



**COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL**

Report IN-033/2018

Incident involving
a LEARJET-45XR aircraft,
registration CS-TFQ,
at the Seville Airport
on 7 July 2018



GOBIERNO
DE ESPAÑA

MINISTERIO
DE TRANSPORTES, MOVILIDAD
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Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

° ' "	Sexagesimal degrees, minutes and seconds
°C	Degrees centigrade
AD	Airworthiness directive
AEMET	Spain's National Weather Agency
AENA	Aeropuertos Españoles y Navegación Aérea
AFM	Aircraft flight manual
AIP	Aeronautical information publication
ANAC	Autoridade Nacional de Aviação Civil (Portugal)
AOG	Aircraft on ground
APP	Approach control
ARC	Authorized release certificate
ATC	Air traffic control
ATM	Air traffic management
ATPL	Airline transport pilot license
ATS	Air traffic system
CAS	Crew alerting system
CAT	Category
CAVOK	Clouds and visibility OK
CECOA	Airport coordination center
cm	Centimeters
CPL	Commercial pilot license
CPL(A)	Commercial pilot license (airplane)
CTA	Control area
DME	Distance measuring equipment
EASA	European Aviation Safety Agency
Ed.	Edition
EDP	Engine-driven pump
EICAS	Engine indicating/crew alerting system
FAA	Federal Aviation Administration of the United States
FFS	Firefighting service
FI (A)	Flight instructor (airplane)
FL	Flight level
ft	Feet
h	Hours
hPa	Hectopascals
IFR	Instrument flight rules
ILS	Instrument landing system
INAC	Instituto Nacional de Aviação Civil (Portugal)
IR	Instrument rating
kg	Kilograms

km	Kilometers
kt	Knots
l, l/h	Liters, liters/hour
LAPL	Light aircraft pilot license
LEMG	ICAO code Málaga Airport (Spain)
LEZL	ICAO code Seville Airport (Spain)
LOC	Localizer
LPCS	ICAO code Cascais Airport (Portugal)
m	Meters
mm	Millimeters
m ²	Square meters
MEP	Multi-engine piston rating
METAR	Meteorological aerodrome report
MFD	Multi-function display
Mhz	Megahertz
MT	Metric tons
NM	Nautical miles
PAPI	Precision approach path indicator
P/N	Part number
psi	Pounds per square inch
QNH	Altimeter subscale setting to obtain elevation when on the ground
QRH	Quick reference handbook
Rev.	Revision
SB(s)	Service bulletin
SEP	Single-engine piston rating
S/N	Serial number
TAF	Aerodrome forecast
TORA	Takeoff runway available
TWR	Aerodrome control tower
UTC	Coordinated universal time
VFR	Visual flight rules
VOR	VHF omni-directional range

Synopsis

Owner and operator:	Airjetsul, Sociedade de Meios Aéreos, Lda.
Aircraft:	LEARJET-45XR, registration CS-TFQ, S/N: 45-302
Date and time of incident:	Saturday, 7 July 2018 at 12:00 UTC
Site of incident:	Seville Airport – LEZL
Persons on board:	Two crew – three passengers
Type of flight:	Commercial air transport – Other – Air taxi
Phase of flight:	En route – Cruise
Flight rules:	IFR
Date of approval:	28/10/2020

Summary of event

On Saturday, 7 July 2018, a LEARJET-45XR aircraft, registration CS-TFQ, took off from the Malaga-Costa del Sol Airport (LEMG, Malaga, Spain) en route to Cascais (Portugal).

During the flight, in the cruise phase, upon reaching FL320, with the aircraft some 11 km east of the Seville Airport, the crew noticed a significant loss of hydraulic fluid in the aircraft's main hydraulic system.

In light of the successive alarms displayed in the cockpit, with constantly decreasing hydraulic pressure readings, the crew decided to divert and make an emergency landing at the nearest airport. They requested clearance to divert to the Seville Airport, where they landed without further incident, although they did use the manual landing gear extension.

Neither the crew nor the passengers were injured.

The aircraft was not damaged.

The technical investigation revealed that the incident was caused by the loss of fluid from the main hydraulic system as the result of leaks that occurred, while in flight, through the electrical connector of the pressure switch with P/N 7629001004-001.

A contributing factor in the incident is the failure to implement SB ref. 45-29-17, dated 28 January 2013, from Bombardier, which recommended replacing the pressure switch

P/N 7629001004-001 with an improved version, P/N 6629101004-001 (S8 and S9), in order to reduce the probability of leaks and pressure drops in the system.

The report contains a recommendation addressed to the operator to have it establish the procedures required to evaluate the implementation of Service Bulletins that could jeopardize the airworthiness of its aircraft, and therefore air safety.

1. FACTUAL INFORMATION

1.1. History of the flight

On Saturday, 7 July 2018, a Bombardier Learjet 45XR, registration CS-TFQ and S/N 45-302, operated by Airjetsul, Sociedade de Meios Aéreos, Lda., took off from the airport of Malaga-Costa del Sol (LEMG) at 11:35 UTC en route to the municipal aerodrome of Cascais (LPCS) in Portugal, where it was based, with 2 pilots and 3 passengers on board. It was scheduled to arrive at 12:30 UTC.

According to the crew, they did not see any abnormalities or any leaks or spills of any kind during the pre-flight inspection.

After starting the flight, during the climbing, a white MAIN HYD QTY LO message was displayed in the CAS display area in the upper-right corner of the EICAS display.

While flying over the SVL VOR (Seville) in IFR at 12:00 UTC, already at the cruise altitude of FL320, an amber caution message, MAIN HYD PRESS, was shown on the EICAS. The wind was variable from 290° at 3 kt in CAVOK conditions.

The crew noticed that the engine-driven hydraulic pumps were cavitating, and the “HYD” (hydraulic system) synoptic page on the MFD showed large variations in the hydraulic fluid pressure. Both pumps cycled from amber to white to amber several times, until both turned amber in the diagram and the pressure fell continuously.

At that point, the crew decided to divert to LEZL, since it was the closest suitable airport.



Photograph 1: Incident aircraft

They contacted ATC, which gave them the levels and vectors needed to divert to LEZL, informing Seville APP of their situation.

The crew began to perform the "MAIN HYD PRESS" actions in the QRH procedure as per their testimonies.

They descended and at FL170, at an appropriate speed to lower the landing gear, tried firstly the landing gear extension according to normal ckecklist though no success, and secondly as per the free fall procedure.

According to crew's statements,since there was no hydraulic pressure in the system, they decided to make the approach to LEZL without flaps in order to have enough hydraulic fluid in the auxiliary system for the conventional brakes to work.

They made the visual approach to runway 27 and landed without further incident.

The brakes worked normally until the third time they were applied, on taxiway A1, where the system ran out of pressure. The emergency brakes were used. ATC informed them that the aircraft would be towed from that point on, since taxiing was no longer considered safe.

After a nearly two-hour wait, the airplane was towed to stand R39. While the aircraft was stopped on A1, the leak in the hydraulic system was confirmed visually, since hydraulic fluid had spilled, which was later cleaned up by the firefighters.

