location near nameplate and apply a clear polyurethane topcoat (Akzo Nobel item 683-3-2, 683-3-9 or equivalent).

Goodrich Landing Gear Division
Goodrich Aerospace Canada Ltd.

B. For SN FAH0644 through FAH0687

NOTE: Before removal of nameplate make a record of serial number for transfer to replacement nameplate.

(1) Remove old nameplate and wipe surface clean.

(2) Apply new nameplate PN IFA01138-5 with epoxy adhesive (3M item 2216B/A or equivalent).

(3) Use the vibropeen method, identify SSV as PN 48302-5 on the new nameplate. Use the vibropeen method and transfer the serial number to the new nameplate.

(4) Apply a clear polyurethane topcoat (Akzo Nobel item 683-3-2, 683-3-9 or equivalent).

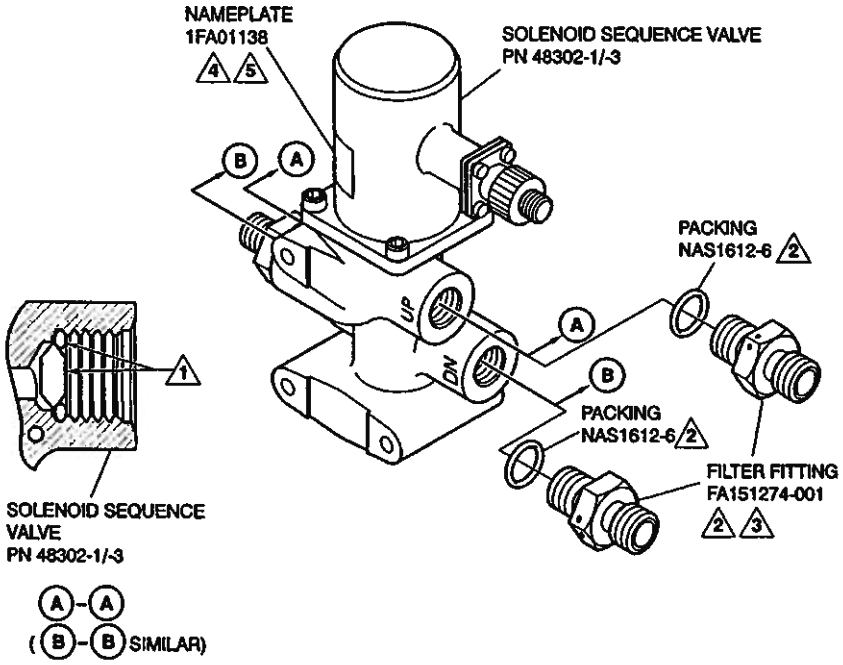
SECTION III - MATERIAL INFORMATION

New P/N	Qty*	Keyword	Old P/N	Qty	Disposition
FA151274-001	2	Fitting, Filter	MS21902J6	2	Discard
**IFA01138-5	1	Nameplate	IFA01138-3	1	Discard
NAS1612-6	2	Packing	NAS1612-6	2	Discard

* Qty per landing gear

** Required for SSV SN FAH0644 through FAH0687 only

Goodrich Landing Gear Division
Goodrich Aerospace Canada Ltd.



NOTES

1. INSPECT FILTER AND PACKING FOR ANY EVIDENCE OF MISSING MATERIAL.
2. LUBRICATE NEW PACKING AND NEW FILTER FITTING THREADS WITH SKYDROL.
3. TORQUE TO 160-180 LBF-IN. AND SAFETY WITH LOCKWIRE.
4. FOR SSV WITH SERIAL NUMBER FAH0001 - FAH0643; VIBROPEEN 'B' IN THE 'MODS INCORP' FIELD ON NAMEPLATE.
   RUBBER STAMP SB 32-58 AT A SUITABLE LOCATION NEAR NAMEPLATE. APPLY A CLEAR TOPCOAT.
5. FOR SSV WITH SERIAL NUMBER FAH0644 AND SUBS; APPLY NEW NAMEPLATE WITH EPOXY ADHESIVE 2216B/A.

