الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Accident

- Final Report -

AIFN/0001/2017

Balloon Basket Fire on Landing

Operator:	Balloon Adventures Emirates LLC
Make and Model:	Ultramagic N-500
Nationality and Registration:	The United Arab Emirates, A6-BOB
Place:	Sharjah
State of Occurrence:	The United Arab Emirates
Date of Occurrence:	14 January 2017

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Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

Accident Brief

AAIS Case No.:	AIFN/0001/2017
Operator/owner:	Balloon Adventures Emirates LLC
Aircraft Make and Model:	Ultramagic N-500, hot air balloon
Registration Mark:	A6-BOB
MSN:	500/12
Number and Type of Engines:	Not applicable
Date and Time (UTC):	14 January 2017, 0330
Place:	Sharjah, the United Arab Emirates
Category:	Transport (Passenger)
Persons on-board:	24
Injuries:	1

Investigation Objective

This Investigation is performed pursuant to the *UAE Federal Act No. 20 of 1991*, promulgating the *Civil Aviation Law,* Chapter VII – *Aircraft Accidents*, Article 48. It is in compliance with the *Civil Aviation Regulations* of the United Arab Emirates, Part VI, Chapter 3, in conformity with *Annex 13* to the Convention on International Civil Aviation; and in adherence to the *Air Accidents and Incidents Investigation Manual*.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Investigation Process

The occurrence involved a Ultramagic N-500 hot air balloon, registration A6-BOB, and was notified to the Air Accident Investigation Sector (AAIS) by phone call to the Duty Investigator (DI) Hotline Number +971 50 641 4667.

After the Initial/On-Site Investigation phase, the occurrence was classified as an 'Accident'.

An investigation team was formed in line with the *Annex 13* obligations of the United Arab Emirates, being the State of Occurrence, Registry, and the Operator.

The scope of the investigation into this accident is limited to the events leading up to the occurrence, and critical non-contributing safety issues.

Notes:

[1] Whenever the following words are mentioned in this Final Report with the first letter Capitalized, it shall mean:

- (Accident). This investigated accident
- (Balloon). The balloon involved in this accident

- (Investigation). The investigation into this accident
- (Operator). Balloon Adventures Emirates LLC
- (Pilot). The pilot of the accident balloon flight
- (Report). This accident investigation Final Report.

2 Unless otherwise mentioned, all times in this Report are 24-hour clock in Coordinated Universal Time (UTC), (UAE Local Time minus 4).

Synopsis

On 14 January 2017, at approximately 0700 Local Time (LT) of the United Arab Emirates, an Ultramagic N-500 hot air Balloon, registration mark A6-BOB, operated by Balloon Adventures Emirates (BAE) LLC, took off on a commercial sightseeing flight from Al Faqa, Dubai, the United Arab Emirates. There were a total of 24 persons on-board comprising the Pilot and 23 passengers.

Initially, the Balloon was cold inflated by the ground crew. Thereafter, the Pilot started to hot inflate the Balloon envelope with the assistance of the ground crew. During hot inflation, the Pilot did not open the Velcro tabs of the parachute/deflating system. Later, a gust of wind exerted a significant force on the envelope while it was still in a semi-inflated condition. This force, and the low angle of the envelope relative to the basket, caused most of the Balloon's eight nylon rods[1] to break. The Pilot was not aware of the problem and continued with the hot inflation and boarding the passengers. The ground crew standing nearby were immediately aware of the problem and attempted to alert the Pilot. However, the Pilot did not notice their efforts to gain his attention, as he was focused on operating the burners.

Following liftoff the flight proceeded normally, and during the descent to the landing area, the Pilot instructed the passengers to adopt the landing position, as briefed before takeoff.

When the Balloon came to a full stop, the gas was still feeding the burner and the flame was continuous. The basket, with the Pilot and all of the passengers still on-board, tilted over and the burner flames impinged on the Balloon structure and the Pilot suffered burns to his face.

The ground crew were at the landing site and they started to lift the basket with the assistance of some of the passengers in order to release those still on-board. The ground crew quickly extinguished the fire.

The Investigation concluded that the causes of the Accident are the Pilot performing the takeoff with most of the nylon rods fractured or bent, failure of communication between ground crew and the Pilot during pre-takeoff, the burner pilot lights remaining active during landing, and the Pilot grabbing of the burner handle by both hands causing inadvertent activation of the liquid valve

The Report contains three Safety Recommendations addressed to the Operator and the General Civil Aviation Authority (GCAA) of the United Arab Emirates.

[1] Support rods for burner assembly

Abbreviations

AAIS	Air Accident Investigation Sector
BAE	Balloon Adventure Emirates
CAAP	*Civil Aviation Advisory Publication*
CAR	*Civil Aviation Regulations* of the United Arab Emirates
DGAC	(Spain) Direccian General de Aviacion
EASA	European Aviation Safety Agency
FDS	Fast deflation system
GCAA	The General Civil Aviation Authority of the United Arab Emirates
GPS	Global positioning system
ICAO	International Civil Aviation Organization
MTOW	Maximum take-off weight
SOP	Standard operating procedures
UAE	The United Arab Emirates
UTC	Coordinated Universal Time
VHF	Very high frequency

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1. Factual Information

1.1 History of the Flight

On 14 January 2017, at approximately 0700 Local Time (LT) of the United Arab Emirates, an Ultramagic N-500 hot air Balloon, registration mark A6-BOB, operated by Balloon Adventures Emirates (BAE) LLC, took off on a commercial sightseeing flight from Al Faqa, Dubai, the United Arab Emirates. There were a total of 24 persons on-board comprising the Pilot and 23 passengers.