The aircraft was not damaged and all of its occupants disembarked normally. No one required medical treatment.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				
None	2	3	5	
TOTAL	2	3	5	

1.3. Damage to aircraft

The aircraft was not damaged.

1.4. Other damage

None.

1.5. Personnel information

1.5.1. Pilot

The pilot, a 41-year-old Portuguese national, had an airline transport pilot license, ATPL(A), issued by Portugal's Autoridade Nacional de Aviação Civil (ANAC) on 30 May 2018, with the following ratings:

- Instrument rating, IR(A), valid until 28 February 2019.
- SEP (land) rating, valid until 31 May 2020.
- FI (A) rating, valid until 31 July 2021.
- Learjet 45 type rating, valid until 28 February 2019.

He had a class-1 medical certificate that was valid until 3 August 2019.

He had a total of 2079 flight hours, of which 570 had been on the type, and the rest on Cessna Citation Mustang (CE-510), Cessna Citation CJ3 (CE-525) and Bombardier Global Express (BD700).

He had been at the company for over four years.

His recent activity had been as follows:

- In the last 90 days, he had flown: 110:50 h.
- Last 30 days: 31:05 h.
- Last 24 h: 00:00 h.
- Rest prior to flight: last flight 29/06/2018.

Language proficiency level: 6, indefinite.

1.5.2. First officer

The first officer, a 33-year-old Portuguese national, had a commercial pilot license, CPL(A), and a "frozen" airline transport pilot license, ATPL(A), issued by Portugal's Autoridade Nacional de Aviação Civil (ANAC) on 27 March 2018, with the following ratings:

- Instrument rating, valid until 31 March 2019.
- Learjet 45 type rating, valid until 31 March 2019.

He had a total of 1520 flight hours, of which 155 had been on the type and the rest on the Embraer Phenom 100.

He had a class-1 medical certificate that was valid until 31 July 2019.

He had been at the company over 5 months.

His recent activity had been as follows:

- In the last 90 days, he had flown: 108:50 h.
- Last 30 days: 31:05 h.
- Last 24 h: 00:00 h.
- Rest prior to flight: last flight 29/06/2018.

Language proficiency level: 5, 28 February 2023.

1.6. Aircraft information

1.6.1. General information

The Learjet 45XR, designed and manufactured by the American company Learjet Inc., is a low-wing, T-tail aircraft with a capacity for two pilots and eight passengers.

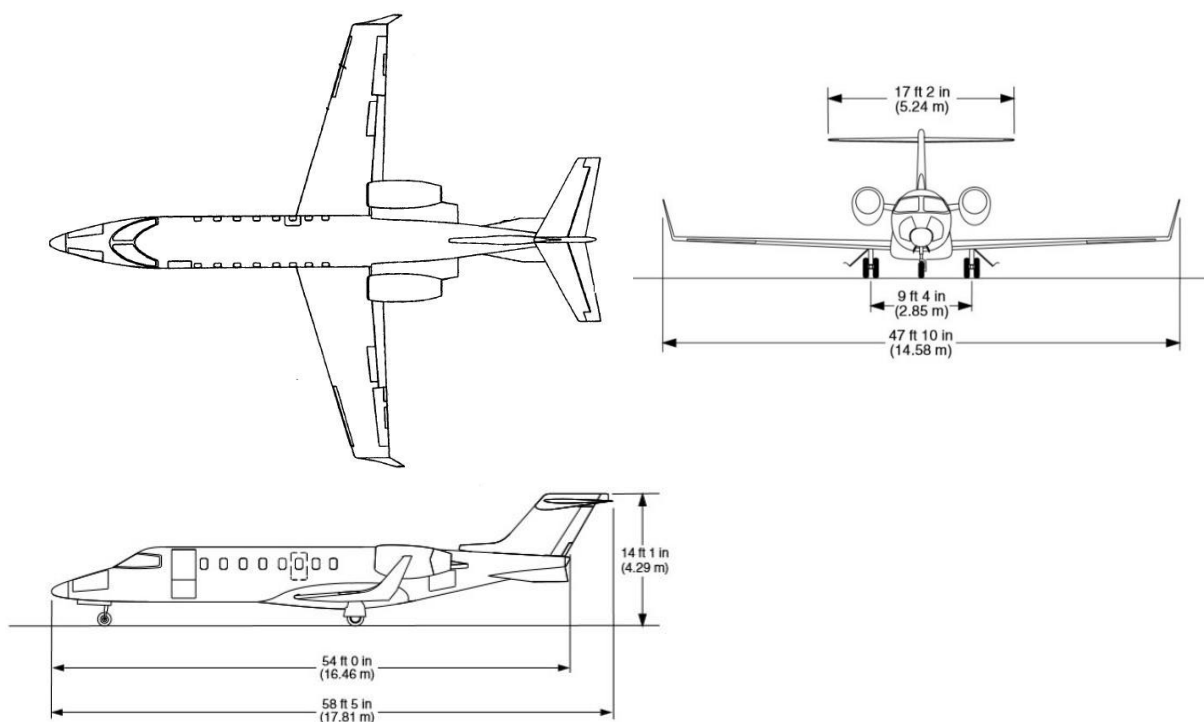


Figure 1: Dimensional drawing of the aircraft

Made completely of metal, it is pressurized and it has cantilevered wings with winglets. The fuselage uses semi-monocoque construction. Its empty weight is 6212 kg and its MTOW is 9752 kg, which is more in the XR version than in the original Learjet 45.

It is outfitted with two Honeywell TFE731-20BR turbofan engines. It has independent fuel systems that supply fuel to the engines from tanks in the wings and fuselage.

Hydraulic engine-driven pumps provide hydraulic energy to brake, extend and retract the landing gear, flaps, spoilers and thrust reversers.

The aircraft has a tricycle retractable landing gear with dual wheels in the main gear, nose-wheel steering and a brake and anti-skid electronic control system.

The ailerons, rudder and elevator are controlled manually using cables, levers, pulleys and push-pull tubes.

The aircraft has an air conditioning system that relies on an air cycle machine to provide heating, cooling and pressurization for the cockpit, passenger compartment and aft toilet.

1.6.2. Information about the operator

The operator and owner of the event aircraft had a valid air operator certificate for the commercial air transport of both cargo and passengers that was issued by the Portuguese civil aviation authority, ANAC (Autoridade Nacional da Aviação Civil).

The certificate covers other aircraft and the incident aircraft, whose operational specifications were valid.

1.6.3. Maintenance records

According to the ANAC's registry, the aircraft with serial number 45-302 and registration CS-TFQ was registered on 15 November 2016 with registration number 2803/2.

The maintenance was performed by a maintenance center that is approved by the Portuguese civil aviation authority (ANAC) as a Part-145 EASA organization. It is located in Cascais, Portugal, and it is authorized to perform base and line maintenance on Learjet 45 aircraft with Honeywell TFE731 engines. It has certifying personnel in categories B1, B2 and C.

At the time of the event, the aircraft had a total of 2,165:40 flight hours and 1776 cycles, as did the two engines.