SB48302-32-58-1

Solenoid Sequence Valve – Inspection of Filter and Replacement of Fitting

Figure 1

BOMBARDIER

SERVICE BULLETIN (SB) – RECORD OF INCORPORATION – Q SERIES DASH 8 AIRCRAFT

To: Partner Data Co–Ordinator (Toronto)
Bombardier Aerospace Regional Aircraft
Phone: (1) 416 375 3534
Facsimile: (1) 416 375 4538
E–mail: partner.data.ra.techpubs@aero.bombardier.com

From: _____
Company: _____
Phone: _____ **Extn:** _____
Facsimile: _____ **Date:** _____
E–mail: _____

The data that you provide below will help us record the incorporation of this modsum and the aircraft effectivity in the maintenance manual.

Operator: _____ **Service Bulletin:** _____ **Revision:** _____

Aircraft Serial Number: _____ Model Number: _____ Date Bulletin Completed: _____

Aircraft Serial Number: _____ Model Number: _____ Date Bulletin Completed: _____

Aircraft Serial Number: _____ Model Number: _____ Date Bulletin Completed: _____

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Aircraft Serial Number: _____ Model Number: _____ Date Bulletin Completed: _____

Fax this sheet to (1) 416 375 4538 or PDF to:

partner.data.ra.techpubs@aero.bombardier.com

BOMBARDIER

SERVICE BULLETIN (SB) COMMENT SHEET – Q SERIES DASH 8 AIRCRAFT

To: SB Focal (Toronto) "Bob Barriault"	**From:** _____
Bombardier Aerospace Regional Aircraft	**Company:** _____
Phone: (1) 416 375 4078	**Phone:** _____ **Extn:** _____
Facsimile: (1) 416 375 4538	**Facsimile:** _____ **Date:** _____
E-mail: bob.barriault@aero.bombardier.com	**E-mail:** _____

Select appropriate box(es) and add comments or suggestions you would like us to know that may enhance the quality of our service bulletins.

Service Bulletin: _____ **Revision:** _____ **ModSum:** _____

1. PLANNING INFORMATION

☐ Effectivity ☐ Reason ☐ Description ☐ Compliance

☐ Approval ☐ Manpower ☐ Material ☐ Weight and Balance

☐ Electrical Load ☐ Tooling ☐ References ☐ Publications Affected

2. MATERIAL INFORMATION

☐ Kit Content ☐ Special Tools/Equipment ☐ Parts to Modify Spares

☐ Consumables ☐ Disposition of Existing Parts ☐ Other _____

3. ACCOMPLISHMENT INSTRUCTIONS

☐ Job Set–Up ☐ Procedure ☐ Close–Out ☐ Test

☐ Illustration(s) ☐ Other _____

4. COMMENTS, REMARKS, SUGGESTIONS

_____

_____

_____

_____

_____

Fax this sheet to (1) 416 375 4538 or PDF to:

bob.barriault@aero.bombardier.com

Nov 2006

Appendix F

Modification Summary Package No. IS4Q3200033

BOMBARDIER

MODIFICATION SUMMARY PACKAGE

1 CERTIFYING AUTHORITY NO.	2 MODEL / TYPE	3 MODSUM NO. COMPLETE ☐	4 SHEET
N/A	DHC-8-400	IS4Q3200033	1 OF 7

5 CURRENT REVISION												
	A	-B	-C									

6 PRIME DESIGN ACTIVITY

BOMBARDIER INC. ☐ 3AB48

BOMBARDIER INC., MONTRÉAL ☐ 88308 LEARJET INC. ☐ 24210

BOMBARDIER INC., DOWNSVIEW ☒ 71867 SHORT BROTHERS PLC ☐ K4585

7 SUPPLIER NAME AND CAGE CODE

8 TITLE

In-Line Filter Installation, MLG Actuator, Retract Hose Ass'y.

10 APPROVED INITIATING DOCUMENT

N/A	N/A

9 MAJOR ASSY OR COMPONENT AFFECTED

Main Landing Gear, Retract Actuator, hydraulic hose assembly to the retract port.

