GENERAL INFORMATION

Identification number:	2004009
Classification:	Serious incident
Date, time[1] of occurrence:	3 February 2004, 17.50 hours
Location of occurrence:	En route from Amsterdam to Copenhagen
Aircraft registration:	OY-KGT
Aircraft model:	Boeing McDonnell Douglas MD-82
Type of aircraft:	Passenger aircraft
Type of flight:	Scheduled passenger flight
Phase of operation:	Cruise
Damage to aircraft:	Minor
Cockpit crew:	2
Cabin crew:	4
Passengers:	78
Injuries:	None
Other damage:	None
Light conditions:	Dusk

SUMMARY

The aircraft made an emergency return due to a malfunctioning in a cabin light system, resulting into smoke in the cabin. Though the production of smoke stopped, the cabin was secured and prepared for an emergency landing whereupon the aircraft landed safely. The investigation revealed a deficiency in the emergency checklist, impairing safety in case of smoke or fire from electrical origin.

FACTUAL INFORMATION

About 20 minutes into the flight from to Copenhagen Kastrup Airport one of the four cabin attendants on board reported smoke from the overhead bin in the aft cabin. The crew declared an emergency to air traffic control ('mayday call') and the aircraft immediately turned back to Amsterdam Schiphol Airport. The first officer inspected and verified smoke from the reading light area on the right side of seat rows 27-29. Circuit breakers of the reading lights in the cockpit were pulled although the smoke had already stopped. Besides circuit breakers of the reading lights also circuit breakers of the upper and lower sidewall cabin lights exist in the cockpit.

During the remainder of the flight the passengers were briefed and some of them reseated. The cabin was secured and prepared for an emergency landing. The landing was uneventful and while taxiing to a remote parking area the aircraft was escorted by vehicles of the fire and rescue department. After all passengers and crew had disembarked, the aircraft was inspected by the fire brigade for fire.

[1] All times in this report are local times unless otherwise specified.

During a technical inspection of the aircraft engineers found a burnt ballast[2] of a set of sidewall tubular lamps (TL) in the aft cabin near seat rows 27-28.

INVESTIGATION AND ANALYSIS

The initial notification to the Dutch Safety Board was received one day after the incident. Because the crew and the aircraft had already left the Netherlands no investigation on site was possible. As a consequence this report is primarily based on factual information supplied by the technical handling agent (ground engineers), the Boeing Company and the involved operator. The operator is home based in three countries and its aircraft are registered Norwegian, Danish and Swedish. This also implies that oversight on the operator and aircraft is carried out by the civil aviation authority of each country.

The failed ballast
The ballast design of the TL assemblies, that were built in prior to August 2001, employed a capacitor (C3) with a high "dissipation factor" which overheated sometimes in operating conditions. The manufacturer conducted tests under different environmental conditions in an attempt to duplicate the ballast failures.

A series of tests were specifically performed to investigate the ability of the capacitor to withstand excessive ripple voltage, as this seemed to be one of the possibilities to overstress the capacitor, but the reported failures could not be replicated. However, the ballast manufacturer determined that a higher than normal ripple current probably caused the failures. Dielectric breakdown of the component is unlikely to be the initial cause of the failure, but once the capacitor starts to heat, the dielectric fails and the overheating is sustained until the input fuse opens to remove the source power. In all reported cases of overheating of the capacitor the ballast's internal protection systems detected the abnormal condition and shut itself down before any damage could occur. Due to the overheating an odor is produced before any smoke becomes visible.

The ballast is equipped with several protection features: for lamp faults, for filament faults, input protection, over-voltage protection, over-temperature protection and control line protection. The ballast is also equipped with a temperature detection circuit to monitor the unit sidewall temperature. It will shut down when the case temperature exceeds a safe level. If this circuit fails, the ballast fails safe by blowing the input fuse. Faulty connections at the interface may trip the circuit breakers in the aircraft system. The ballast manufacturer did not consider a retrofit of ballasts manufactured prior to August 2001 necessary, but nevertheless offers a retrofit program to rework the C3 capacitor.

Initial findings
Inspection by technicians at Amsterdam revealed that the smoke was caused by a burnt ballast of the cabin sidewall lights. According to the operator the *Smoke or Fumes checklist* of the *Emergency/Malfunction checklist* was applied. In this event it seems the "fail safe" design of the ballast worked well and prevented worse as it probably shut itself down. Circuit breakers labeled as "reading lights" from the cockpit circuit breaker panel were pulled. The electrical buses of the cabin side wall lights were not isolated from electrical power.

The position of the ballast is behind a panel in the overhead bins and is not easily accessible by either a passenger or a cabin crew member. A malfunctioning ballast causing overheat requires a quick elimination of the ignition source, for fighting a fire or smoke development with a fire extinguisher is difficult and less effective. Isolating the bus which feeds the ballast takes place at 'system use level'[3] by pulling the circuit breaker of that bus. This is only effective if the suspected buses are included in the appropriate checklist.

Other investigated reports of smoke incidents indicated that smoke or fire are not necessarily caused by short circuitry, but sometimes by bad electrical contacts, for instance in plugs. In contradiction to short circuitry when the current increases and circuit breakers usually trip, current decreases as a result of bad electrical contact (increase in electrical resistance) and circuit breaker

[2] Ballast – Integrated voltage regulator and rectifier to provide electrical power to tubular lamps.

[3] Systems or components which use electrical power such as light, computers, galley heating equipment, pumps, aircraft systems et cetera usually having an own circuit breaker on the circuit breaker panels.

contacts do not trip. Provided sufficient development of heat is present, a fire or smoke may start. Under this condition the ignition source can only be eliminated by pulling the circuit breaker to de-power the affected bus.