The approved maintenance program in effect at the time of the event was AJS-AMP45XR Ed. 0 Rev. 5, dated 14 February 2018. The operator opted for an inspection program in which phases A, B, C and D are done together in their corresponding approved periods.

The main scheduled inspections have to be carried out every 300, 600, 1200 and 2400 hours. All the inspections in phase A are done together at 300-hour or 12-month intervals, the phase B inspections at 600-hour or 24-month intervals, the phase C inspections at 1200-hour or 48-month intervals, and the phase D inspections at 2400-hour or 96-month intervals.

The inspections are categorized in the program by zone in order to better plan the maintenance and organize work areas and components. The airplane is divided into eight zones, numbered from 100 to 800 in increments of 100, and these are in turn divided into sub-zones.

According to this program, the elements/components in the hydraulic system to be inspected in the programmed checks are as follows:

- Elements of the main hydraulic manifold, filters: once at or before 30 flight hours, and every 300 flight hours thereafter.
- Visual inspection of the hydraulic components and associated lines in the wheel well and the area forward of the rear spar: every 1200 h or 48 months.
- Visual inspection of the hydraulic components and associated lines in the fuel zone of the fuselage: 1200 h or 48 months.
- Operational test of the auxiliary hydraulic system: every 1200 h or 48 months.
- Visual inspection of the hydraulic components and associated lines in the area aft of the rear spar: every 2400 h or 96 months.
- Elements of the auxiliary hydraulic manifold, filters: every 2400 h.

The aircraft's maintenance history in the 18 months leading up to the incident was reviewed, and the records indicate that all of the scheduled inspections were properly carried out. In addition, the corrective maintenance tasks documented do not suggest any connection to the event.

The most recent satisfactory inspections are listed below:

- Inspection on 7 July 2018: with 2165:05 flight hours and 1775 cycles on the aircraft. Corrective replacement of the switch in the nose wheel.
- Inspection on 25 June 2018: with 2163:25 flight hours and 1773 cycles on the aircraft. Scheduled.
- Inspection of 11 June 2018: with 2148:40 flight hours and 1760 cycles on the aircraft. Corrective maintenance of EDP.
- Inspection of 24 May 2018: with 2119:05 flight hours and 1739 cycles on the aircraft. Engines.
- Inspection of 11 May 2018: with 2106:10 flight hours and 1726 cycles on the aircraft. Scheduled: airplane, engines, corrective and directives.

There is an access service panel for maintenance personnel to verify the various systems. Specifically, as concerns the hydraulic system, the routine check involves verifying that the indicators for the main and auxiliary system filters illuminate, and for the hydraulic fluid reservoir, if the ADD or OVER message is shown, in which case maintenance is required. The BRUSH light can also turn on, which indicates that the brushes on the auxiliary hydraulic pump are nearing the end of their service life. The airplane can fly with this message on, but maintenance is required at the next possible opportunity.

1.6.4. *Airworthiness status*

The aircraft had certificate of airworthiness No. PT-0321/09, issued by Portugal's INAC (Instituto Nacional de Aviação Civil) on 16 December 2009, which declared the aircraft as a "large aircraft", as well an airworthiness review certificate dated on 23 November 2017, when the aircraft had 2026:45 flight hours, that was valid until 14 December 2018.

The date of the last weight and balance report is from 13 February 2016.

The aircraft also had the following authorizations:

- Aircraft station license issued by INAC and valid until 14 December 2018.
- Noise certificate issued by INAC on 11 March 2018.

1.7. Meteorological information

1.7.1. *General situation*

At low levels, there was a large Atlantic high-pressure area that went from the east of the Azores to the British Isles and through the north of the Iberian Peninsula to the Western Mediterranean. There was a thermal low over the center and south of the peninsula, and small, low-pressure centers that drove convergence in numerous areas. The best defined seemed to be in cool air flows from the N in Cantabria, from the SW in the center-south of Castilla y Leon, and from the E in the Ebro River Valley.

In the southeast of the peninsula and the Balearic Islands, there was a band of medium and high clouds with embedded convection and precipitation that did not reach the ground.

1.7.2. *Conditions in the area of the incident*

The operator's report cited a variable wind of 3 kt, CAVOK, clear skies, 32° C and a QNH of 1016.

Aloft, at FL320, the windspeed was 35-40 kt from the west-southwest, and no phenomena were forecast on the significant weather charts, nor were they seen on satellite images.

According to data from the airport, the situation described in the METARs was as follows:

METAR LEZL 071200Z 29003KT 230V040 CAVOK 32/12 Q1016 NOSIG=
METAR LEZL 071230Z 31005KT CAVOK 34/12 Q1015 NOSIG=

(Interpretation: Seville Airport, the conditions described by the METAR on the 7th between 12:00 and 12:30 UTC were as follows: wind from 3 to 5 kt, temperature of 32 to 34° C, visibility OK, dewpoint 12° C and QNH between 1016 and 1015 hPa.)

And the aerodrome forecast was:

TAF LEZL 070800Z 0709/0809 VRB03KT CAVOK TX36/0716Z TN20/0805Z BECMG
0718/0720 24010KT BECMG 0800/0802 VRB03KT=

(Interpretation: Seville Airport, the conditions described by the TAF on the 7th at 08:00 UTC, forecast valid from the 7th at 09:00 UTC until the 8th at 09:00 UTC: variable wind, speed below 3 kt, visibility OK, maximum temperature on the 7th of 36° C at 16:00 UTC, and minimum temperature on the 8th of 20° C at 05:00 UTC; changing conditions between 18:00 and 20:00 UTC on the 7th, wind direction 240° and speed 10 kt; and between 00:00 and 02:00 UTC on the 8th, variable direction with speed below 3 kt)

1.8. Aids to navigation

The flight was taking place under instrument flight rules (IFR) when the incident occurred. At the time, the aircraft was at FL320 in the cruise phase flying over the SVL VOR.

After identifying the fault in the hydraulic system, the crew decided to divert to the Seville Airport, since it was the closest one that provided suitable conditions for landing. They initiated the diversion with assistance from ATC services at LEZL, which provided them with the necessary levels and vectors. They were then transferred to Seville APP and made a visual approach, using LOC 27 as a reference.

1.9. Communications

The aircraft took off from the Malaga Airport (LEMG) at 11:35:00 UTC. The communications between the crew and the control tower at the airport did not indicate any problems prior to, during or after takeoff.

The aircraft, level at FL140 outbound from LEMG, contacted sector LECSCEN and was cleared to FL240 and transferred to LECSMA4.

At 11:50:35 UTC while climbing to FL240, the crew asked the LECSMA4 CTA to climb to FL320, which the CTA did after coordinating with and transferring it to the adjacent sector, LECSSEV.

At 11:54:37 UTC, the aircraft radioed LECSSEV, and 5 minutes later reported that it had a problem on board and requested to descend. This was the first report from the crew involving the emergency.

At 12:00:58 UTC, the crew reported having a problem on board and that they might need to divert to the Seville Airport. The crew requested to descend and the closest vectors possible to land on the active runway in Seville, stating that they had the runway in sight and asking if a visual approach was possible.

Due to said technical problem, the crew eventually requested to land at LEZL and its flight plan was amended at 12:02:39 UTC. The LECSSEV CTA immediately transferred it to APP and informed Portugal about the amended flight plan.