BASKET MODSUM

☐ SEE INDIVIDUAL AUTH DOCUMENTS

11 DESCRIPTION OF MODIFICATION

An In-line filter / screen (P/N 31001LD08E006) will be introduced to the landing gear hydraulic system. This will reduce the possibility of large piece/s of FOD becoming lodged in orifices within the system. This modification is applicable to both the left and right sides of the airplane, and both sides should be completed for the modsum to be complete.

12 REASON FOR MODIFICATION

This is an additional precautionary measure which has been implemented based upon preliminary findings reported by the DAIB in their investigation of Q400 flight SK2867 landing gear incident at Copenhagen Airport , October 27/07.

13 ENGINEERING REMARKS

This Modsum is for in-service aircraft only and will not be incorporated on production aircraft.

APPROVED BY: #239 DATE: 15 NOV 2007

APPROVED IN ACCORDANCE WITH TRANSPORT CANADA DAO NO. 93-Q-02

14 RELATED MODSUM

4Y122420

16 PRODUCTION EFFECTIVITY

N/A

15 ENGINEERING VALIDITY

4003-4999

17 RECOMMENDED SERVICE EFFECTIVITY

4003, 4004, 4006, 4008 to 4016, 4016 to ~~4990~~ 4187 (B)

18 CLASS	19 AIRWORTHINESS CLASSIFICATION
C	LEVEL 1** ☐ LEVEL 2* ☒ LEVEL 3 ☐

**DCCP OR *ACRL & SOC OR FAA FORM 8110-3 REQUIRED

BOMBARDIER

MODIFICATION SUMMARY PACKAGE

AUTHORIZATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	2

5 CURRENT REVISION	A	- B	- C	
21 ORIGINATOR	R. Daukant, 13/11/07	B Caudell 2007 NOV 14	R. DAUKANT, 22 NOV 07	
22 DESIGN	M. Babin	2007 NOV -15	G Wilkins 22 Nov 2007	
23 DESIGN AUTHORITY	A. Waller 15 NOV 2007	15 NOV 2007 CIPRIAN CHEORGHIU	G Houston 22 Nov 2007. G Houston,	
24 ~~PP&C~~ Release	M. Thornton 2007/11/15	M. Thornton 2007/11/15	M. Thornton 2007/11/23	
5 CURRENT REVISION				
21 ORIGINATOR				
22 DESIGN				
23 DESIGN AUTHORITY				
24 PP&C				

25 REVISION DESCRIPTION

Initial Issue, Rev 'A'

B: EFFECTIVITY RESTRICTED TO 4187, WAS TO 4990. FOR PRODUCTION IMPLEMENTATION REFER TO 4~~X~~/22 420.

C: CORRECTED FILTER P/N, TO: 3100IL008E006, FROM: 3100IL008E006, ON SHEET 5 (IN GOODRICH SCR, PG 2 OF 4).

BOMBARDIER

MODIFICATION SUMMARY PACKAGE

C MODSUM NO.	D SHEET
15483200033	2.1

AIRWORTHINESS CLASSIFICATION

H REV	V AIRWORTHINESS CLASSIFICATION							
-A	**LEVEL 1	-						
	*LEVEL 2	✓						
	LEVEL 3	-						
W DISCIPLINE CODE		LDC						
X CERT AUTH DES REP SIGNATURE		[illegible]						
Y CERT AUTH DES REP NAME		233						
H REV	V AIRWORTHINESS CLASSIFICATION							
-B	**LEVEL 1	-						
	*LEVEL 2	-						
	LEVEL 3	-						
W DISCIPLINE CODE		LG						
X CERT AUTH DES REP SIGNATURE		G Houston						
Y CERT AUTH DES REP NAME		Houston						
H REV	V AIRWORTHINESS CLASSIFICATION							
-C	**LEVEL 1	-						
	*LEVEL 2	-						
	LEVEL 3	✓						
W DISCIPLINE CODE		LG						
X CERT AUTH DES REP SIGNATURE		G Houston						
Y CERT AUTH DES REP NAME		G HOUSTON						
H REV	V AIRWORTHINESS CLASSIFICATION							
	**LEVEL 1							
	*LEVEL 2							
	LEVEL 3							
W DISCIPLINE CODE								
X CERT AUTH DES REP SIGNATURE								
Y CERT AUTH DES REP NAME								
H REV	V AIRWORTHINESS CLASSIFICATION							
	**LEVEL 1							
	*LEVEL 2							
	LEVEL 3							
W DISCIPLINE CODE								
X CERT AUTH DES REP SIGNATURE								
Y CERT AUTH DES REP NAME								
H REV	V AIRWORTHINESS CLASSIFICATION							
	**LEVEL 1							
	*LEVEL 2							
	LEVEL 3							
W DISCIPLINE CODE								
X CERT AUTH DES REP SIGNATURE								
Y CERT AUTH DES REP NAME								