The Pilot reported for duty at approximately 0500 LT on the day of the Accident. There were three BAE balloons flying together that morning. The three pilots reviewed the weather conditions together, including the valid TAF for OMAL[2] and they decided to operate the flights as conditions were suitable. They also checked the Operator's weather station located at the take-off site.

At the take-off site, the Pilot of the Accident Balloon provided the safety briefing to the passengers approximately five minutes before they boarded the Balloon. The briefing included instructions for takeoff and landing and other safety information. The briefing highlighted the importance of wearing the safety harness for the duration of the flight and explained how to connect the harness to the floor anchor in the basket. For the landing, the briefing referred to the 'landing position', in which the passengers must keep their backs towards the direction of flight, their knees bent at an angle of about 45 degrees, and stand side-by-side in a shoulder-to-shoulder position, while holding the rope handles in the basket with both hands.

Before hot inflation, the lead pilot communicated with Dubai Approach using a mobile phone to obtain take-off clearance, and the takeoff was approved.

Initially, the Balloon was cold inflated by the ground crew. Thereafter, the Pilot started to hot inflate the Balloon envelope with the assistance of the ground crew. During hot inflation, the Pilot did not open the Velcro tabs of the parachute/deflating system. Later, a gust of wind exerted a significant force on the envelope while it was still in a semi-inflated condition. This force, and the low angle of the envelope relative to the basket, caused most of the Balloon's eight nylon rods[3] to break. The Pilot was not aware of the problem and continued with the hot inflation and boarding the passengers. The ground crew standing nearby were immediately aware of the problem and attempted to alert the Pilot. However, the Pilot did not notice their efforts to gain his attention, as he was focused on operating the burners.

The Operator's *standard operating procedures (SOP)* stated that the lead balloon must be under the command of a senior pilot, and the other balloons were required to follow the lead balloon. The Accident Balloon was supposed to take off after the other two balloons, but in fact, the Accident Balloon took off first.

At approximately 0630 LT, the passengers boarded the Balloon with a different number of passengers in each of the five basket compartments. The Balloon then took off in a wind speed of approximately 5 knots, and ascended quickly to an altitude of 1,937 feet.

During the flight, the Pilot attempted to test the Balloon parachute system (figure 2). He experienced some difficulty in carrying out the test. The flight covered a distance of about 24 kilometers with a duration of approximately 60 minutes. The maximum altitude was 1,937 feet, while the maximum Balloon speed was 9.1 knots.

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2 ICAO Code for Al Ain International Airport

3 Nylon rods, which support the burner load frame. These support rods and cables, as well as the burner hoses are kept inside padded zipped covers when erected

During the descent to the landing area, the Pilot instructed the passengers to adopt the landing position, as briefed before takeoff. Between five and six feet above the ground, the Pilot deployed the fast deflation system (FDS), but maintained the burner pilot lights[4] on.

The rate of decent was approximately 53 feet per minute according to the on-board variometer when the Balloon contacted the ground, which is considered to be a smooth touchdown.

When the Balloon came to a full stop, the gas was still feeding the burner and the flame was continuous. The basket, with the Pilot and all of the passengers still on-board, tilted over and the burner flames impinged on the Balloon structure and the Pilot suffered burns to his face.

The ground crew were at the landing site and they lifted the basket with the assistance of some of the passengers in order to release those still on-board. The ground crew quickly extinguished the fire.

Three of the passengers received minor burn injuries during the Accident, only the Pilot suffered serious injuries. The Pilot was hospitalized for medical treatment following the Accident.

1.2 Injuries to Persons

Table 1 shows the injuries.

Table 1. Injuries to persons

Injuries	Flight Crew	Cabin Crew	Other Crew On-board	Passengers	Total On-board	Others
Fatal	0	0	0	0	0	0
Serious	1	0	0	0	1	0
Minor	0	0	0	3	3	0
None	0	0	0	20	20	0
Total	**1**	**0**	**0**	**23**	**24**	**0**

1.3 Damage to Aircraft

The Balloon envelope scoop was fire damaged and all eight nylon rods were broken.

1.4 Other Damage

There was no damage to property or the environment.

1.5 Personnel Information

The qualifications of the Pilot were as shown in table 2.

Table 2. Qualifications of the Pilot

Gender	Male
Date of birth	28 October 1975
UAE GCAA license category and rating	Hot Air Balloon
Issue date	18 December 2016
Expiry date	17 December 2024
Class and date of last medical	Class II, 13 September 2016
Flying Experience	
Total hours all balloon types	2,232.03
Total hours on type	10
Total hours for last 7 days	6.03

[4] A small gas flame, which serves as an ignition source for a more powerful gas burner

Total hours for the last 28 days	17.67
Total hours for the last 24 hours	55 minutes
English language proficiency (ELP)	Level 4

The Pilot had been employed by the Operator since September 2016. The Pilot was scheduled to operate one flight only on the day of the Accident.