The LECSAPR sector gave the crew the information requested, providing them the relevant vectors. It also asked the crew to report the type of emergency, to which the crew replied that they had a hydraulic failure and that they might not have the flaps or landing gear available.

As per procedure, the CTA asked the crew:

- If they would need assistance on the ground: the pilot said they would need a tug in case they could not maneuver and needed to be towed.
- Their fuel level: the pilot replied "2500 pounds".
- The number of occupants on board: the pilot confirmed that it was five.
- At 12:10:23 UTC, if they would be able to complete the final approach: the pilot requested to hold, so he was instructed to descend to point ROTEX.

At 12:14:27, the pilot was informed that they were first on approach and could proceed at his discretion when ready to do so. At 12:18:00 UTC, the pilot reported they were ready to make the visual approach, that they were stabilized 16 NM out from the localizer and that everything was normal except for the hydraulic failure.

At 12:23:03 UTC, the aircraft was transferred to the LEZL TWR.

According to the information provided by the duty manager at AENA Seville, the aircraft landed normally at 12:26:00 UTC, exiting the runway via E1 before subsequently stopping on A1 and being towed to stand R39.

At 12:41:00 UTC, the airport terminated the Local Alert.

1.10. Aerodrome information

The Seville Airport (LEZL), or San Pablo Airport, is located in the south of Spain, 10 km northeast of the city of Seville, between the city limits of Seville and Rinconada. Its geographic coordinates are 37° 25' 04.80" N and 5° 53' 35.18" W.

It is managed by AENA and it has one asphalt runway in a 09/27 orientation, a TORA of 3362 m and a width of 45 m. It is at an elevation of 34 meters above sea level. The runway has a CAT ILS/DME for low-visibility approaches, and a 3° PAPI system for visual approaches. Its assigned frequency is 118.100 MHz.

According to the Aeronautical Information Publication (AIP), the airport has one taxiway that is 23 m wide, 28 m wide at holding point HP4. On either side of the taxiway are asphalt shoulders that are 11.5 m wide.

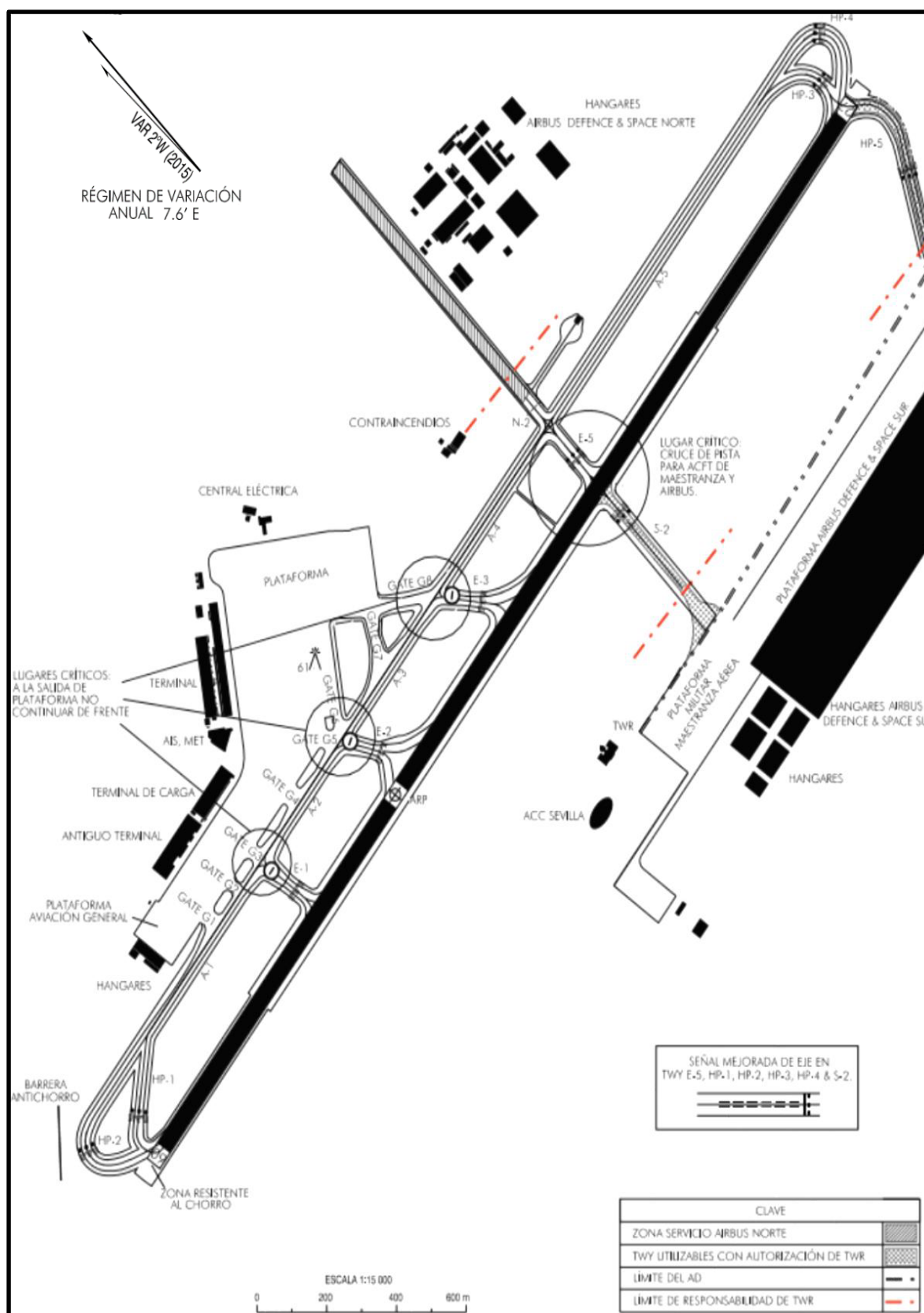


Figure 2. Aerodrome ground movement map

1.11. Flight recorders

The flight data from the aircraft recorded on the Flight Data Recorder (FDR) were not available to investigators since the incident was not reported to the CIAIAC until 19 days after it occurred and according to the operator information then they were no longer available. As a result, they could not be analyzed.

1.12. Wreckage and impact information

The landing did not cause any damage to the aircraft. The hydraulic fluid spills on the runway surface were only detected when the aircraft stopped. There were also stains left by the hydraulic fluid on the underside of the fuselage, as shown in photographs 2, 4 and 5.



Photograph 2. Spilled hydraulic fluid

Photograph 3 shows the indication on the hydraulic system panel in the cockpit after the aircraft stopped on the runway, before it was towed. The light refers to the level in the hydraulic fluid tank, and the ADD indicates the need to refill the tank.

The damage report written by the operator after inspecting the aircraft following the incident identified a



Photograph 3: Hydraulic system indicating panel

series of small, non-structural (esthetic) defects, but that the operator decided would be monitored in the future as per Bombardier letter 45302-22439. These defects consisted of small dents in the right and left spoilers.