AFTER TYPE APPROVAL,**DCCP OR *ACRL & SOC OR FAA FORM 8110-3 REQUIRED

BOMBARDIER

MODIFICATION SUMMARY PACKAGE

CONTINUATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	3

5 CURRENT REVISION	A	-B	-C									

References:

Parts Required:

QTY per A/C	Description	P/N
2	Strainer, High Pressure, 1/2" Tube, .006" Hole	31001LD08E006

(Parts available from: BFGoodrich, Landing Gear Division, 1400 South Service Road W. Oakville, On, L6L 5Y7, Canada. Phone: 905-827-7777, Fax: 905-825-1583)

Special Tools:

None

Procedure:

1. Note that this modification is applicable to both the LH MLG, and the RH MLG, and both sides should be completed for the modsum to be complete.
2. Prepare the aircraft as per MLG Retract Actuator removal, Ref. AMM TASK 32-31-11-000-801, Removal of the MLG Retraction Actuator (but do not remove the actuator).
3. Disconnect the MLG retract hose ass'y (P/N 46455-13) from the MLG actuator port (Ref. Goodrich SCR 123-07).
4. Disconnect the MLG retract hose ass'y (P/N 46455-13) from the aircraft bulkhead union (Ref. Goodrich SCR 123-07).
5. Flush the hose ass'y (P/N 46455-13) with clean hydraulic fluid (Ref. AMM, Chapter 29).
6. Inspect the tube and sealing surfaces for damage and rectify as necessary.
7. Inspect the restrictor fitting on the actuator retract port for FOD, and remove as necessary.
8. Install a new in-line filter (P/N 31001LD08E006) into the hydraulic hose with the filter cone pointing into the hose (Ref. Goodrich SCR 123-07).
9. Re-attach the hose ass'y to the actuator, and to the aircraft bulkhead union, torque, and close out as per AMM TASK 32-31-11-400-801, Installation of the MLG Retraction Actuator.

General Notes:

1. All work must be accomplished and signed off by qualified personnel as required by local regulatory authorities.
2. This rework is limited to the components as specified in IS4Q3200033.
3. Weight and Balance - No Change
4. Electrical Load Analysis - No Change

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MODIFICATION SUMMARY PACKAGE

CONTINUATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	4

5 CURRENT REVISION												
	A	-B	- C									

PRINT DATE 11/12/07 TIME 2:47 PM

GOODRICH	SERVICE CONCESSION REQUEST			SCR NUMBER	REV	PROG
				SCR 123-07	NC	2130
	AIRCRAFT DETAILS			INDICATE IF		
EVENT DATE (Y/M/D)	AIRLINE	A/C S/N	TSN	CSN	A.O.G. ☒	
ANY	ALL	4001 AND SUB				

ITEM	PART NO.	NAME	S/N	TSN	CSN
N.H.A ⇨					
N.H.A ⇨	46350-13	YOKE ASSEMBLY	ALL		
PART ⇨	46455-13	HYDRAULIC HOSE	ALL		

LIMITED FLIGHT REQUESTED	REQUEST CATEGORY	AFFECTED SYSTEM
YES ☐ NO ☒ (IF YES, AUTHORIZED ENGINEER SIGNATURE REQUIRED)	IN-SERVICE PROBLEM ☒	MLG ☒ BRAKING ☐ NLG ☐ STEERING ☐ WLG ☐ RET / EXT ☒ BLG ☐ DRESSINGS ☐ FLTC ☐ OTHER ☐

