



Statens haverikommission
Swedish Accident Investigation Board

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Final Report RL 2011:10e

**Serious incident to Aircraft LN-KKD
at Arlanda airport, Stockholm County,
Sweden on December 20, 2009**

Case L-22/09

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Statens haverikommission
Swedish Accident Investigation Board

2011-09-01

L-22/09

The European Aviation Safety Agency
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Report RL 2011: 11e

The Swedish Accident Investigation Board (Statens haverikommission, SHK) has investigated a serious incident to personal injury that occurred on December 20, 2009 at Stockholm/Arlanda airport in Stockholm County, involving an aircraft with registration LN-KKD.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a final report on the investigation.

The Board will be grateful to receive, by 1 december 2011 at the latest, particulars of how the recommendations included in this report are being followed up.

Carin Hellner

Stefan Christensen

Duplicate to the Swedish Transport Agency

Report RL 2011:10e	5
1 FACTUAL INFORMATION	7
1.1 History of the flight.....	7
1.2 Injuries to persons	9
1.3 Damage to the aircraft	9
1.4 Other damage	9
1.5 Crew information.....	9
1.5.1 Commander	9
1.5.2 Co-pilot	10
1.5.3 Cabin crew members	10
1.5.4 The crew members' duty schedule.....	10
1.6 Aircraft information	10
1.7 Meteorological information.....	11
1.8 Aids to navigation	11
1.9 Communications.....	11
1.10 Aerodrome information.....	11
1.11 Flight recorders	12
1.12 Site of occurrence	12
1.12.1 Site of incident	12
1.12.2 Videorecording of the incident	12
1.13 Medical information	12
1.14 Fire.....	12
1.15 Survival aspects	12
1.15.1 General.....	12
1.15.2 Rescue service	13
1.16 Tests and research	13
1.16.1 The crew.....	13
1.16.2 The cabin crew's description of the evacuation	13
1.16.3 The pilots' description of the evacuation.....	15
1.16.4 Initial and recurrent training of emergency situations and evacuation	16
1.16.5 The ground services	17
1.16.6 The airplane	19
1.16.7 The operator's actions after the incident.....	20
1.16.8 The Swedish Transport Agency's actions after the incident..	20
1.16.9 Passenger's reactions after the incident	20
1.17 The operator's organisation and management.....	21
1.18 Additional information.....	21
1.18.1 Gender issues.....	21
1.18.2 Environmental aspects	21
2 ANALYSIS	21
2.1 The flight.....	21
2.1.1 General.....	21
2.1.2 Flight preparations at the gate.....	22
2.1.3 The engine start	22
2.2 The emergency evacuation	23
2.3 Initial and recurrent training of emergency situations	24
3 CONCLUSIONS.....	25
3.1 Findings	25
3.2 Cause.....	25
4 RECOMMENDATIONS	26

General

The Swedish Accident Investigation Board (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended so far as possible to determine both the sequence of events and the cause of the events, along with the damage and effects in general. An investigation shall provide the basis for decisions which are aimed at preventing similar events from happening again, or to limit the effects of such an event. At the same time the investigation provides a basis for an assessment of the operations performed by the public emergency services in respect of the event and, if there is a need for them, improvements to the emergency services.

SHK accident investigations try to come to conclusions in respect of three questions: *What happened? Why did it happen? How can a similar event be avoided in future?*

SHK does not have any inspection remit, nor is it any part of its task to apportion blame or liability concerning damages. This means that issues concerning liability are neither investigated nor described in association with its investigations. Issues concerning blame, responsibility and damages are dealt with by the judicial system or, for example, by insurance companies.

The task of SHK does not either include as a side issue of the investigation that concerns emergency actions an investigation into how people transported to hospital have been treated there. Nor are included public actions in the form of social care or crisis management after the event.

The investigation of aviation incidents are regulated in the main by the Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The investigation is carried out in accordance with the Chicago Convention Annex 13.

The investigation

SHK was notified on December 20, 2009, that an aircraft with registration LN-KKD had an incident at 08:37 hrs on that day at Stockholm/Arlanda airport, Stockholm County.

The incident has been investigated by SHK represented by Carin Hellner, Chairperson, and Roland Karlsson, Chief investigator flight operations, until 31 December 2010 and thereafter Stefan Christensen, Staffan Jönsson, Chief technical investigator aviation, and Pia Jakobsson Human Factors investigator.

The investigation was followed by Britt-Marie Kärlin, Swedish Transport Agency until September 9, 2010, and by Billy Nilsson thereafter.

Report RL 2011:10e

L-22/09

Report finalised 2011-09-01

<i>Aircraft; registration and type</i>	LN-KKD, Boeing 737-33V
<i>Class, Airworthiness</i>	Normal, Valid Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC) ¹
<i>Owner/Operator</i>	Celestial Aviation Trading 10 Ltd/Norwegian Air Shuttle ASA
<i>Time of occurrence</i>	2009-12-20, 08:37 hours, in daylight Note: All times are given in Swedish standard time (UTC + 1 h)
<i>Place</i>	Stockholm/Arlanda airport, Stockholm County (pos. 59 38 42 N 017 55 33 E, 31 m above sea level)
<i>Type of flight</i>	Scheduled flight
<i>Weather</i>	According to SMHI ² 's analysis: Wind 080 degrees 5 kts, visibility 1.7 km, vertical visibility 700 feet, temp./dew point -4/-5 °C, QNH ³ 1004 hPa.
<i>Persons on board:</i>	
<i>crew members</i>	5
<i>passengers</i>	140
<i>Injuries to persons</i>	None
<i>Damage to aircraft</i>	No damage
<i>Other damage</i>	None
<i>Commander:</i>	
<i>Age, licence</i>	45 years, ATPL (A)
<i>Total flying time</i>	10 700 hours, of which 3 400 hours on type
<i>Flying hours previous 90 days</i>	78, of which 45 hours on type
<i>Number of landings previous 90 days</i>	30, on type
<i>Co-pilot</i>	
<i>Age, licence</i>	30 years, CPL (A)
<i>Total flying time</i>	2 500 hours, of which 104 hours on type
<i>Flying hours previous 90 days</i>	174 of which 104 hours on type
<i>Number of landings previous 90 days</i>	56, on type
<i>Cabin crew members</i>	3

¹ ARC – Airworthiness Review Certificate

² SMHI – Swedish Meteorological and Hydrological Institute

³ QNH – air at the airport reduced to sea level

Summary

The flight was a regular flight with passengers from Stockholm/Arlanda airport to Nice in France. The airplane was equipped with 148 seats and had 145 passengers on board.