Photographs 4 and 5: Hydraulic fluid spills and stains on the fuselage

1.13. Medical and pathological information

Not applicable.

1.14. Fire

Not applicable.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Information from the crew

According to the crew's statements, the pre-flight inspection of the aircraft was satisfactory and revealed no spills or leaks of hydraulic or any other kind of fluid. Specifically, on the hydraulic system panel, the green "OK" light was on and no CAS messages were displayed after start-up. The engine-driven hydraulic pumps showed a normal pressure of around 3020-3040 psi.

After the flight started, a MAIN HYD QTY LO advisory/status white message was received.

At cruise altitude, FL320, very close to the SVL VOR, a MAIN HYD PRESS amber caution was received on the EICAS. According to the crew's statements, they noticed that the engine-driven pumps were cavitating, and the synoptic page for the hydraulic system on the MFD started showing large variations in the hydraulic fluid pressure, which resulted in both pumps cycling several times from amber to white and back again, until both pumps turned amber in the diagram and the hydraulic fluid pressure fell consistently.

At that point, the crew decided to divert to LEZL since it was the closest suitable airport and the aircraft's flight parameters allowed landing there.

They contacted ATC. After receiving the levels and vectors, they began their descent into LEZL. The situation was then reported to Seville APP, confirming that there were 5 occupants on board and 2500 pounds of fuel, and that when they landed, they would try to clear the runway as fast as possible but that the possibility existed that they would be immobilized due to a problem with the hydraulic system.

In the meantime, the crew started executing the MAIN HYD PRESS pages in the QRH.

After descending through FL170, the airspeed remained within the normal operating values for the landing gear, so they tried to lower it, but to no avail, so it was deployed using the emergency gravity extension procedure in the QRH.

Since the hydraulic pressure in the system was below normal, the crew decided to fly the approach to LEZL without flaps and thus conserve the hydraulic fluid in the auxiliary system to operate the brakes.

They flew the approach visually, using LOC 27 as a reference. They landed normally and the brakes worked correctly, allowing them to vacate the runway.

After the third application of the brakes, once on taxiway A1, between G2 and G3, they had no more pressure, so they had to apply the emergency brakes.

While it was stopped at this point, the hydraulic fluid leak was confirmed visually. The airplane's tail section was stained with hydraulic fluid, and there were also small fluid leaks dripping on the taxiway, which were later cleaned up by the airport firefighters. The amber ADD light was on in the hydraulic system panel.

According to the crew, ATC informed them that the aircraft would have to be towed, since any additional taxiing was not safe. After a nearly two-hour wait, the aircraft was towed to stand R39.

According to the crew, the aircraft was dispatched with no deferred items. They were aware of the last maintenance task, resulting from an amber "NWS FAIL" caution on the EICAS, which required the aircraft to be AOG in Malaga. They stated that no task

involving the hydraulic system or near said system at the rear of the fuselage had been performed.

When asked if he had ever experienced anything before like the event involved in this incident on this airplane type or on this very airplane, the pilot stated that nothing similar had occurred, but that there had been two minor faults, at different times, involving the hydraulic system on the incident aircraft in recent months:

- HYD FILTER BYPASS amber light on the hydraulic system panel. The airplane was AOG until the hydraulic filter was replaced.
- The in-flight failure of the engine-driven hydraulic pump on the right side, which rendered the airplane AOG until the pump was replaced.

1.16.2. Relevant reports/communications

1.16.2.1. Report from the airport's Operations Department

At 12:05 UTC, the TWR informed the CECOA that the incident aircraft had declared an emergency due to a technical problem and would divert to LEZL.

At 12:09 UTC, the TWR reported the aircraft had problems with its flaps.

At 12:11 UTC, after checking with the duty manager, a Local Alert was declared.

At 12:15 UTC, it was confirmed that the airplane would land with its fuel tanks full, without specifying the amount.

At 12:19 UTC, the TWR reported that the aircraft had a hydraulic failure, that it would probably need the entire runway, that the crew had been able to lower the gear but that the aircraft would probably block the runway after landing.

As 12:21 UTC, the TWR cleared it to land, which it did at 12:26 UTC.

At 12:29 UTC, the aircraft stopped on the taxiway near Gate 2, and at 12:41 UTC, the local alert was terminated.

At 14:03 UTC, after various arrangements by the operations center, and between the duty manager and the FFS, the handling companies and the operator, the aircraft was finally towed to stand R39 under the supervision of the mechanics from the company who happened to be traveling on the airplane. The tow maneuver finished at 14:07 UTC.

At 14:26 UTC, the FFS informed the CECOA that they had cleaned up a hydraulic fluid spill measuring less than 1 m² in the area where the aircraft had come to a stop.

At 15:38 UTC, a small hydraulic fluid stain was identified at R39, where the aircraft had been parked, measuring 45 to 50 cm in diameter, which was cleaned up by the FFS.

1.16.2.2. Information from the executive controller on duty

The executive controller in the Seville sector reported that the incident aircraft was transferred to him after coordinating with Sector M4A and while it was climbing to FL320.

Practically from the initial contact, the pilot reported a problem with the airplane and requested to land at the Seville Airport. He also stated that he was in visual contact with the ground.

The pilot did not declare an emergency on that frequency.

He cleared it to FL210, since he could descend it to this level in his sector without having to coordinate the descent with anyone, and he reported the diversion to LEZL.

In coordination with Seville approach, he transferred the aircraft to the approach sector and informed the control room supervisor, who monitored the situation until it landed at LEZL.

According to the TWR log of the ATS at LEZL, he reported that APP had informed that the incident aircraft was diverting to LEZL due to a fault with the flaps. Located at FL250, it was estimated to land in about 15 minutes. He informed the CECO and waited for APP to provide more information. After several calls, APP reported the amount of fuel, number of occupants and that, due to a probable failure of the brakes, the aircraft could need to use the entire runway to land. APP confirmed that the pilot had not declared an emergency; even so, the TWR coordinated with the CECO and the FFS, as well as with APP, at all times to clear other inbound aircraft until the runway was operational. It finally landed normally at 12:26 UTC, vacating the runway via taxiway E2. Once at A1, at 12:29 UTC, he requested a tow, since its brakes no longer worked. The runway was operational but taxiways A1 and G2 remained unavailable until the aircraft was towed, at 14:07 UTC. The pilot later confirmed that they had had a hydraulic failure that affected the flaps, brakes and landing gear (which had been lowered and locked manually).

Later, during a conversation over a dedicated line with the Tower Supervisor, APP confirmed that the traffic had declared an emergency to them. The only traffic affected was an airplane headed to Dublin, whose departure was delayed eight minutes.

The transcripts of the conversations revealed that the pilot had indeed confirmed that they had had a real problem with the pressure in the main hydraulic system, and not just a low hydraulic pressure reading in the cockpit, since they had lost a large amount of hydraulic fluid and had been unable to lower the landing gear automatically, and had been forced to use the emergency system. They were forced to land without flaps to ensure the brakes worked normally, which they did during the landing run, but after turning toward the apron, the brakes stopped working, so they had to use the emergency brakes to stop the aircraft.