1.6 Balloon Information

1.6.1 General

The certification basis for the Ultramagic N-500 balloon is in accordance with the requirements of la Direccion General de Aviacion Civil (DGAC) of Spain, following 14 Code of *Federal Regulations (CFR)*, Part 31, Amendment 5. The type certificate approval of the Ultramagic N-500 balloon was obtained on 30 April 2001 from the Spanish DGAC. European Aviation Safety Agency (EASA) certification for the Ultramagic N-500 balloon type was issued on 19 January 2006.

The Balloon configuration was:

- Envelope: type N-500 (volume 14,415 m^3)
- Quadruple Burners: type MK-21
- Basket: C14 (170 x 520 cm)
- Empty Weight: 1,055 kg
- Maximum Lift (Lmax): 5,000 kg

The Balloon data is shown in table 3.

Table 3. Balloon data		
Manufacturer		ULTRA MAGIC, S.A
Model		ULTRAMAGIC N-500
Manufacturer serial number (MSN)		500/12
Date of manufacture		March 2012
Nationality and registration mark		UAE, A6-BOB
Name of the owner		Balloon Adventure Emirates LLC
Name of the operator		Balloon Adventure Emirates LLC
Certificate of airworthiness		
	Number: Issue date: Valid to:	UAE-COA-0087 27 September 2012 1 year as Airworthiness Review Certificate (ARC) valid to 8 June 2017
Certificate of registration		
	Number: Issue date: Valid to:	COR-0294 27 September 2012 Non Terminating
Date of delivery		27 September 2012
Time since new (TSN) (flight hours)		709.80
Last inspection and date		25 May 2016
Engines		burner
Maximum take-off weight (MTOW)		5000 Kgs

The maximum allowable rate of descent was 1,000 feet per minute.

1.6.2 Burners

The burner is the engine of the Ultramagic N-500 hot air balloon which converts the fuel (liquid propane) stored in the fuel cylinders into heat energy. This energy is used to heat the air inside the balloon envelope and thus provide the means of inflation and altitude control during flight. (Figure 1).

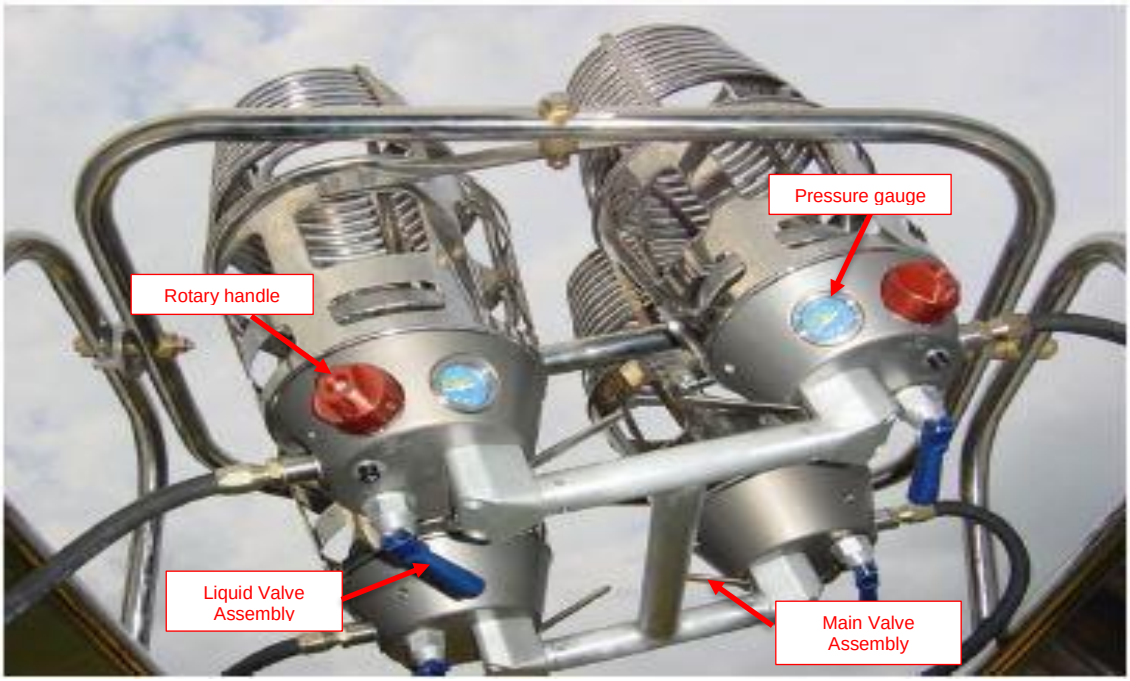

Figure 3. Burners [Source: the Balloon *maintenance manual*]

The MK-21 quadruple type burners are used to inflate the Ultramagic N-500 balloon envelope to provide lift.

The burners are controlled by an on-off main blast valve mounted below the burner, and within easy reach of the Pilot.[5]

A toggle action handle and a rotary handle are used to control the liquid fire function of the burner. Unlike the toggle control, the rotary handle may be released at any intermediate position from fully 'off' to fully 'on', allowing fine control of the liquid fire power and hands free operation. Control rotation enables or disables the flow of fuel to the liquid fire jet.