Checklists
While dealing with the cabin smoke situation the first officer visually inspected and verified smoke from the reading light area on row 27-29 on the right hand side. The *Smoke or Fumes* of the *Emergency/Malfunction checklist* was performed by the crew and, though smoke had already stopped, circuit breakers (labeled "reading lights") from the cockpit circuit breaker panel were pulled. The purpose of such an action is to eliminate the ignition source of smoke or fire by isolating (un-power) the suspected electrical bus. According to the aircraft manufacturer the aircraft operating manual does not contain a procedure entitled *Smoke or Fumes* of the *Emergency/Malfunction checklist.* Except from the circuit breakers pulled by the crew the results of applying this checklist were unknown in this investigation.

During the investigation the Boeing Air Safety Investigation Department forwarded excerpts from the *Boeing MD-80 Flight Crew Operating Manual* to the Dutch Safety Board. They contain procedures for dealing with smoke or fumes and evacuation, either caused by electrical source or via air conditioning. It includes the emergency procedure *Electrical smoke of unknown origin*, dated 15 July 2005. Boeing suggests that the operator follows the applicable manufacturer checklist to better assure isolation of the affected electrical bus.

In essence the checklist prescribes a top down approach by first verifying whether the electrical failure is in buses which are powered during normal operation or in buses which are powered when emergency power is selected.[4] Depending on the emergency power behaviour (*normal*, or *abnormal*) engine and auxiliary power unit generators are switched off with emergency power on, or vice versa. This enables the crew to ensure better switching off an affected bus quickly.
In next steps, now depending on smoke condition (*increasing* or *decreasing*) and required flight time (*more than 30 minutes*, or *less than 30 minutes*) to the nearest airport, further selections of buses (either to power them or un-power them) are made in the checklist.

Previous electrical failure events with this operator.
When the Dutch Safety Board exchanged its findings with the Accident Investigation Branch Norway (AIBN), two previous electrical failure events with McDonnell Douglas MD-82 aircraft of this operator, in these cases with Norwegian registration, were found.

AIBN report 50/2000 describes a serious in-flight incident on 21 November 1998 with smoke and smell in the passenger cabin of a McDonnell Douglas MD-82 registered as LN-RMD. The AIBN report was issued in September 2000.
The smoke came from behind an overhead panel and the investigation revealed that it was caused by an overheated electrical plug for cabin lights. In total 10 recommendations were made by the operator based upon their internal investigation addressing a broad range of findings and related to prevent water ingress in the plug. Two other recommendations were:

- *The operator to consider changing Cabin Fire and / or smoke Removal checklist to include "turning off internal lighting".*

- *The operator to consider simplifying or adding a new checklist concerning electrical smoke and / or fumes isolation.*

AIBN report 19/2001 describes a serious in-flight incident on 22 December 1999 with bangs and for a short moment a long flame coming out of the ceiling of the forward galley of a McDonnell Douglas MD-82 registered as LN-ROR. The AIBN report was issued in June 2001.
The investigation demonstrated that a wire bundle was damaged (chafing) and consequently created short-circuiting. The bundle had not been routed correctly around the housing of a lamp. In total 5 recommendations were brought up by the internal investigation of the operator addressing maintenance and inspection issues, and:

- *The operator to consider simplifying or adding a new checklist concerning electrical smoke and electrical smoke or fumes isolation.*

[4] The *Electrical smoke of unknown origin* checklist prescribes to switch on the emergency power first.

- *The operator must ensure that important knowledge and experience is spread throughout the organization. This information must be incorporated in actual documentation when this is deemed necessary.*

AIBN recited its recommendation from report 50/2000 and commented that CAA Norway should check how the operator reacted to this serious incident. According to AIBN the CAA Norway reported in a letter to AIBN that the operator followed their own recommendations. Because CAA Norway was satisfied with the actions of the operator regarding report 19/2001 it ceased their follow up of the case.

Via the Accident Investigation Board of Denmark (AIBD) the checklist for smoke or fumes, used in Danish registered McDonnell Douglas MD-80 aircraft family with this operator, was received from the operator. The checklist is dated December 2007 and is not identical to Boeings' checklist mentioned earlier, but it provides a similar approach in (de)selecting electrical power sources and electrical buses. The checklist contains an item to switch off the affected bus of the side wall lights more upstream in the electrical system in an early stage when carrying out the checklist.

Because the design of the ballast and its problems with the C3 capacitor have not further been investigated, no conclusions can be drawn with respect to this component and the root of the cause of the ballast failure. The investigation shifted to the effectiveness of the emergency checklist in case of smoke in the cabin.

By pulling the circuit breakers of the affected bus an isolation of the ignition source is ensured. This is important as not every electrical malfunction causes a circuit breaker to trip or automatically shuts down an affected electrical component or system. In this event the affected bus was not isolated as the side wall cabin lights circuit breakers were not pulled. Instead, only the reading lights circuit breakers were pulled indicating that circuit breakers more upstream were in the 'not pulled' position. It is assumed that isolation was not ensured by the checklist used by the operator during the event.

CONCLUSION

It seems that earlier events with the LN-RMD and LN-ROR and corresponding recommendations did not result into an effective checklist within this operator when smoke developed in the cabin of OY-KGT. Based upon the found issues with checklists concerning electrical malfunctions, the exchange of information within the organization of the operator had not been sufficient during at least the period starting from the events with LN-RMD and LN-ROR through the event with OY-KGT. However, feedback from (the Danish part of) the operator indicated that its current checklist for smoke or fumes in the cabin in an event similar to the OY-KGT event would have been effective.

Note: This report has been published in English and Dutch language. If there are differences in interpretation the Dutch text prevails.