1.16.2.3. FFS log

The CECOIA had informed them that an aircraft was inbound with hydraulic problems. After landing, it came to a stop near gate 2.

Since the aircraft weighed more than 9 MT, they were unable to tow it with their own resources. On the airplane were three mechanics, to whom they gave slings to tow the aircraft and move it to a stand.

The CECOIA was then informed that the FFS had cleaned up a hydraulic fluid spill covering less than 1 m² in the area where the aircraft had come to a stop.

The CECOIA later asked the FFS chief to check if the aircraft was still leaking hydraulic fluid, to which the chief replied that there was a small hydraulic fluid stain at R39, where the aircraft was parked, measuring about 45-50 cm in diameter, which the FFS also cleaned. The chief reported seeing no other leaks.

1.16.3. Tests / Inspections

In light of the actions reported by the crew, as well as of the damage and findings identified on the aircraft, it was deemed useful to evaluate the applicable service bulletins and airworthiness directives.

1.16.3.1. Service Bulletins and Airworthiness Directives

A service bulletin (SB) is a document issued by the entity responsible for the aviation product (aircraft, engine, propeller, device or component) or by the holder of the type certificate in order to: correct a fault or malfunction in the product; introduce changes and/or improvements to the original design that result in reduced maintenance costs or improved performance; implement a new corrective or preventive maintenance task, in which case it is included in the product manufacturer's maintenance program.

Changes can be optional to improve the optimal operating conditions of an aircraft up to mandatory to maintain its airworthiness. However the regulator could determine that if an unsafe condition exists in the product, the condition must be corrected.

Improvements normally require changes that could entail additional costs, which is why their implementation is recommended to clients or air operators as an option, unless the improvement is related to an airworthiness directive (AD).

An SB is typically issued before an AD. As part of the procedure for issuing an AD, a notice of proposal to issue an AD and/or an SB may be included. Because of this, the manufacturer can classify it as recommended, meaning its implementation is not mandatory.

Once the SB is incorporated as a reference in an AD, the actions contained in it become mandatory, regardless of how the SB was initially classified (mandatory, recommended, etc.). As a result, the information contained in the AD always takes precedence in the event of a conflict with the information contained in the documents to which it refers.

In the incident investigated herein, which specifically involved a fault identified in the hydraulic system, there is no applicable AD, since the only AD related to the hydraulic system is 2009-11-13, dated 17 June 2009, on inspections of hydraulic lines in the engines.

It should be noted, however, that SB 45-29-17, issued in January 2010, and applicable to Learjet 45 aircraft with SN 45-005 to 45-396 and 45-398 to 45-404, and therefore applicable to the incident aircraft (S/N 45-302), recommended replacing the pressure switch, P/N 7629001004-001, with an improved pressure switch, P/N 6629101004-001 (S8 and S9), in order to reduce the likelihood of leaks in the hydraulic system and the resulting loss of pressure in the system.

The reason for replacing it is that hydraulic fluid leaks had been found at the electrical connector of the low-pressure switches in the hydraulic system (main, auxiliary and for the spoilers). According to the manufacturer, implementing this SB would reduce the likelihood of leaks and pressure drops in the hydraulic system.

However, even if there was a loss of pressure in the hydraulic system, this aircraft is certified to fly and land safely in these conditions. As detailed in earlier sections, in this aircraft, hydraulic pressure is used to brake, to lower and raise the landing gear, extend and retract the flaps, spoilers and thrust reversers. The ailerons, elevators and rudder, however, are controlled manually via cables, while the trim is controlled and actuated

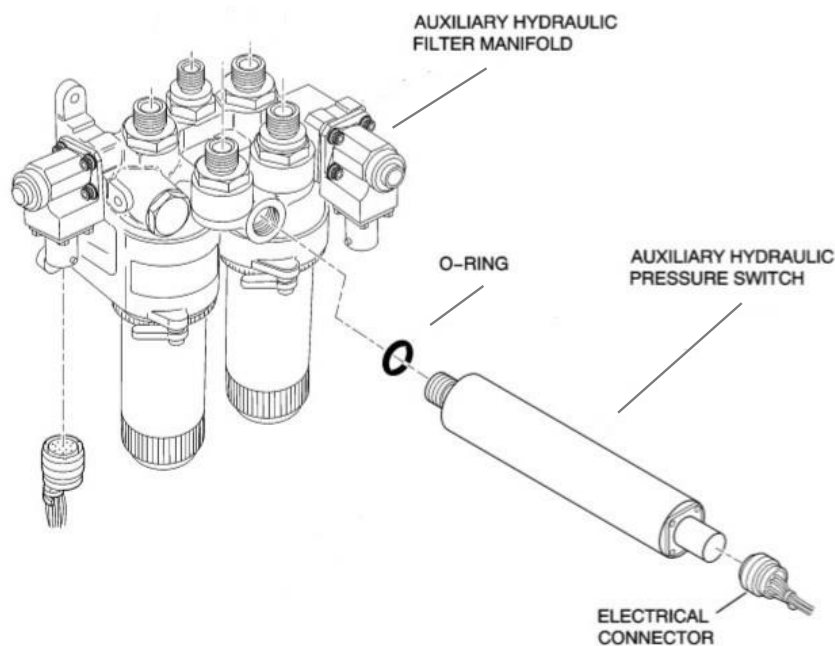


Figure 3. Hydraulic pressure switch (auxiliary and main)

electrically, meaning no hydraulic energy is required to control the aircraft in flight. The landing gear can also be lowered without hydraulics using the emergency gravity extension system, and the brakes also have an emergency brake system.

As for the implementation of this SB, Bombardier Learjet Inc. recommended that its instructions be implemented when deemed appropriate by the owner of the aircraft.

The SB was not the subject of an AD from a regulator, and was therefore not mandatory. The technical contents of this publication, which affect the design of the airplane type, were approved by the FAA and EASA.

After the incident, on 22 August 2018, the aircraft manufacturer issued a reminder in its Customer Forum & Newsletter, No. 17, Volume 15, stating that it issued Service Bulletins 40-29-05 and 45-29-17 on 29 January 2010 titled "Replacement of the hydraulic system low pressure switch assemblies", which is applicable to Learjet 40/45 aircraft, and which offers kits for installing improved pressure switches for the main, auxiliary and spoiler hydraulic systems. The SB stated that these updated switches had been shown to be more reliable than the switches they replace.

Likewise, Bombardier reported that considering that lately there had been several events of loss of hydraulic fluid caused by the lack of incorporation of these SBs that install improved low pressure hydraulic switches, it recommended that any aircraft outfitted with the previous version of the hydraulic switches implement these SBs in order to reduce the potential for hydraulic fluid leaks and any resulting AOGs.

1.16.4. Report from the Operator

In its report, the operator collected the information provided by the crew and maintenance personnel, and identified the following key events that occurred during the flight:

- After the flight started, during the climbing, a MAIN HYD QTY LO advisory/status white message was received.
- At cruise altitude, FL320, near the SVL VOR, a MAIN HYD PRESS amber caution message was received.
- The crew noticed that both engine-driven pumps were cavitating, and the HYD synoptic page on the MFD showed large swings in hydraulic pressure, with both pumps cycling from amber to white and back again several times.
- Both pumps turned amber on the diagram and the HYD pressure fell continuously.
- At that point, the crew decided to divert to LEZL.
- The crew continued carrying out the steps in the MAIN HYD PRESS pages on the QRH.
- The gear was lowered using the emergency gravity extension procedure in the QRH.