INDICATE FC OR FH LIMITATION:	DISPOSITION SUMMARY		PREVIOUS CONCESSIONS GRANTED FOR THIS SERIAL NUMBER COMPONENT
FC* _____ *WHICH EVER COMES FIRST	NORMAL USE AFTER REPAIR	☒	NONE
IF ONLY FC IS SPECIFIED INDICATE FH NOT RELEVANT ☐	LIMITED SERVICE	☐	
OR SPECIFY LIMITATION IN TERMS OF AIRCRAFT CHECKS: A ☐ C ☐ L ☐ X	TEMPORARY REPAIR	☐	
	REMOVE & REPAIR	☐	
	REPLACE PART	☐	

SCR RAISED BY	DATE RAISED
S.HEALEY	2007/11/06

ITEM	PROBLEM DESCRIPTION
1	THE INTENT OF THIS SCR IS TO INTRODUCE AN IN-LINE FILTER / SCREEN TO THE MAIN LANDING GEAR HYDRAULIC SYSTEM. THIS WILL REDUCE THE POSSIBILITY OF LARGE PIECE/S OF FOD BECOMING LODGED IN ORIFICES WITHIN THE SYSTEM. THIS SCR IS APPLICABLE TO BOTH THE LEFT AND RIGHT SIDES OF THE AIRPLANE. THIS IS AN ADDITIONAL PRECAUTIONARY MEASURE WHICH HAS BEEN IMPLEMENTED BASED UPON PRELIMINARY FINDINGS REPORTED BY THE DAIB IN THEIR INVESTIGATION OF THE Q400 LANDING GEAR INCIDENT AT COPENHAGEN AIRPORT. OCTOBER 27/07.

REPORTED CAUSE OF PROBLEM:

ADDITIONAL INFORMATION ATTACHED ☐

SEE SHEET 2 AND SUBS FOR MORE INFORMATION

FORM NO. GLG-ENG-F-2767-03-07 REV A

BOMBARDIER

MODIFICATION SUMMARY PACKAGE

CONTINUATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	5

5 CURRENT REVISION	A	–B	–C									

PRINT DATE 11/07/07 TIME 1:53 PM

GOODRICH	SERVICE CONCESSION REQUEST	SCR NUMBER	REV	PROG
		SCR 123-07	NC	2130

AIRCRAFT DETAILS				INDICATE IF
EVENT DATE (Y/M/D)	AIRLINE	A/C S/N	TSN	CSN	A.O.G.
ANY	ALL	4001 AND SUB			

ITEM	PART NO.	NAME	S/N	TSN	CSN
N.H.A ⇨					
N.H.A ⇨	46350-13	YOKE ASSEMBLY	ALL		
PART ⇨	46455-13	HYDRAULIC HOSE	ALL		

ITEM	CONTINUATION SHEET / INSTRUCTIONS
	ENGINEERING NOTES THIS SCR FORMS THE BASIS FOR BOMBARDIER IS MODSUM IS4Q3200033, WHICH INSTALLS AN IN-LINE FILTER IN THE HYDRAULIC LINE TO THE MLG RETRACT ACTUATOR, RETRACTION PORT.
1.	1. SHUT DOWN HYDRAULIC SYSTEM 2, AND INSTALL MLG GROUND LOCK PINS.
	2. DISASSEMBLE AS REQUIRED, TO DISCONNECT MLG ACTUATOR HYDRAULIC HOSE ASSEMBLY P/N 46455-13 (SEE PAGE 3) FROM AIRCRAFT BULKHEAD UNION, AND FROM MLG ACTUATOR, RETRACT PORT, PER BOMBARDIER AMM REQUIREMENTS.
	3. FLUSH HYDRAULIC LINE P/N 46455-13 IN ACCORDANCE WITH AMM PROCEDURES.
	4. INSPECT - ENSURE NO DAMAGE TO HYDRAULIC SEALING SURFACES OF HYDRAULIC TUBE ASSEMBLY P/N 46455-13, AT BOTH ENDS.
	5. VISUALLY INSPECT RESTRICTOR FITTING TO ENSURE NO EVDIENCE OF F.O.D PRESENT
	6. REASSEMBLE HYDRAULIC HOSE TO RETRACT ACTUATOR, AND TORQUE PER BOMBARDIER AMM REQUIREMENTS.
C	7. INSTALL NEW IN-LINE FILTER P/N 31001LD08E006 INTO HYDRAULIC LINE, WITH TOP OF FILTER CONE POINTING INTO THE 46455-13 HOSE ASSEMBLY, SEE PAGE 4.
	8. REASSEMBLE RETRACT ACTUATOR HYDRAULIC HOSE P/N 46455-13 TO AIRCRAFT INTERFACE AND TORQUE IN ACCORDANCE WITH BOMBARDIER AMM REQUIREMENTS.
	9. PERFORM RETURN TO SERVICE TASKS AS REQUIRED IN THE BOMBARDIER AMM.
	C: Corrected filter P/N. Is: 31001LD08E006 Was: 310001LD08E006

DISPOSITION AUTHORIZATION

	NAME (PRINT)	SIGNATURE	DATE(Y/M/D)	AUTHORIZED ENGINEER OR HIGHER ENGINEERING AUTHORITY
ENGINEER	S.HEALEY		2007/11/07	
STRESS				
OTHER (SPECIFY)	M. PERRELLA		2007/11/07	DATE.
				Page 2 of 4

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BOMBARDIER

MODIFICATION SUMMARY PACKAGE

CONTINUATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	6

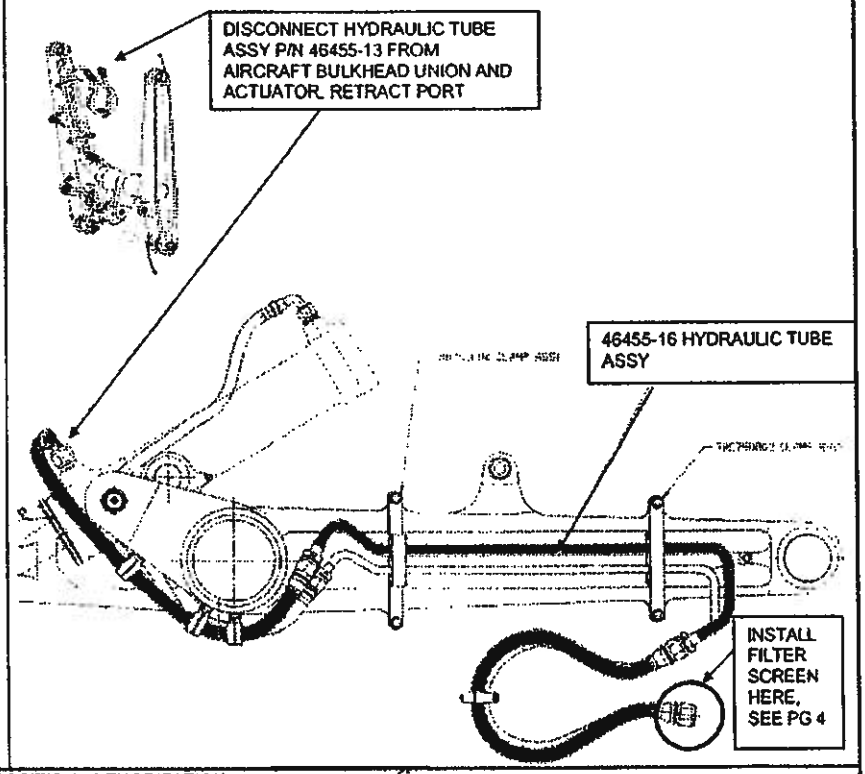
5 CURRENT REVISION												
	A	-B	-C									

PRINT DATE 11/07/07 TIME 1:53 PM

GOODRICH	SERVICE CONCESSION REQUEST			SCR NUMBER	REV	PROG
				SCR 123-07	NC	2130
	AIRCRAFT DETAILS			INDICATE IF		
EVENT DATE (Y/M/D)	AIRLINE	A/C S/N	TSN	CSN	A.O.G.	
ANY	ALL	4001 AND SUB				