During the preparations for engine start on the apron the electrical power from the airplane's APU⁴- generator ceased, and resulted in that the main lighting in the cabin extinguished and the cabin internal communication- and advertisement system stopped to function.

The pilots continued with the preparations for flight and during start of the right engine short fire flames from engine's exhaust appeared. A small pool of fuel on the ground behind the engine also caught fire, but soon extinct spontaneously.

Some of the passengers observed the fire flames and called "it is on fire". This led to that a number of passengers left their seats and moved forward toward the exits. The cabin crew in the forward part of the cabin could not properly assess the situation, since the passengers prevented both view and passage backward, but concluded that there was a safety risk. An emergency evacuation was therefore initiated by the cabin crew in the forward part of the cabin.

The cabin crew member in the rear part of the cabin observed that both the flames from the engine and the fire on the ground soon ceased, considered that there was no further risk for fire. Because of the electrical power loss, there was however no possibility by normal procedures to communicate with the other crew members.

The airplane was evacuated through the front doors. No person was injured in the emergency evacuation.

The serious incident to personal injury at the unexpected evacuation of the aircraft was caused by that the cabin attendants were unable to control or prevent the course of events in the cabin, when spontaneous calls about "fire" had started a reaction among the passengers.

Recommendations

The European Aviation Safety Agency is recommended to:

- consider the need for improved initial and recurrent training of crews in emergency situations on the ground, especially before the aircraft is ready for flight, and consequences of failures of electrical systems that affect the aircraft's internal communication systems. (RL 2011:10 R1).
- consider the need for expanded information and checking of understanding emergency evacuation procedures, of passengers who are expected to act in emergency evacuation of aircraft. (RL 2010:10 R2).

⁴ APU – Auxiliary Power Unit – turbine engine on the aircraft for electrical and pressurized air supply on the ground and in certain emergency situations in the air.

1 FACTUAL INFORMATION

1.1 History of the flight

The incident occurred at Arlanda airport on apron D, outside of Gate 63 at Terminal 2.

The flight was a scheduled flight from Stockholm / Arlanda to Nice in France, with flight number NAX 3855.

The airplane had a remaining complaint that the APU generator intermittently was unserviceable. The APU normally delivers both power and compressed air to the airplane's various systems. The air supply from the APU was however without complaint and could be expected to function normally. The APU was started at the gate to get the air supply for starting engines, heating and air conditioning on board. Power supply of the airplane was done by a cable connection to the airport's fixed electrical power supply.

It was initially intended to start one engine at the gate by means of compressed air from the APU and electrical power from the ground. There was however much snow and ice on the airplane so that a comprehensive de-icing and anti-ice treatment was required to get the airplane airworthy, which must be carried out at the apron outside the gate and before starting the engines. The pilots tried, however, to connect the APU generator at the gate and the generator turned out to function normally. When the ground crew discovered that the airplane was electrically self-supported, which is indicated on a panel outside the airplane, the ground supply cable was disconnected. This was done without signalling or communication with the pilots if the ground power could be disconnected. When the power was disconnected the first officer tried in vain to make contact with the ground staff by opening the side window, but the staff was already moving away from the airplane.

When the airplane was pushed out from the gate there had been a shift change of the ground staff. The person who monitored the push back, the start-up manager, did not use a headset⁵ for duplex wire communication with the airplane. The communication with the Commander was instead performed by using hand signals. Certain procedures for hand signalling were described in both the pilot's manuals in the ground crew instructions.

The airplane was pushed out by truck from the gate and parked on the apron, and then de/anti-icing treatment with anti-ice fluid began by using a mobile de-icing truck. Communication between the Commander and the crew in the de-icing vehicle was by radio transmission. During the de-icing of the airplane, the APU generator tripped off and the pilots did not manage to restore the function. When the APU generator stopped supplying power, the cabin's main lights extinguished and only emergency lighting was working. The main purpose of the emergency lighting is to mark escape routes and exits, and the general lighting in the cabin is considerably reduced. The power loss also caused that the intercom system in the cabin ceased to function, and the passenger announcement from the cabin also became unserviceable. The door to the cockpit was therefore opened, to facilitate communication between the Commander and the cabin crew. The Commander made a passenger announcement that they might return to the gate due to a technical failure.

⁵ Headset – earphones and microphone for duplex communication with the aircraft

When the anti-ice treatment was completed and the airplane was still on the apron, the right engine was however started with the airplane's batteries. The batteries supply direct current, while the APU generator, the engine alternators and the ground power cable supply alternating current. When alternating current is not available but only direct power is available in the airplane, some electrical systems are shed to reduce electrical load, such as cabin lighting, cabin intercom system and the possibility to make passenger announcement calls from the cabin.

During the engine start indications on the instrument panel showed that the engine's ignition was not functioning normally, and the engine start was aborted. It turned out that the selector on the instrument panel for engine ignition was set to start with alternating current, which is normal mode. After the aborted engine start, the engine was ventilated by the pilots according to a procedure in the airplane checklist. The purpose of this procedure is to expel any excess fuel in the combustion chambers. The procedure for the ventilation of the engine includes running the engine with the starter for a specified time, without fuel supply and ignition. The ignition selector was then set to the position for starting with direct current, and a new start attempt was made.

The renewed start procedure of the right engine was initially normal, but when the engine ignition occurred a couple of flames appeared in the engine exhaust pipe, a so-called tailpipe fire⁶. The person in the de-icing vehicle saw this, but thought that it involved no risk of fire because the flames were temporary and went out spontaneously. The person had at some previous occasions seen tailpipe fire during engine start, which caused neither fire nor damage to the airplane or engines. The pilots were not aware of the flames during engine start, which in other respects was normal.

However, during start of the right side engine, some passengers in the forward cabin shouted – “fire, fire”. The Senior Cabin Crew Member⁷ and one other cabin crew member⁸, who were at the airplane door and service door respectively in the forward cabin, tried to assess the situation, by trying to look backwards into the cabin and by looking out through the inspection window in the service door. A number of passengers in the forward cabin had however already risen from their seats and were moving forward towards the airplane exits. At this time the right side engine was running in idle.

The aisle was now blocked and prevented the cabin crew to view the rear part of the cabin, and the field of vision through the inspection window in the door was too narrow to allow inspection of the right side engine and the surrounding area. It was therefore not possible for the cabin crew in the forward cabin to find out if a fire had occurred in or outside the airplane, or if other hazards existed. The cabin crew at the front doors therefore found it safer to evacuate the aeroplane after the alert from the passengers. The aeroplane's two front doors were opened and the evacuation slides⁹ were deployed automatically.