- Since the hydraulic pressure in the system was not normal, the crew decided to make the approach without flaps to conserve the hydraulic fluid in the auxiliary system so the normal brakes could work.
- The approach was performed visually.
- The landing was executed normally, the normal brakes worked and allowed the aircraft to vacate the runway.
- After the third normal application of the brakes, the hydraulic pressure was gone and they applied the emergency brakes gently.
- The leak in the hydraulic system was confirmed visually, since there were two hydraulic fluid spills. The spill was cleaned up later by the firefighters and the airplane was towed to a stand. The aircraft was AOG until it was repaired.

1.16.5. Report from the Maintenance Organization

Before the flight, the aircraft was dispatched with no deferred items.

When the aircraft landed after the in-flight incident, and while it was parked waiting to be towed, the hydraulic fluid leak was confirmed visually. The airplane's tail section was dirty with hydraulic fluid, and there were small leaks dripping on the ground. The maintenance personnel checked the cautions in the hydraulic system panel, which showed the "ADD" message illuminated in amber.

Based on the faults reported (MAIN HYD PRESS and MAIN HYD QTY LOW), two work orders were opened to inspect and repair the aircraft, which had 2,165:40 flight hours and 1,776 cycles.

The maintenance personnel confirmed that a hydraulic pressure switch that could not be repaired was the source of the hydraulic fluid leak, which had caused the total loss of fluid in the system.

The two pressure switches S8 and S9, p/n: 7629001004-001, were replaced by the p/n: 6629101004-001. The s/n: 1344 by the s/n: 1247, and the s/n: UNK (unknown) by the s/n: 1063.

The entire hydraulic system was checked and inspected, and the hydraulic fluid reservoir was purged and filled. No leaks were found following this action. The aircraft was released to service following the corrective maintenance three days after the incident.

According to Bombardier, the operator contacted its Customer Service to help return the incident aircraft to service. Bombardier was told that the operator's maintenance personnel had identified a defective pressure switch, P/N 7629001004-001, as the source of the leak that drained the hydraulic system. In light of SB 45-29-17, dated 28 January 2013, the defective switch was replaced with a new one, P/N 6629101004-001, in keeping with the aircraft manufacturer's recommendation.

1.17. Additional information

Not applicable.

1.18. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Analysis of the weather situation

The weather conditions present in the area of the incident at the flight level at which the aircraft was flying, as well as in the area of the Seville Airport, at the time of the event were suitable for the flight. There is no record of any significant meteorological event that could have contributed to the incident.

2.2. Analysis of the operation and handling of the emergency

When a MAIN HYD QTY LO (main hydraulic quantity low) advisory/status white message appeared after the aircraft was airborne, the crew did not take any actions in particular and continued climbing to their cruise level, FL320. Although this message on the ground would imply a no-go for the aircraft, in the air, it requires monitoring the HYD page for any related information that may be displayed.

It was near the SVL VOR that a MAIN HYD PRESS amber caution message was received on the EICAS. According to the statements from the crew, they noticed that the engine-driven pumps were cavitating, meaning they were working at a vacuum. This showed that the crew had good knowledge of the system.

Moreover, the synoptic page for the hydraulic system showed large swings in the hydraulic fluid pressure, such that both pumps cycled several times from white to amber and back again, until eventually both pumps turned amber in the diagram and the hydraulic fluid pressure fell completely. This level of detail shows that the crew were properly monitoring the system indications, and that they were performing the checklist for the MAIN HYD PRESS message on CAS. Having noticed that the pressure in the normal system was below normal, they did not use the HYD XFLOW system for the flaps, they remained below 35000 ft and they initiated the procedures for an emergency landing and for failure of the main hydraulic system.

Deciding at that point to divert to the Seville Airport was appropriate and timely, given the performance of the airplane and considering that the EICAS reading was informing them that the main hydraulic system was no longer available due to a lack of fluid pressure.

The crew showed that they were familiar with the aircraft and with the applicable emergency procedures, since they correctly assessed that the loss of pressure in the hydraulic system would not prevent them from making a safe flight and landing in these conditions.

As explained in previous sections, hydraulic power on this aircraft is used for the brakes, and to extend and retract the landing gear, flaps, spoilers and thrust reversers. The

ailerons, rudder and elevators, however, are controlled manually via cables, while the trim is electrically controlled and actuated, meaning directional control of the aircraft in flight does not require hydraulic pressure. The landing gear can also be lowered without hydraulic pressure by using the emergency gravity extension procedure, and the brakes also have an emergency braking system.

The crew performed the landing procedure for a failure of the main hydraulic system by selecting the pages for MAIN HYD PRESS in the QRH, which was the appropriate choice.

The procedure begins with the instruction to complete the descent, and the crew descended to FL170. Since the speed was within the normal values for lowering the landing gear, the crew attempted to do so per the normal checklist but without success, so they initiated the emergency gravity extension procedure as per the QRH. Therefore, the QRH procedure for "MAIN HYD PRESS" referred to the "Main Hydraulic System Failure Landing" was not strictly executed, since, after completing the descent by the normal checklist, the QRH indicates as a second step the completion of the landing gear extension procedure by the emergency system ("Landing Gear Free Fall"), not to try the normal extension procedure first.

As for configuring the flaps for landing, the crew decided to land without extending the flaps so they could use the hydraulic power available in the auxiliary hydraulic system to brake on the runway, since the main system was completely inoperable. The "Main Hydraulic System Failure Landing" procedure instructs, however, that if the auxiliary hydraulic system is available, as it was, the flaps should have been deployed at 20°.

Once on the ground, the normal brakes allowed them to vacate the runway, but after applying the brakes three times, they lost their effectiveness while taxiing to parking, so they had to use the emergency/parking brake system, actuating it as specified in the procedure, gently and without pumping them. Their actions were therefore appropriate.

As for the handling of the communications between the various ATM services, the crew reported the emergency at the proper time, preparing, without undue haste, to deviate from their flight plan and land at the Seville Airport, which they did without worsening the situation that had caused the incident. They properly reported their fuel load, occupants, etc., and landed with the minimum consequences possible for other aircraft.

Therefore, after analyzing the information available, it is concluded that ATM did not contribute to the incident or to the management of the flight, and further, that the emergency situation was handled properly by the crew, which quickly identified the warnings and cautions on the aircraft's instrument panel, thereby exhibiting good knowledge of the aircraft's performance and properly executing the applicable procedures and checklists.

2.3. Analysis of the maintenance of the aircraft

An analysis of the scheduled maintenance checks and inspections of the aircraft shows that the aircraft was airworthy.

The visual inspection of the aircraft after landing identified fluid that was still leaking on the runway, thus confirming the leaks in the hydraulic system, although in smaller amounts since the system was practically empty. There were also obvious marks on the underside of the airplane's tail section, running along the surface from the belly, starting at the main gear fairing and toward the rear of the airplane, which provided evidence that hydraulic fluid had leaked out during the flight.