Increasing the degree of rotation from the 'off' position will increase the power output from the liquid fire jet. The direction of rotation for the right hand control is opposite to the direction of rotation for the left hand control. Each control body is engraved with a '0', '1' and an arrow.

When viewed from above, the '0' indicates that the control is in the 'off' position. Similarly, the '1' indicates that the control is in the 'on' position, the arrow indicates the direction of rotation necessary to turn the control to the off position.

The liquid valve assembly is identical in construction to the main valve with the following exceptions:

- The valve handle is a toggle type action and may be rotated to any convenient position.
- The nylon thrust washer is thinner allowing the handle to rest at an angle.

[5] Reference: the Balloon *maintenance manual*

- The handle is attached to the stem using a pin with a machined flat. Grub screws located on the underside of the handle are used to secure the pin in position.

The igniter assembly is a 'cartridge' type and is inserted into the bore provided in the valve block. The assembly is held in position by a grub screw positioned on the side of the valve block. The assembly is provided with an O-ring seal to prevent the seepage of water from the upper surface of the valve block during operation.

The assembly consists of a tube in which are housed a piezzo[6] igniter and an electrode permanently mounted in temperature resistant spark plug grade ceramic. When assembled, the piezzo igniter makes contact with the electrode thus allowing the transmission of the high voltage to the electrode tip. Upon operation of the piezzo igniter button, a high voltage spark is produced between the electrode and a tag mounted on the side of the pilot light causing the pilot light to ignite.

1.6.3 Envelope

1.6.3.1 General

The Balloon was equipped with N-500 type envelope, which was composed of 32 gores stitched together.

The envelope material was manufactured from a high resistance polyamide fabric, reinforced by several polyester load tapes. The tapes transmit load forces via stainless steel cables to the load frame. The lowest part of the envelope was made of heat resistant Nomex.

Further details of the envelope are as follows:

- Volume: 14,415 m^3
- Total height: 32.20 meters
- Weight: 422 kg
- Diameter at the equator: 31.3 meters
- Diameter at the mouth: 5.50 meters
- Parachute diameter: 9.0 meters with FDS

1.6.3.2 Parachute

On the top of the envelope was a large opening, where there was no fabric only the mesh of the load tapes. This opening was covered on the inside of the envelope by a loose panel of fabric, which was centred by a system of cords. The fabric panel resembles a parachute. The parachute is kept closed by the internal pressure of the hot air in the Ultramagic N-500 balloon, so that the parachute seals tightly against the mesh of the opening formed by the load tapes. The parachute can be opened from the balloon basket by pulling a chord. When the chord is released, the parachute reseals after several seconds.

The parachute control cord activates the parachute vent, or valve. This could either vent off hot air, or completely deflate the envelope. Final deflation is achieved by pulling the line completely and holding it in this position. Figure 2 shows the parachute control mechanism.

[6] Piezzo ignitor uses the principle of piezoelectricity, which, in short, is the electric charge that accumulates in some materials in response to high pressure

The parachute control cord, which was red and white colored polyester on the outside with a Kevlar interior, runs through a pulley inside the envelope to the parachute lines to another pulley and then back to a fixed point on the inside of the envelope. The pulleys reduce the effort required to open the parachute.

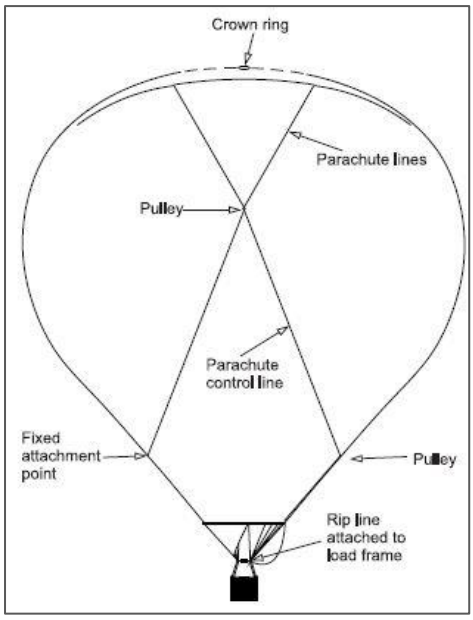

Figure 4. Controlling the parachute
[Source: *maintenance manual*]

Based on the *flight manual*, in-flight use of the parachute vent system should be no longer than 3 seconds at any one time. Re-use must not be attempted until the envelope has re-inflated. This limitation is labelled as a CAUTION in the manual.

1.6.3.3 Fast deflation system (FDS)

The Balloon was equipped with FDS, which incorporates the parachute venting system with extra opening capabilities. As shown in Figures 3a and 3b, the rip line, which was red in colour, pulls the center of the parachute together creating a large opening, which allows a large outflow of hot air for final deflation of the envelope. The line must not be used for venting. The opening action of the red rip line (FDS) can be reversed by pulling on the red/white parachute (vent) cord/line.

According to the *flight manual*, the use of the red rope of the FDS is prohibited at an altitude higher than 10 m (30 feet) above the ground, and this is labelled in the manual as a 'warning'.