In preparation for starting the left side engine the Commander heard, through the open door to the cabin, that the airplane's front doors were opened and the evacuation slides were inflated. It then became obvious to the Commander that an emergency evacuation was initiated and the right side engine was shut

⁶ Tailpipe fire – a fire of short duration in the exhaust part of the engine

⁷ Senior Cabin Crew Member – SSCM or C/A 1

⁸ Cabin Crew Member – CCM, and specifically C/A 2, C/A 3 or higher number

⁹ Evacuation slide – inflatable slide for emergency evacuation of the aeroplane

down with the "Fire Switch¹⁰". No warning or other indications of fire occurred in the cockpit and the engine fire extinguishing system was not activated. The Commander informed the air traffic control tower that the airplane was being evacuated because of a possible fire in the right side engine.

Passengers sitting near the right side engine's rear part saw flames, and cried out "fire, fire". There was a confused situation in the rear of the cabin and the passengers left their seats and began to move rapidly towards the front of the airplane.

The third cabin crew member was in the airplane's rear part. That person had observed a flame from the right side engine during the engine start, and even a small liquid stain on the ground, about the same size as half an A4 page, which burned. The fire was however quickly extinguished, and since no other hazards existed according to that person's judgement, no emergency evacuation was initiated in the rear part of the cabin.

An emergency window exit on the airplane's left side was opened by passengers, but no one evacuated through it. The emergency exit door was left inside the airplane. The emergency folder of the airplane showed that the emergency door should be thrown onto the ground through the opening. The wing was covered with the jelly-like anti-icing fluid, which made the wing look slippery.

The passengers and crew left the plane on the evacuation slides on both sides of the airplane and were directed to the terminal building, where they were taken care of by staff. No one was injured during the evacuation.

1.2 Injuries to persons

	<i>Crewmembers</i>	<i>Passengers</i>	<i>Others</i>	<i>Total</i>
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	5	140	–	145
Total	5	140	–	145

1.3 Damage to the aircraft

No damage.

1.4 Other damage

None.

1.5 Crew information

1.5.1 Commander

The commander was 45 years old had a valid ATPL (A) - license.

<i>Flying hours</i>			
<i>latest</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	~	78	10 700
This type	~	45	3 400

¹⁰ Fire-switch – a lever which cuts the supply of fuel and hydraulic power to the engine, and for activation of the engine fire extinguishing system

Number of landings this type previous 90 days: 30.
 Flight training on type concluded on 26 February 2002.
 Latest Proficiency check (PC) was carried out on 24 October 2009.

1.5.2 Co-pilot

The Co-pilot was 30 years old at the time and had a valid CPL (A) - license.

<i>Flying hours</i>			
<i>latest</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	1:38	174	2 500
This type	0	104	2 200

Number of landings this type previous 90 days: 56.
 Flight training on type concluded on 22 November 2005.
 Latest Proficiency Check (PC) carried out on 31 January 2009.

1.5.3 Cabin crew members

1 Senior Cabin Crew Member and 2 Cabin Crew Members.

1.5.4 The crew members' duty schedule

The Commander was on his first day of planned three, and had a rest period of 65 hours before the incident. The first officer was on day three of four and had a rest of 22 hours before the incident.

The duty times of the crew are within the limits in the Operator's Manual Part A¹¹, (OM Part A), of revision date 15 August 2009.

1.6 Aircraft information



Fig. 1. Boeing 737-33V, LN-KKD.

¹¹ OM Part A – the operator's flight operational handbook for pilots

AIRCRAFT	
<i>TC-holder</i>	The Boeing Company
<i>Type</i>	373-33V
<i>Serial number</i>	29339
<i>Year of manufacture</i>	1999
<i>Gross mass</i>	Max authorised takeoff/landing mass 62 822/52 888 kg, actual 59 400 kg
<i>Seating capacity</i>	148
<i>Total flying time</i>	29 242 h
<i>Number of cycles</i>	24 761
<i>Fuel loaded before event</i>	10 200 kg

ENGINE		
<i>TC-holder</i>	CFM International S.A.	
<i>Model</i>	CFM 56 – 3C-1	
<i>Number of engines</i>	2	
	<i>EngineNo 1</i>	<i>No 2</i>
<i>Total operating time, hrs</i>	24 149	24 014
<i>Operating time since overhaul</i>	386	135

The aircraft had a Certificate of Airworthiness and a valid Airworthiness Review Certificate.

1.7 Meteorological information

METAR¹² Arlanda at 08:20. Wind 080 degrees, 5 kt, visibility 1.7 km, vertical visibility 700 feet, temperature -4 °C, dew point -5 °C, QNG 1004 hPa.

Weather conditions at 08:38 LMT, were the same as above.

1.8 Aids to navigation

Not applicable.

1.9 Communications

A printout of the radio communication between the air traffic control and the fire and rescue service at the airport has been safeguarded, as well as a list of steps taken by both the fire and rescue service at the airport and the municipal fire and rescue service.

1.10 Aerodrome information

The airport was an instrument airport with runway code 4E, according to AIP¹³ -Sverige/Sweden. The airport had fire and rescue services of Category 9 with three stations.

¹² METAR – METeorological Aerodrome Report – regular meteorological report from airport

¹³ AIP – Aeronautical Information Publication – information material for aviation published by LFV

1.11 Flight recorders

Data were not safeguarded.

1.12 Site of occurrence

1.12.1 Site of incident

On Apron D at Terminal 2, outside gate 63, at 59 38 42N 017 55 33E, 31 m above sea level, see Fig. 2.

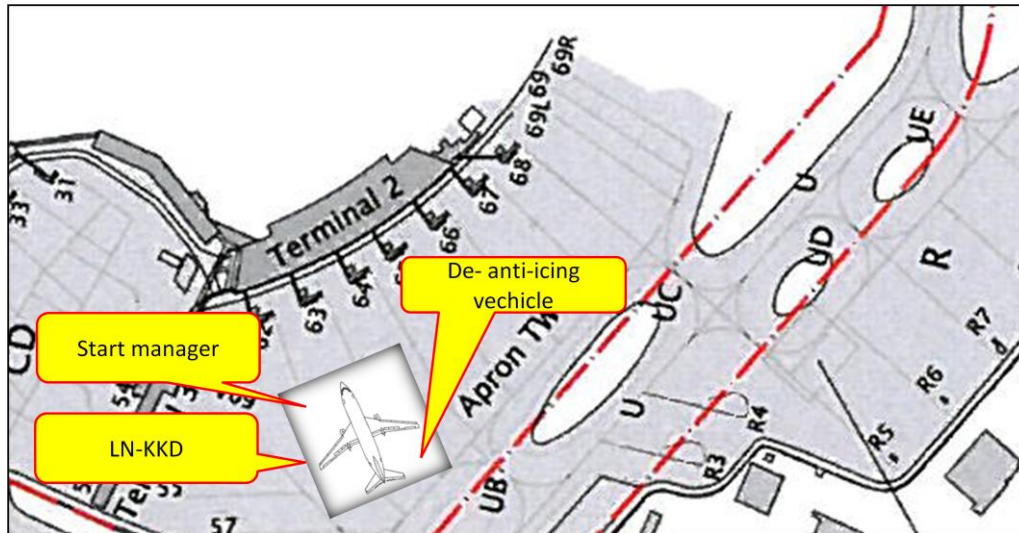


Figure 2. Magnified part of the Arlanda airport map of LFV AIP Sweden showing the positions of the airplane, de-icing vehicle and ground staff at the incident.