The main hydraulic system was confirmed to be depleted, as indicated by the HYD maintenance panel, where the amber ADD message was lit. As the aircraft was being checked and repaired, it was confirmed that the reservoir of the main hydraulic system was in fact empty.

Maintenance personnel confirmed that a hydraulic pressure switch was the source of the hydraulic fluid leak; specifically, P/N 7629001004-001, which, in SB ref. 45-29-17 dated 28 January 2013 (and applicable to the incident aircraft), Bombardier had suggested replacing with an improved pressure switch, P/N 6629101004-001 (S8 and S9), since hydraulic fluid leaks had been found at the electrical connector for the switches in the main, auxiliary and spoiler hydraulic systems. According to the manufacturer, implementing this bulletin reduced the likelihood of leaks and pressure losses in the hydraulic system.

The location on the airplane's surface of hydraulic fluid stains and the spills on the runway after the landing were consistent with the location of the pressure switch identified as having caused the loss of hydraulic fluid.

Maintenance personnel replaced said pressure switch, both with the same P/N, S8 and S9, on the right and left sides of the aircraft respectively, with a new switch, P/N 6629101004-001. They then checked the entire hydraulic system, purged it, filled the hydraulic fluid reservoir and verified the absence of leaks.

The aircraft is designed to fly and land safely with no pressure in the hydraulic system, since the ailerons, elevators and rudder are controlled manually via cables, meaning the aircraft's direction while airborne can be controlled in flight without hydraulic pressure. The landing gear can also be lowered without hydraulic pressure by using the emergency gravity extension procedure, and, lastly, the braking system also features an emergency system. Despite this, the manufacturer's recommendation to replace the pressure switches specified in SB ref. 45-29-17, dated 28 January 2013, should have been implemented, as it would have avoided this incident.

2.4. Analysis of the organization and the management

The operator's documentation and procedures were all valid, and its management of the aircraft and crew was correct.

After the incident, the operator contacted the aircraft manufacturer to receive support involving its determination of the cause of the loss of hydraulic fluid in the main system. As a result of this support, the maintenance organization implemented SB ref. 45-29-17, dated 28 January 2013, stating it had been unaware of the existence of said SB, or at least of the manufacturer's recommendation in terms of the affected components.

In the incident investigated herein, the crew acted correctly in reaction to the emergency, managing the diversion from the route and landing without further incident at the Seville Airport.

The aircraft was airworthy and the weather conditions favorable, which helped the crew remain focused on the CAS messages, which identified without a doubt the source of the problem. The circumstances were thus conducive to the proper management of the situation.

Although implementation of the SB was recommended, and thus the operator did not violate any safety regulations, in less favorable circumstances, a failure of the hydraulic system could have resulted in greater complications to the proper management of the flight.

As a consequence, the operator should ensure that the authorized maintenance organization implements the SBs of the aircraft manufacturer in order to minimize the occurrence of incidents that could affect aviation safety.

3. CONCLUSIONS

3.1. Findings

- The pilot had an airline transport pilot license, ATPL(A), with valid SEP (land), IR(A), FI(A) and Learjet type ratings.
- The pilot had a valid class-1 medical certificate.
- The pilot had a total of 2079 flight hours, of which 570 had been on the type.
- The first officer had a commercial pilot license, CPL(A), a frozen airline transport pilot license, ATPL(A), with IR(A) and Learjet 45 type ratings, all of which were valid.
- The first officer had a valid class-1 medical certificate.
- The first officer had a total of 1520 flight hours, of which 155 had been on the type.
- The owner and operator of the aircraft had a valid air operator certificate for the commercial air transport of both cargo and passengers.
- This certificate included within its scope the aircraft involved in the incident.
- The aircraft was maintained by an EASA Part-145 approved maintenance center that was authorized to perform line and base maintenance on LEARJET 45 aircraft with Honeywell TFE731 engines. Its personnel were certified in categories B1, B2 and C.
- At the time of the event, the aircraft had a total of 2165:40 flight hours and 1776 cycles, as did both engines.
- The aircraft had valid airworthiness and airworthiness review certificates.
- The last scheduled maintenance check was done on 25 June 2018, 12 days before the incident, with 2163:25 flight hours and 1773 cycles on the aircraft, which was deemed airworthy.
- The hydraulic system has two independent sources of hydraulic energy, a main and an auxiliary system. The auxiliary system provides hydraulic pressure to the brakes, landing gear and flaps when there is a problem with the operation of the main hydraulic system.
- During the flight, a MAIN HYD PRESS message was displayed on the CAS, which progressed into a complete loss of pressure in the main hydraulic system.
- The crew declared an emergency, amended their destination and landed at the Seville Airport.
- The landing was uneventful. The flaps were not deployed and the landing gear was lowered using the emergency gravity extension procedure.
- While taxiing to vacate the runway, the normal brakes lost all hydraulic power, so

the crew were forced to use the emergency brakes.

- A visual check of the aircraft identified hydraulic fluid leaks on the runway and stains on the underside of the fuselage caused by the hydraulic fluid leaks during the flight.
- The investigation showed that the hydraulic fluid leaks that left the main system without any pressure were produced as a result of the faulty operation of the pressure switch with P/N 7629001004-001.
- On 28 January 2013, the aircraft manufacturer published SB ref. 45-29-17, which recommended replacing the pressure switch with P/N 7629001004-001 with an improved switch, P/N 6629101004-001 (S8 and S9), since hydraulic fluid leaks had been found at the electrical connection to the switch, and implementing the bulletin reduced the likelihood of leaks and pressure losses in the system.
- The operator, through its authorized maintenance organization, had not implemented SB ref. 45-29-17.
- The crew managed the flight and the emergency situation properly, carrying out the applicable procedures and checklists accurately and effectively.
- The crew and passengers were uninjured and were able to exit the aircraft under their own power.
- The aircraft was not damaged as a result of the incident.

3.2. Causes/Contributing factors

The technical investigation revealed that the incident was caused by the loss of fluid from the main hydraulic system as the result of leaks that occurred while in flight through the electrical connector of the pressure switch with P/N 7629001004-001.

A contributing factor in the incident is the failure to implement SB ref. 45-29-17, dated 28 January 2013, from Bombardier, which recommended replacing the pressure switch P/N 7629001004-001 with an improved version, P/N 6629101004-001 (S8 and S9), in order to reduce the probability of leaks and pressure drops in the system.

4. SAFETY RECOMMENDATIONS

As a result of the incident, the aircraft manufacturer informed the CIAIAC of its intent to remind operators of the recommendation to implement Service Bulletin SB 45-29-17, Rev. 2, dated 28 January 2013.

This reminder was issued by way of Bombardier Business Aircraft Customer Forum & Newsletter / Wednesday, August 22, 2018 / Volume 15 / Issue 17.

REC 27/20: It is recommended that Airjetsul enhance in its organization the procedures needed to assess the suitability of implementing the Service Bulletins published by aircraft manufacturers in order to minimize the number of incidents that could affect the operation of its aircraft.