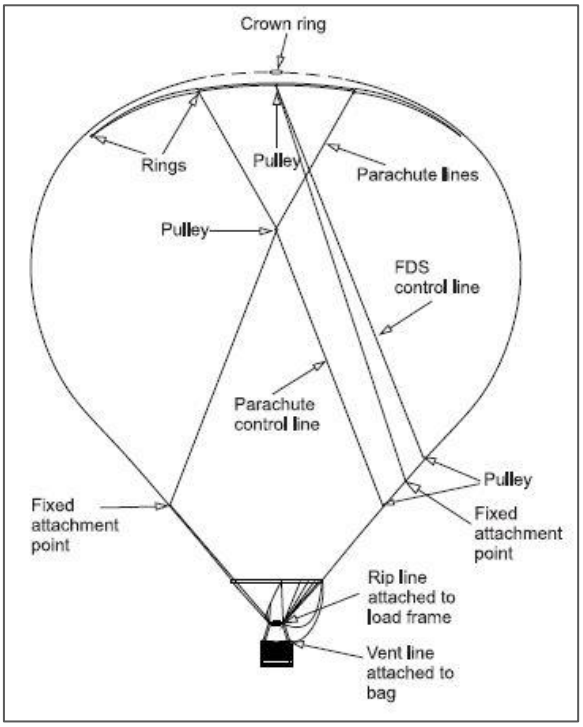

Figure 5a. FDS closed

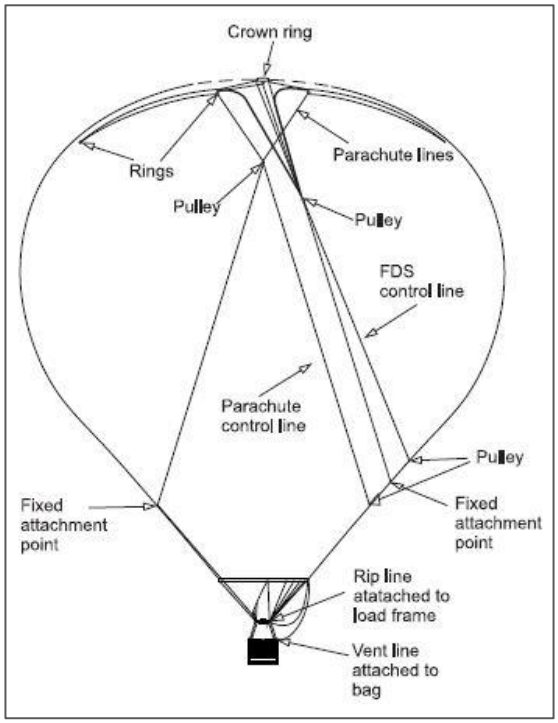

Figure 4b. FDS open

1.6.4 Basket

The Balloon was equipped with a C14 type basket which contained five partitioned compartments (figure 5). Passengers can be accommodated in four compartments, and the Pilot and fuel cylinders were accommodated in a separate fifth compartment. The maximum allowable number of passengers in each passenger compartment was six.

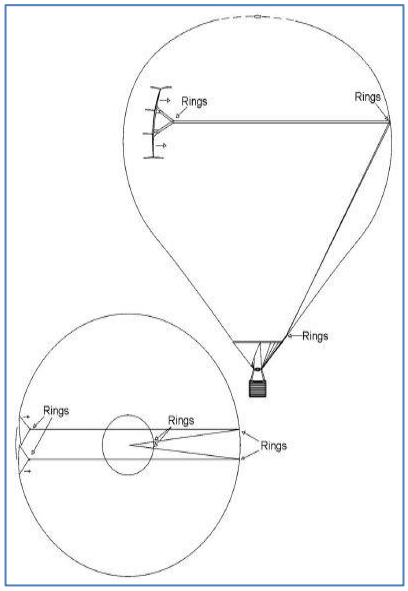

Figure 4. Turning vents assembly

The basket was made up of woven willow and cane on a marine plywood base. Various openings were woven in to accommodate step holes and strap holes for cylinders.

The basket was connected to the load frame by four stainless steel cables that pass down the sides and through and under the base. These cables were continuous in pairs.

The detail of the Basket C14 type were as follows:

- Basket weight: 533 kg
- Size: 1.7 x 5.2 in meters
- Maximum loading weight: 5,000 kg.

1.6.5 Maintenance

According to the technical log, all the Balloon maintenance tasks were carried out and there were no reported defects recorded, nor was any mechanical anomaly noted prior to the takeoff.

Figure 5. Basket with exposed nylon rods

1.6.6 Nylon rods

The nylon rods were designed to maintain the distance between the burner frame and the basket. Their ends were machined down to a smaller diameter to fit into the sleeves on the frames. The rods were non-structural items and were not fixed to either the burner frame or to the basket. They slid into sleeves welded to the frames.

During inflation and landing, the nylon rods function to hold the burner frame at a distance from the basket and to deflect the heat from the inside of the Ultramagic N-500 balloon. For transportation, they are pulled out of their sleeves and stored in the basket.

According to the Balloon *maintenance manual*, the rods are to be periodically inspected for 'bad' bending or twist. The manual calls for replacing a rod when it is found broken or cracked.

According to the Operator Operations Manager, the Operator did not have a policy in place to have all nylon rods replaced annually prior to the accident.