1.12.2 Videorecording of the incident

The later phase of the airplane's evacuation has been registered by airport surveillance cameras. The recording was made available to SHK.

1.13 Medical information

Nothing indicates that the mental and physical condition of the crew members has been impaired before or during the flight.

1.14 Fire

Fire flames burst momentarily out from the rear part of the right engine during engine starting. A small amount of fuel had leaked onto the ground and formed a pool of about 15 cm in diameter. The fuel was ignited, but the fire was short-lived and extinguished without action.

1.15 Survival aspects

1.15.1 General

The Emergency Locator Transmitter (ELT) was not activated.

1.15.2 *Rescue service*

An accident alarm was triggered by the air traffic control after a radio call from the airplane about evacuation because of a possible fire on board.

The airport fire and rescue vehicles arrived at the airplane about a minute after the alarm. The municipal fire and rescue services, who were alerted by the SOS center, arrived at the site ten minutes after the alarm. The airport's fire and rescue services assisted in the evacuation. No other efforts were required by the rescue units.

1.16 **Tests and research**

1.16.1 *The crew*

SHK has interviewed all the crew after the incident. The crew consisted of a Commander and co-pilot who were employed by the Norwegian branch of the company. The Senior Cabin Crew Member, C/A 1, was employed by the Swedish branch of the company, while the other two cabin crew members, C/A 2 and C/A, 3, were employed by Proffice Aviation AB. The company was in the process of integrating all the crew to the Norwegian branch of the company.

1.16.2 *The cabin crew's description of the evacuation*

The planned flight was a morning service to Nice in France. The passengers carried a lot of hand luggage, and there was very much catering on board in different units and cabinets. The cabin crew routinely checked that no disabled persons or children were seated at the emergency exits.

The safety demonstration was performed manually and covered standard information according to OM Part B - CCM¹⁴. C/A 1 was located in the forward part of the cabin, C/A 3 in the middle and C/A 2 in the rearmost part of the cabin. C/A 2 was giving the oral information, which is also according to procedures in OM Part B - CCM. During the safety demonstration the sound from the cabin speakers disappeared and it became almost dark in the cabin.

When the safety demonstration was interrupted the C/A 3 went through the aisle to C/A 2 in the rear of the cabin and heard a passenger saying, "this does not feel okay". After that C/A 3 went to the forward cabin and asked the Commander to inform the passengers about the situation. The C/A 3, also tried to contact C/A 2 via intercom, but did not succeed since it was out of order. The Commander announced that they might go back to the gate.

C/A 3 was in the forward cabin and talking to C/A 1 when a passenger said "it's burning, we must get out". The passengers were standing in the aisle and some were moving forward in the cabin. C/A 3 looked out the inspection window in the service door but could not see any fire, and thereafter opened the door to activate the evacuation slide. The inspection window in the service door is small and the field of vision is limited, see Figs. 3 and 4. C/A 3 was of the opinion that there were many problems with the intercom on this airplane type.

When C/A 1 heard about a fire, C/A 1 tried to reach the halon fire extinguisher that was in the hatrack at the second and third seat rows. It was however not possible to reach it, since the passengers were standing in the aisle and were

¹⁴ OM Part B – CCM – Operations Manual Part B, Cabin Crew Manual – operator's manual for the cabin crew

leaving the plane via the service door, which had been opened by C/A 3. Furthermore, it was not possible for C/A 1 to reach the megaphone that was placed in a locker at the main entrance. C/A 1 therefore opened the main door and started the evacuation even that way.

Neither the C/A 1 nor C/A 3 signalled to the flight deck about the evacuation, but the door to the cockpit was open and they presumed that the Commander was aware that an evacuation was initiated. C/A 1 considered the evacuation as calm and controlled, but that it was difficult to get passengers to stay at the slide to assist those coming after, a request which had to be repeated to several passengers.

According to C/A 1, an evacuation was the only possibility in this situation when the passengers were standing and calling out on fire, while they moved forward in the cabin. The C/A 1 considered it to take far too long to locate and extinguish a fire, so the quickest and safest was to evacuate the airplane as soon as possible.

C/A 2 was placed in the rear part of the airplane facing backwards when a loud abnormal noise was heard. Then C/A 2 heard a passenger yelling "there is a fire in the engine" and pointing out on the ground. C/A 2 walked up and looked out and saw what looked like a round piece of paper, about 15 cm in diameter, on the ground in the snow burning. Nothing seemed abnormal with the engine. C/A 2 experienced the situation as stressful with passengers standing and moving in the aisle. C/A 2 tried to contact the cabin crew in the forward cabin, but the intercom was out of service. Since C/A 2 could not see any fire, C/A 2 tried to calm passengers. Shortly thereafter C/A 2 noticed that the front door was open and that the passengers were on their way out and assumed that the airplane was back at the gate. At that time C/A 2 was not aware of an evacuation was underway.

C/A 3 walked to the rear part of the cabin towards C/A 2, and told passengers to leave their hand luggage on board. When C/A 2 passed by the wing it was noted that the window emergency exit on the left side was open, and soon after that the evacuation slides in the forward cabin were deployed. Only then did C/A 2 realize that an evacuation was going on and thought "why haven't I evacuated?" Coming out of the plane C/A 2 was surprised that the fire and rescue service was there, and they asked why they had not evacuated by the rear doors. C/A 2 felt it was unpleasant to be in the rear of the plane without being able to communicate with the other cabin crew, or knowing that an evacuation was initiated. At the incident in question, C/A 2 was also responsible for an unaccompanied child, but could not come forward in the cabin to take care of the child during the evacuation.