ITEM	PART NO.	NAME	S/N	TSN	CSN
N.H.A ⇨					
N.H.A ⇨	46350-13	YOKE ASSEMBLY	ALL		
PART ⇨	46455-13	HYDRAULIC HOSE	ALL		

INSTRUCTIONS / CONTINUATION SHEET



DISPOSITION AUTHORIZATION

	NAME (PRINT)	SIGNATURE	DATE(Y/M/D)	AUTHORIZED ENGINEER OR HIGHER ENGINEERING AUTHORITY
ENGINEERING	S HEALEY		2007/11/07	
STRESS				
OTHER (SPECIFY)	M. PERRELLA		2007/11/07	DATE
				Page 3 of 4

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BOMBARDIER

MODIFICATION SUMMARY PACKAGE

CONTINUATION SHEET

3 MODSUM NO.	4 SHEET
IS4Q3200033	7

5 CURRENT REVISION	A	-B	-C									

PRINT DATE 11/06/07 TIME 4:48 PM

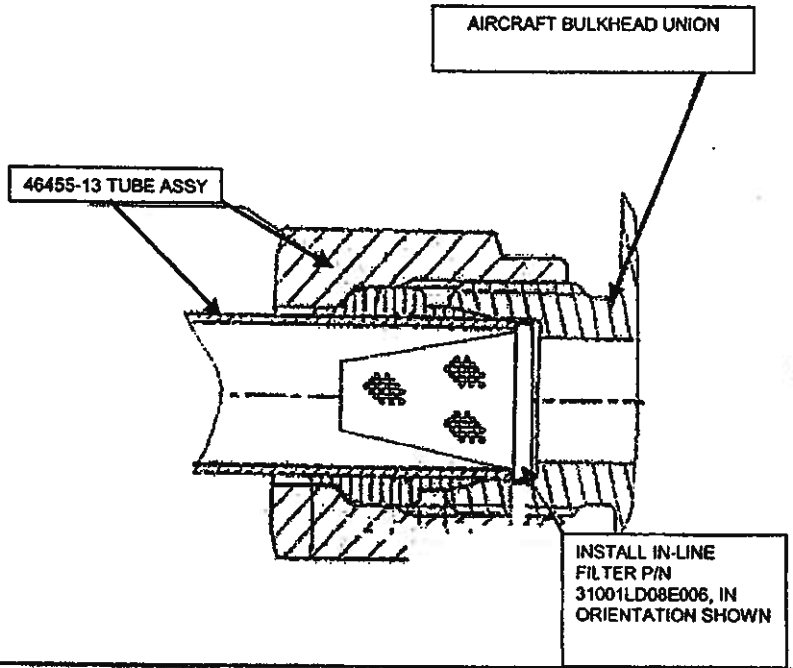
GOODRICH	SERVICE CONCESSION REQUEST	SCR NUMBER	REV	PROG
		SCR 123-07	NC	2130

AIRCRAFT DETAILS

EVENT DATE (Y/M/D)	AIRLINE	A/C S/N	TSN	CSN	INDICATE IF
ANY	ALL	4001 AND SUB			A.O.G. ☒

ITEM	PART NO.	NAME	S/N	TSN	CSN
N.H.A ⇨					
N.H.A ⇨	46350-13	YOKE ASSEMBLY	ALL		
PART ⇨	46455-13	HYDRAULIC HOSE	ALL		

INSTRUCTIONS / CONTINUATION SHEET



DISPOSITION AUTHORIZATION

	NAME (PRINT)	SIGNATURE	DATE(Y/M/D)	AUTHORIZED ENGINEER OR HIGHER ENGINEERING AUTHORITY
ENGINEERING	S.HEALEY		2007/11/07	
STRESS				
OTHER (SPECIFY)	M. PERRELLA		2007/11/07	DATE:
				Page 4 of 4

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