This has been suggested by Operator's Maintenance Manager, after the Accident, to be introduced if deemed necessary. The current Balloon maintenance manual calls for replacement only when the nylon rods show damage during inspection.

The Operator's Maintenance Manager elected to replace the nylon rods once a year, at the beginning of the ballooning season. The Operator stores the nylon rods in their warehouse in an environment, which can reach up to 60°C.

There was no evidence to indicate that any of the eight rods of the Balloon were replaced due to an inspection finding, or as required by Operator policy as mentioned by the Operations Maintenance Manager.

1.6.7 Ultramagic N-500 inflation

1.6.7.1 Cold inflation

When the Ultramagic N-500 balloon is cold inflated (i.e inflated by use of a fan), the pilot checks the inside of the balloon for any twisting of ropes, and the general condition of the envelope. The attachment of the karabiners to the envelope burner uprights and the basket and the burner is next.

1.6.7.2 Hot inflation

After the Ultramagic N-500 balloon is hot inflated (i.e by use of the burners), the pilot first of all must open (detach) the Velcro tabs (de-tabbing) the parachute. This procedure allows for the free movement of the parachute vent system which is essential for a safe landing. The de-tabbing has to be done before takeoff. It is very difficult to de-tab in-flight due to the increased pressure holding the parachute in. Once the de-tabbing is done, the pilot can check the free movement of the handling lines (red and white) which is fundamental to the safety of the flight.

1.7 Meteorological Information

The METAR for a period of time including the time of the Accident was as shown in table 4.

Table 4. METAR, 14 January 2017, 0600 to 0800 UTC

METAR OMDB 140200Z 28016KT 9999 SCT035 21/12 Q1011 NOSIG METAR OMDB 140300Z 28016KT 9999 SCT043 21/11 Q1012 NOSIG METAR OMDB 140400Z 28015KT 260V320 9999 FEW043 21/10 Q1013 NOSIG

1.8 Aids to Navigation

The Balloon was equipped with a portable global positioning system (GPS) and an iPad which was uploaded with the required positon software applications. The Balloon was also equipped with a transponder, and a Flytec 6040 altimeter. All of which were operating normally.

1.9 Communications

The Balloon was equipped with a portable very high frequency (VHF) radio and a mobile phone to communicate with ATC and the ground crew.

1.10 Aerodrome Information

The Balloon took off from the Operator's take-off area located in the desert near Al Faqa, Dubai, the United Arab Emirates, and landed in an area in the desert near Al Madam, Sharjah, the United Arab Emirates.

1.11 Flight Recorders

Both the GPS, and the iPad had the capability to record flight data, which was used to assist the Investigation.

The downloaded altitude and rate of climb, are given in figure 6, which represents the time period from takeoff to landing.

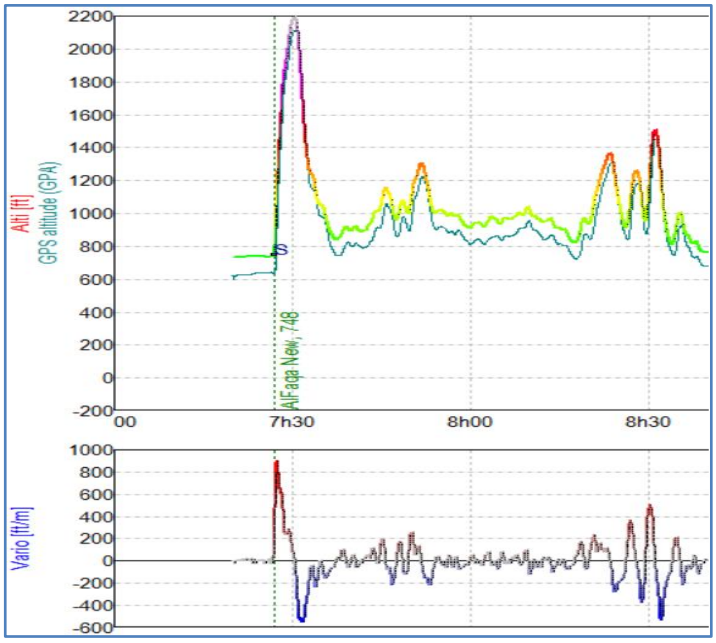

Figure 6. Vertical speed and altitude.
[Source: on-board variometer]

1.12 Wreckage and Impact Information

All eight nylon rods were identified as broken and the envelope scoop showed signs of fire damage.

The scoop was burned over an area of about one square meter^2. There was scorching on the top corner of the basket over an area of approximately 30 cm by 30 cm.

1.13 Medical and Pathological Information

Neither the Pilot nor any of the passengers reported any medical conditions before takeoff, according to the Operator's boarding pass signed by the passengers.

1.14 Fire

After the Balloon touched the ground and stopped, the Pilot unintentionally ignited the burner. Flames impinged on the Balloon structure and on the Pilot's face. The fire also contacted some of the passengers, without causing serious injuries.

1.15 Survival Aspects

On landing, the initial touchdown was smooth and uneventful. The basket slid along the ground until it turned onto its side just before it came to a stop. All passengers were observed in the Balloon mounted video to be in the correct landing position.