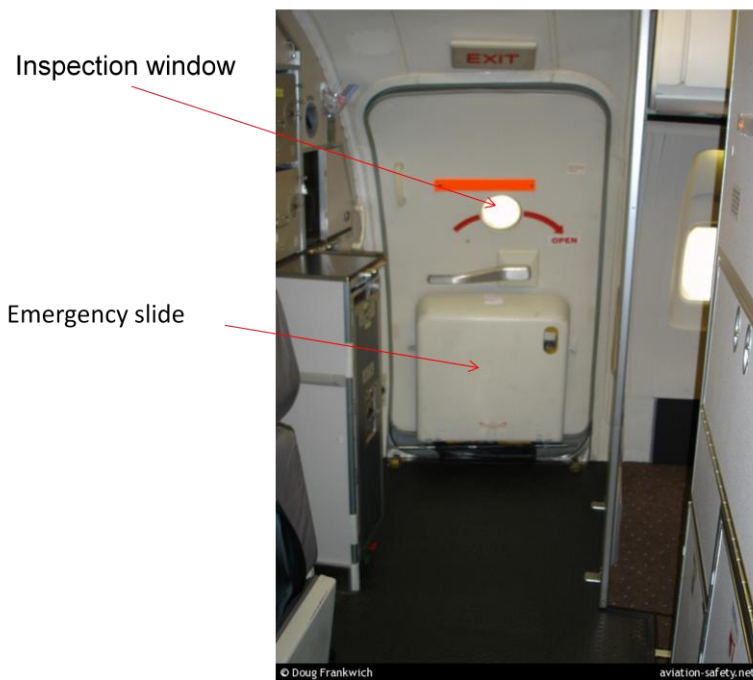


Fig. 3. The service door on the right side of the airplane.

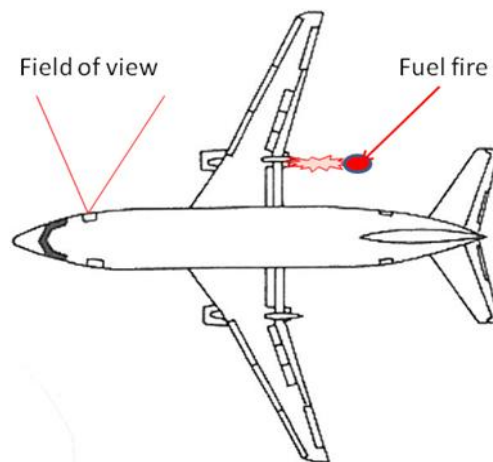


Fig. 4. Approximate field of vision from the inspection window in the service door and the approximate location of the transient fire on the ground.

According to the crew procedures for an emergency evacuation, the Doctor's kit¹⁵ and flashlights should be carried by the cabin crew when they leave the airplane. In this situation it was agreed that this was not necessary as no one was injured and most passengers were already inside the terminal building.

1.16.3 *The pilots' description of the evacuation*

Neither the Commander nor the co-pilot were aware of the situation that the airplane was being emergency evacuated until they heard the sound of the inflating evacuation slides.

¹⁵ Doctor's kit – a rescue kit with containing more than an ordinary first-aid kit

1.16.4 Initial and recurrent training of emergency situations and evacuation

The training is based on classroom instruction using manuals and checklists. Pilots and cabin crew members are trained together in various scenarios in a cabin simulator. The crews are trained both to prepare the airplane and the safety equipment prior to a planned emergency landing with evacuation and actions after an unexpected emergency situation.

In the cabin crew's Manual, OM Part B - CCM, it is described how an evacuation should be conducted. If no signal to evacuate is given by the Commander or co-pilot, and there is an obvious emergency such as fire, smoke, or a peculiar attitude or position of the airplane, the senior cabin crew member or another cabin crew member should verify that the engines are turned off, signal to the Commander with 5 chimes¹⁶ and initiate an evacuation.

The cabin crew checklist for emergency evacuation (Evacuation Procedure) implies that the cabin crew members are at their ordinary work stations. In a cabin crew of, as in this case, three C/As, the C/A 1 is supposed to open both the cabin and service door, C/A 2 should open the left rear door and C/A 3 the rear door on the right side, see Figure 5.

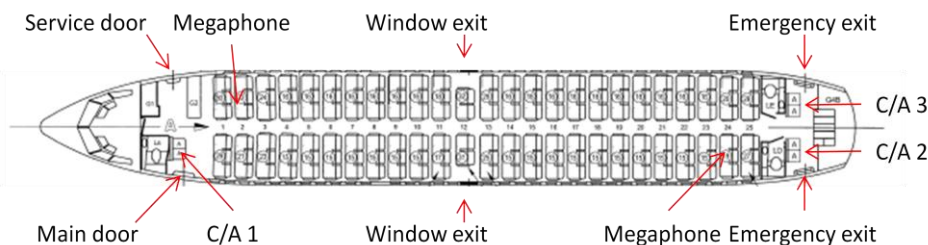


Fig. 5. Location of emergency exits and megaphones, and the work stations of the cabin crew members on take-off and landing.

In the pilots OM Part A, there is a similar text about evacuation as in OM Part B – CCM.

There were no procedures in OM Part B - CCM as to how the cabin crew should communicate with each other if the intercom is unserviceable. Nor were there any examples of situations when the intercom and PA¹⁷- systems are not useable. According to the operator it is, however, instructed at the emergency training that megaphone or voice announcement should be used if the PA system is unserviceable. There were two megaphones on board, one at the second – third seat row in the right hand hatrack in the forward cabin, and one in the left hand hatrack at the second left seat row in the aft cabin.

Each cabin crew member has their own paper copy of the OM B - CCM, which is revised and provided to the cabin crew members once a year. Between the revisions updates may be provided by e-mail.

Suggestions and comments from the interviewed cabin crew members

The interviewed cabin crew members made the following comments and suggestions for improving emergency education and training:

¹⁶ Chime – bell tone signal given from cockpit or cabin crew switch panel

¹⁷ PA-system – Passenger Address system – loudspeaker system for announcements in the cabin

1. Information and training on tailpipe fire.
2. Training of events that can occur while the airplane is on the ground.
3. Procedures for communication and announcements in cases of failure on normal communication systems.
4. More effective control of the size and amount of hand luggage taken on board.
5. Special review of safety issues with passengers sitting at emergency exits as part of the normal procedures before flight.

Comments from the Swedish based cabin instructors after the incident

The Swedish based cabin instructors wish they had got a little faster and more detailed information about the incident, both to answer questions during the training carried out after the incident, but also to plan the appropriate new elements in future courses and trainings. They also felt that the Norwegian based instructors had received more information about the incident.

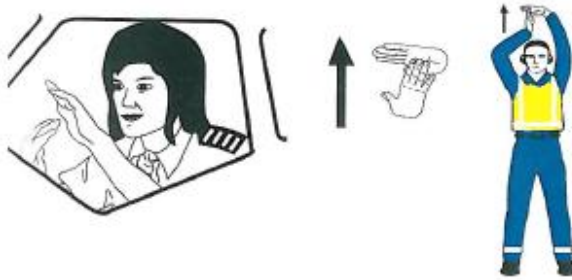
They also stated that different requirements apply to become a senior cabin crew member in the Norwegian and Swedish branches of the company. In the Norwegian branch one could become senior cabin crew member after working as cabin crew member for a minimum of 1 year, while in the Swedish branch 3-5 years experience was required.

1.16.5 *The ground services*

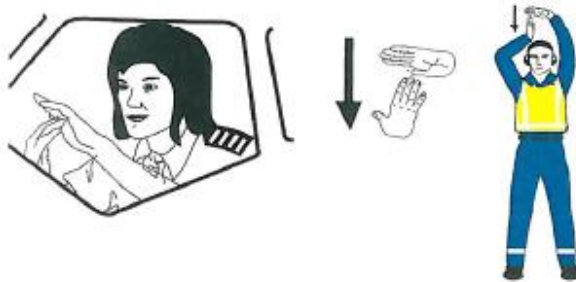
Norwegian had an agreement with Nordic Aero AB on ground service. The agreement included the services: passenger check-in, boarding, loading and unloading of luggage, water and toilet servicing, de/anti-icing of airplane exterior, push back, and monitoring the airplane during engine start. In connection with departure of a flight, 2 - 4 people from the Nordic Aero AB normally worked around the airplane, while others worked in the passenger check-in and boarding gate.

Nordic Aero AB provided specific education and training for staff who served on the ground outside the airplane at departure and arrival. The training material described hand signals that should be used in different situations. For example, signals for connection and disconnection of ground power were shown, Fig. 6, and for engine start, Fig. 7.

Markström



Connect groundpower / Groundpower connected.



Disconnect groundpower

Fig. 6. Hand signals for connection and disconnection of ground power in the Nordic Aero AB's training materials.

Uppstart

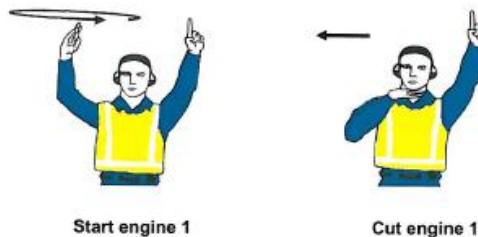


Fig. 7. Hand signals for starting and stopping of engines in the Nordic Aero AB's training materials.

Engine start using hand signals to the Commander was sometimes used for various reasons in both the Norwegian and other flight operator's departures that Nordic Aero AB managed.

During the engine start, the start manager was standing in the Commander's field of vision on the left side of the airplane, with the task of giving the go-ahead sign for engine start and to monitor the starting process. He was from this location not able to see the right side engine, and therefore saw no flames.

In AOM Part B it was stated that the staff monitoring engine start should be visible to the Commander during the start sequence and assure that the area

around the airplane was free of obstacles. There was also a description of AOM Part B of standardized signals for engine start similar to those in the Nordic Aero AB's training material. There was, however, no description of hand signals in the Norwegian's AOM Part, B for connection and disconnection of ground power, and no signs for fire.

At the time of the incident no hand signal for fire was specified in the Transport Agency's BCL-T¹⁸ - LFS¹⁹ 1990:14.

The person in the de/anti-icing vehicle on the airplane's rear right side, stated that two short-lived flames came out from the right side engine's exhaust during the engine start. Over approximately six years of service this person had seen tailpipe fire at 2 - 3 times, all of which had been of short duration and not a reason for alarm. There were no instructions on reporting to the Commander of conditions other than those related to the de/anti-icing service for the de/anti-icing staff.

1.16.6 The airplane

Tailpipe fire for this type of engine

A tailpipe fire is an internal fire in the engine, which can occur if unburned fuel remains in the combustion chamber, turbine, or exhaust pipe at engine start. The fuel can be ignited either by the engine's ignition system, or by hot gases and details in the engine. A tail pipe fire can occur if a start attempt failed, for example, because of low engine rpm when the ignition is activated, or if the ignition switch is set incorrectly. A short lived tailpipe fire does not normally cause damage to the engine and it does not cause fire a warning on the instrument panels. The recommended procedure in the airplane checklist, with venting of the engine, should ensure that excess fuel is expelled and that any internal fire is extinguished by the air flow through the engine. If the engine fire extinguishing system is activated after a tailpipe fire, the ventilating of the engine is not possible, since the starter becomes deactivated.

Danger area around the running engine

The fuel supply to the airplane's right engine was cut but the engine's internal parts were still rotating, when the first passengers slid down on the ground. According to the airplane manufacturer's diagram, the danger zone in front of a running engine is a semicircle of 10 feet (3 m) radius, Figure 8. The distance between the service door opening and the front of the engine is about 6 m.

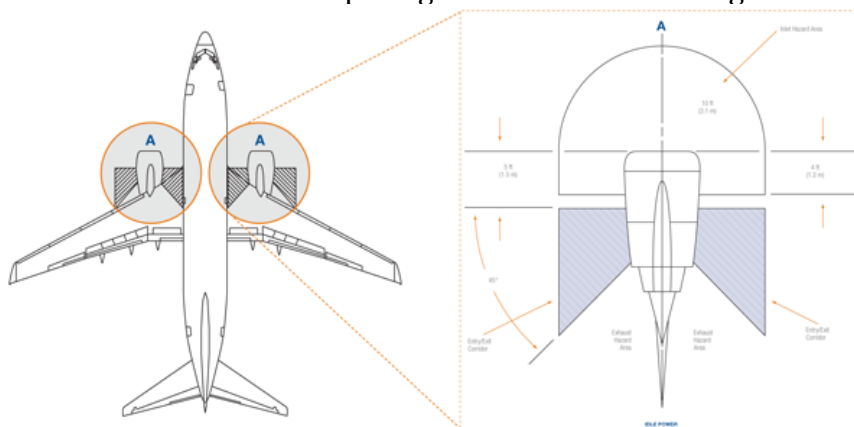


Fig. 8. Danger areas around running engines for Boeing 737.

¹⁸ BCL-T – Bestämmelser för Civil Luftfart - Trafikregler – Swedish regulations for civil aviation – Rules of the Air

¹⁹ LFS – Luftfartsverkets Författningssamling - Swedish regulations for civil aviation

1.16.7 *The operator's actions after the incident*

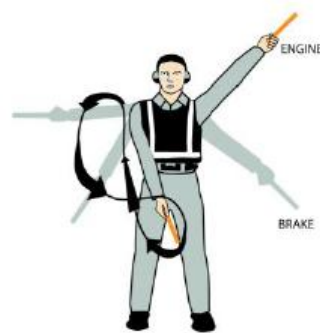
The operator's policy was that the crew should not continue flight duty the same day after an emergency. A crew member could, however, continue flight duty after own assessment of the health state. The cabin crew went off duty after the incident, while the pilots flew the airplane without passengers to Oslo for the restoration of emergency equipment.