After the Balloon stopped, the envelope dropped to the ground and the basket turned upside down trapping all persons on-board.

After the Balloon touched down and stopped, the Pilot was observed moving onto the burner frame, at which time the burner was activated, which resulted in the flames being directed into the basket towards the Pilot and the passengers in the next compartment for approximately 23 seconds.

At this time, ground crew members attempted to lift the basket to liberate the passengers and the Pilot. With the assistance of some passengers who had been freed, the basket was lifted. This was approximately 50 seconds after the first attempt to lift the basket. The remaining fire was extinguished approximately 1 minute 27 seconds after all persons had been released from the basket.

The Pilot suffered from burns to his face and upper body and he was transported to hospital.

1.16 Tests and Research

The nylon rods were sent to the Técnico Investigador, Investigación de Accidentes Subsecretaría de Fomento Comisión de Investigación de Accidentes e Incidentes de Aviación Civil Fruela, which forwarded the rods to a laboratory[7] for forensic testing and analysis. The following tests were conducted on two of the four shipped rods[8] (figure 7):

Chemical Fourier transform infra-red (FTIR) spectroscope analysis[9]

- Thermal differential scanning calorimetry (DSC) analysis
- Thermal thermogravimetric analysis (TGA)
- Density measurement according to *ASTM D- 297*[10]
- Tensile test
- Proctographic study[11].

The laboratory analysis determined that, according to its physical-chemical and mechanical properties (tensile strength and elastic yield), the analyzed material corresponds to a Polyamide 6 (PA6) as specified by the petitioner and to the standard values for this type of material.

According to the examination report, a microscopic exploration was performed by scanning electron microscopy (SEM) in two fractured poles (1 and 2). The surfaces of the fracture in one pole showed various initiation points of fracture, whereas the surface showed single on other pole initiation point underneath the surface (figure 8). In both surfaces, smooth facets could be observed with some radial steps together with bands and conchoidal striations, typical of the progressive advance and a ductile aspect of the fracture. Fracture start zone (red arrow) and propagation directions (green arrows) are indicated in figure 9.

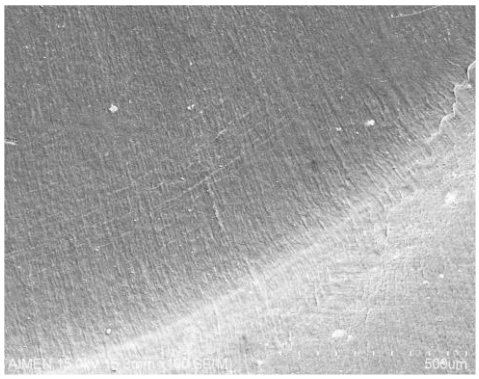

Figure 7. Fracture initiation zone, concentric bands of crack growth

7 The materials were sent to the manufacture in May 2017

8 The lab was requested by Balloon manufacture to carried out the material examination

9 Characterizing molecular properties of matter

10 ASTM: American Society for Testing and Materials

11 Radiological imaging

The lab report concluded that, except for a small pore or internal cavity in one of the poles, no other defects or heterogeneities in the poles were detected that could have induced or facilitated the failure. No machining irregularities (cracks or creases) were found that could have weakened the resistant section. The fracture of the studied poles 1 and 2 (figure 9) happened due to a progressive and ductile mechanism (figure 8), under alternating bending stressed (bending and unbending).

The Fourier-transform infrared spectroscopy (FTIR)[12] spectra revealed that the rods were made up of polyamide (PA). No degradation/oxidation evidence were observed on the material.

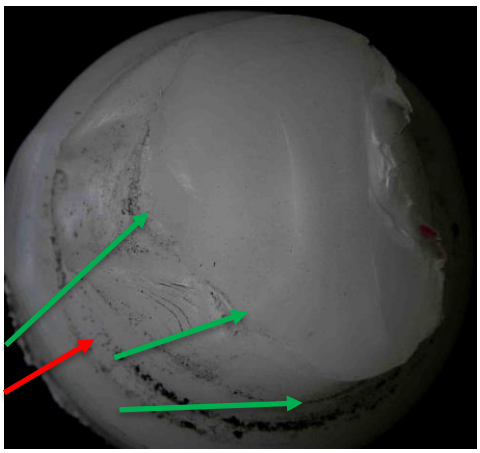

Figure 8. Fracture surface

Figure 9. The four poles identification

1.17 Organizational and Management Information

An air operator certificate was issued to the Operator by the General Civil Aviation Authority (GCAA) of the United Arab Emirates in 2005 with a two-years validity, which had been renewed regularly.

At the time of the occurrence, the Operator was operating three balloons: two Ultramagic N-500, and one Cameron A-500.

According to the Balloon's *flight manual*, a pre-flight check must be carried out before cold inflation.

1.17.1 Pilot training

The Operator's *operations manual,* Part D – *Training*, described the requirements of pilot training, as follows:

> **"Pilot Introductory Training**

[12] FTIR is a technique used to (identify the material composition by) by obtaining an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high-spectral-resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time.

Prior to working as a line pilot introductory training is carried out for all pilots during their induction to the company. This includes specific briefing on company and country procedures and a series of dual flights to familiarize the pilot with the flying area, routes and landing areas.