At the briefing that the operator had with two of the cabin crew a couple of weeks after the incident, a video on tailpipe fire was shown. The third cabin crew member was on holiday at that time and had not been offered a similar review at a later date.

In the spring of 2010, the operator conducted a seminar for the cabin crew instructors in which the recurrent training was evaluated and the incident was discussed with respect to changes in the handbooks on instructions, rules, education and training.

1.16.8 *The Swedish Transport Agency's actions after the incident*

SHK notes that in the regulations of the Swedish Transport Agency and general advice on the rules of the air, TSFS 2010:145, Appendix 5, paragraph 21. Fire, hand signals for fire are established, Figure 9. The regulation came into force on 1 November 2010.



21. Brand

Rita åttor i luften med den högra spaden. Rörelserna ska gå från axel till knä. Peka samtidigt på området för branden med den vänstra spaden.

Fig. 9. Hand signals for fire. (TSFS 2020:145, Appendix 4, paragraph 21).

1.16.9 *Passenger's reactions after the incident*

Many passengers ran away from the airplane after sliding out on the slide, not staying to help the passengers who came after them. When the passengers and crew had entered the terminal building, the Commander informed about what had happened and how the passengers would be taken care of for the onward journey. There was also an opportunity for the passengers to ask questions. The crew also went around among the passengers and talked with them about the incident. Many passengers praised the commander's information about the incident and the cabin crew also considered the Commander's information to the passengers was excellent.

1.17 The operator's organisation and management

Norwegian was in strong expansion at the time of the incident and was in 2009 the fourth largest low cost airline with more than 10 million passengers and flights to more than 90 destinations.

Norwegian operated more than 50 Boeing 737 airplanes in two versions, both the older 737-300 and the new-generation 737-800. The crews were operating on both versions. Norwegian also had orders for about sixty new Boeing aircraft for delivery during the period 2008 - 2014.

The operator had two operating licenses: on Norwegian (ICAO: NAX) and a Swedish (ICAO: NDC). An AOC²⁰, is an operating authorization granted by a country's aviation authority, which gives the holder the right to conduct commercial flight operations. The operations took place exclusively on the Norwegian operating license at the time of the accident.

The operational management was located in Oslo, while there was an administrative function at the Stockholm base. The crews were stationed at bases in either Oslo or Stockholm.

Some theoretical training for the crews, e.g. emergency training, could be performed at the Stockholm base, while all the practical training was carried out in Oslo.

1.18 Additional information

1.18.1 Gender issues

The occurrence has also been examined from a gender perspective, i.e. against the background that there are circumstances which suggest that the actual occurrence or its effects were caused or influenced by men and women not having the same opportunities, rights and obligations in various respects. Such circumstances were not found.

1.18.2 Environmental aspects

No environmental damage was caused by the incident.

2 ANALYSIS

2.1 The flight²¹

2.1.1 General

Engine start without AC power supply of the aircraft is more cumbersome and time consuming than starting with access to AC power from the APU or ground supply. This is partly due to that some checks and preparations of the flight cannot be performed without AC power. It is therefore understandable that the pilots were keen to get AC supply in the aircraft for engine start, by connecting the APU generator when ground power was disconnected. SHK

²⁰ AOC – Air Operator's Certificate

²¹ Flight - from the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked

considers that there was no increased flight safety risk to test the function of the generator at the gate.

It can for various reasons happen that an APU generator spontaneously cease to function under conditions similar to this flight, so it is important for crew members to be prepared and trained for the consequences of a loss of AC power. A tailpipe fire could also occur for various reasons and lead to unexpected situations and acts that are more risky than the phenomenon of tailpipe fire itself. Investigation and analysis of the events in this incident are therefore urgent and should lead to both increased knowledge and attention to improving training for both crew and ground staff.

2.1.2 *Flight preparations at the gate*

It is an established procedure, both in the airline and ground handling company manuals, to use hand signals between ground staff and Commander if communication with the headset cannot be established. Similar procedures exist in many other air operators' contracts and procedures for handling of aircraft in connection with departure and arrival.

The disconnection of ground power was neither signalled by the ground staff nor agreed by the pilots. This did not directly influence the occurrence, but was still a distraction in the preparations for departure. It is noted that hand signals for connection and disconnection of ground power were not described in the Norwegian's pilot manual, AOM Part B. However, it is an established routine that communication should occur between the pilots and ground staff when ground power is disconnected.

2.1.3 *The engine start*

When the pilots found that the selector switch for engine start was not set for the start on DC, the procedure for the ventilation of the engine at a failed start attempt was performed. Despite this, a tailpipe fire occurred, indicating that there still was unburned fuel in the combustion chambers, or in the surrounding area. The reason for this could not be determined, but it is known that small amounts of fuel also for other reasons may remain in the engine at engine start.

During the start of the right side engine the start manager was, according to the instructions for hand signalling, standing on the airplane's left side to have eye contact with the Commander, and therefore could not see the right side engine during start. If the headsets were used for communication between ground and the airplane the start manager would have had more freedom to move around the airplane and monitor both engines while still having contact with the Commander. The start manager would in that case have had a better possibility to discover that a tailpipe fire occurred and also the small liquid fire on the ground. The Commander could then rapidly have been informed of this.

The operator of the de-icing vehicle had however radio contact with the airplane and saw the flames. For this person there was thus an opportunity to inform the Commander of the flames. The person's experience was however that a tailpipe fire is a short-lived phenomenon that does not cause danger or risk of engine damage, since the airplane previously observed affected by the tailpipe fire continued the flight without technical measures. Furthermore, it was not in the job description of the de/anti-icing staff to monitor engine starts.

It is not evident that the Commander would have acted differently if he had information about the short lived tailpipe fire, and the seemingly minor fire on the ground that quickly extinguished by itself. Nor would the Commander have had enough indication to justify an emergency evacuation of the airplane in that situation.

2.2 The emergency evacuation

The emergency evacuation was initiated by the cabin crew when they received an unspecified alert from passengers about fire and assumed that it could be a cabin fire. Even if the Commander had been aware that a tailpipe fire occurred, it is not obvious that he would have ordered to abort an emergency evacuation that the cabin crew initiated because of suspicion of a cabin fire.

However, the chain of events could have been different if the Commander immediately had received information that a short lived tailpipe fire and a self-extinguished small fire on the ground occurred. Information from the Commander via the speaker system on the phenomenon had probably calmed passengers and giving the cabin crew a better opportunity to assess the situation both in and outside the airplane. The cabin crew would also have stronger authority to prevent or mitigate the uncontrolled reaction that arose from the passengers.

With exclamations of fire from the passengers, the situation in the cabin was very difficult to assess by the cabin crew. Fire in an aircraft cabin is always a very serious situation and lethal gases and temperatures may develop within minutes of a developed fire. The situation thus demands that immediate steps be taken for fire fighting or evacuation of the aircraft where possible.

When the passengers alerted about the fire and began moving toward the exits the situation was unique and stressful for the cabin crew. In the current weak light in the cabin and lack of means for internal communication between the front and rear of the airplane as well as the possibility for loudspeaker announcements, there were limited possibilities to determine the location and extent of danger. It is therefore understandable that the airplane was evacuated on the basis of the information available for the cabin crew.

A deviation from the OM Part B CCM described procedure for the initiation of evacuation is however noted, namely that the signal to the Commander about initiating an evacuation did not occur. The signal of five "chimes" would have made the Commander aware that an evacuation had begun on cabin staff initiatives. This gap must however be considered in the light of the cabin crew's ambition to urgently evacuate the airplane and rescue the passengers from fire. Contributing factors were also that stressed passengers were already at the doors and to some extent prevented access to the signal button. The cabin crew also assumed that the Commander, through the open door to the cockpit, had comprehended that an evacuation was underway.

SHK also notes that there was no possibility for the cabin crew to inspect the right side engine through the service door inspection window since the field of vision was too narrow. Without opening the door, there was no possibility for the cabin crew in the forward part of the cabin to determine if there was a fire in the area around the engine.

SHK further notes that since the airplane was not ready for flight, the cabin crew was not at their ordinary work stations. For that reason both C/A 1 and

C/A 3 operated the forward doors, instead of C/A 3 normally operating the rear right side door. However, there was neither possibility nor reason for C/A 3 trying to reach the airplane's rear part, in the situation that prevailed. The sequence of events could possibly been different if C/A 3 had stayed at the normal work station when the passengers alerted about fire. C/A 2 and C/A 3 together would have been in a better position to evaluate if there was a hazardous situation, and thereafter try to calm the passengers in this part of the cabin.

The Commander closed the fuel supply to the right side engine by opening the "fire switch", when the sound of the slide inflation was heard in the cockpit. It is probable that internal parts of the engine rotated when the first passengers came down on the ground. There was however no combustion in the engine and the engine rotation was declining. The distance between the slide and the engine was greater than the danger area in front of the engine and there was no imminent risk of injury due to engine rotation.

Since the cabin intercom system and the passenger announcement from the cabin were unserviceable, the only means for communication and directing the passengers were by megaphone or voice. The access of the megaphone that was placed in the forward of the cabin was limited by passengers standing in the aisle. The megaphone in the aft part of the cabin was probably accessible to C/A 2, but the need to use it was not obvious.

To C/A 2 it appeared first priority to calm the passengers in the airplane's rear part and try to convince them that no danger existed according to C/A 2's assessment. It would have been possible to use the megaphone and call C/A 1 and C/A 2 that no fire or danger existed in the aft area, but C/A 2 was not aware that an evacuation was initiated because of suspicion of fire. C/A 2 also assumed that the airplane had returned to the gate, according to the Commander's announcement. It can generally be fatal if a C/A, not knowing if a fire or other hazard exists in a different part of the cabin, trying to stop an on-going evacuation.

SHK notes that the window emergency exit door on the airplane's left side, was opened by the passengers, and placed on the seats near the emergency exit and not thrown out on the ground as shown on the emergency briefing card. This indicates a lack of knowledge or understanding of emergency procedures of the person who opened the exit. The reason that the door should not be placed inside the airplane is that it may prevent passage to the emergency exit. It is known that some operators conduct a special review of emergency procedures with persons who sit at emergency exits. In this way ensuring that procedures for opening of emergency exits are known and understood by passengers who are expected to assist with an evacuation of the aircraft.

Several passengers delayed the evacuation by bringing hand luggage and other belongings before leaving for the exits. In this incident it had no effect on the outcome, but it shows the need for clear instructions and command in the emergency evacuation of the airplane.

2.3 Initial and recurrent training of emergency situations

The investigation shows that the incident was preceded by several factors, each of which was known and included in both initial and recurrent emergency training of crews.

The study however also shows that there is room for a general review of the training. Specifically of emergencies when the airplane is on the ground, at a stage before all preparations for take-off have been completed, and the cabin crew are not at their normal work stations.

Knowledge and understanding of how different technical faults might adversely affect the normal system of communication between crew members and access to passenger announcement should also be given more emphasis in the training.

Alternative methods for communication between cabin crew members in situations when the intercom system is unserviceable should be developed and trained, as well as how to manage stress- and panic situations among passengers in the cabin.

3 CONCLUSIONS

3.1 Findings

- a) The pilots were qualified to perform the flight.
- b) The cabin crew was qualified to perform the duty.
- c) The operator possessed a valid AOC.
- d) The airplane had a valid ARC.
- e) The airplane had a remaining complaint on the APU-generator working intermittently.
- f) Short lived fire flames occurred in exhaust during start of right side engine.
- g) The ground crew was qualified to perform the duty.
- h) The ground crew did not signal to the flight crew about disconnecting the ground power.
- i) The AOM Part B did not include hand signals for connection and disconnection of ground power.
- j) The ground crew did not use headsets for communication with the pilots.
- k) The crew in the de/anti-icing vehicle was aware of the flames.
- l) Hand signal for fire was missing in LFS.
- m) The emergency evacuation of the airplane was initiated by the cabin crew without communication with the pilots.
- n) The window exit door on the left side was opened and placed inside the airplane.
- o) The evacuation was delayed by passengers bringing hand luggage and belongings before evacuating.

3.2 Cause

The serious incident to personal injury at the unexpected evacuation of the aircraft was caused by that the cabin attendants were unable to control or prevent the course of events in the cabin, when spontaneous calls about “fire” had started a reaction among the passengers.

4 RECOMMENDATIONS

The European Aviation Safety Agency is recommended to:

- consider the need for improved initial and recurrent training of crews in emergency situations on the ground, especially before the aircraft is ready for flight, and consequences of failures of electrical systems that affect the aircraft's internal communication systems (RL 2011:10 R1).
- consider the need for expanded information and checking of understanding emergency evacuation procedures, of passengers who are expected to act in emergency evacuation of aircraft (RL 2011:10 R2).