"FLIGHT CREW OPERATIONAL COMPETENCY CHECKS

Flight Crew Checks General

A. Checks carried out within 60 days of the due date will be deemed to have been carried out on the due date.

B. Checks will be comprehensive to ensure the maintenance of pilot skill, operational area knowledge, operation competency and procedure standardisation.

C. Checks will be carried out in accordance with the BAE OPS-04 Pilot Competency Check Form in the type of balloon typically operated by the pilot for passenger carrying.

D. Theory examination may be oral, or written, or a combination of both. In the case of oral examination the topics covered and standard achieved are to be written in the comments sections of the BAE OPS-04 Pilot Competency Check Form. If questions are written, then these, and their answers and standards are to be attached to the BAE OPS-04 Pilot Competency Check Form.

E. A record of all checks shall be kept on the respective pilots file."

"Contents of Flight Crew Check

Flight checks may include but not be limited to the following:

a) Weather assessment and launch site selection.

b) Organisation of crew passengers and equipment.

c) Passenger emergencies

d) Conduct and control of the take-off site.

e) Pre-flight routine.

f) Balloon handling technique.

g) All normal and emergency manoeuvres.

h) Use of airspace.

i) Selection and use of landing site.

j) Post flight administration.

k) Knowledge and use of safety equipment.

l) Knowledge of the operational area and airspace.

m) All emergency procedures.

n) Knowledge of this operations manual and associated documentation.

o) Knowledge of the balloon manufacturers approved flight manual.

p) Knowledge of any relevant regulations, CAAP, procedures or directives.

Pilot Further Training

If as the result of the comprehensive testing of overall competency and performance, any deficiencies are found, then it shall be the company's responsibility to provide remedial training so that a pilot may correct these deficiencies. The Manager Crew Training shall formulate a written course of further training with objective curriculum and performance standards. These will be discussed with the pilot concerned prior to commencing further training. If, after further training the required standard is not met to the satisfaction of the Director Flight Operations or other authorized person, the pilot's

employment may be reviewed. This is a final measure and will only be considered after all options have been exhausted."

1.17.2 Pre-flight check

The Ultramagic N-500 *flight manual* requires the pilot to conduct a pre-flight check when the balloon envelope is in the vertical position. (Refer *flight manual* FM04, paragraph 4.8, attachment 8). However, it is not evident in the video that the Pilot had observed the breakage of the burner poles including the one which is closer to his field of View. The Pilot was not able to comment on the conduct of the pre-flight check as he could not recollect any details of the check nor was he in a proper condition to have a full discussion with the Investigators.

A pilot's pre-flight checks are to be conducted in two steps in accordance with the Operator 's *flight operation manual*:

- Cold inflation:

  When the Ultramagic N-500 balloon is cold inflated the pilot checks inside of the balloon for any twisting of ropes, and the general condition of the envelope. The attachment of the karabiners to the envelope burner uprights and the basket and the burner is next.

- Hot inflation:

  After the Ultramagic N-500 balloon is hot inflated, the pilot first of all must open the velcro tabs 'de-tabbing' the parachute. This procedure allows for the free movement of the parachute vent system which is essential for a safe landing. The de-tabbing has to be done before takeoff. It is very difficult to do it in-flight due to the increased pressure holding the parachute in. Once the de-tabbing is done, the pilot can check the free movement of the handling lines (red and white) which is fundamental to the safety of the flight.

In this case, the Pilot did not open the Velcro tabs prior to takeoff. The Pilot was observed well after takeoff trying to open the tabs at altitude. It is very difficult to properly open a large balloon in flight, especially if the tabs are new. The Balloon's Velcro tabs were replaced/renewed just a few days before this flight making this procedure especially difficult to carry out in-flight.

The pre-flight check after hot inflation also includes the visual check of the burner poles/uprights to see if any nylon rods are damaged or dislocated from their sockets. It is usually easy to detect any problems as the rods are almost at eye-level. The check also covers inspection for any karabiners or flying wires that are twisted. If there is damage to nylon rods the balloon must not take off. The Balloon took off with most of the nylon rods broken.

It was immediately obvious to the ground crew present that a number of nylon rods were damaged. The ground crew attempted to alert the Pilot by walking up to the basket and trying to communicate with him, however the Pilot did not notice as his attention was focused on operating the burners.

1.18 Additional Information

1.18.1 Balloon operations in the United Arab Emirates

In the United Arab Emirates, balloon operations are limited because of seasonal variations due to high ambient temperatures and localized regional variations in wind speed and direction. Generally, the balloon flying season starts in September and finishes at the end of May, depending on the weather, and flying conditions.

1.19 Useful or Effective Investigation Techniques

The Balloon was equipped with a video camera, which recorded footage from the beginning of the cold inflation until the Accident, and provided the Investigation with valuable information.

2. Analysis

The Investigation collected data from various sources for the purpose of determining the causes and contributing factors that led to this Accident.

The Analysis covers the areas of the required safety briefing, the operations and landing technique used, human factors, and the *Civil Aviation Regulations* of the United Arab Emirates. This section of the Report explains the *contribution* of each investigation aspect to the Accident.

The Analysis also contains safety issues that may not be contributory to the Accident, but are significant in adversely affecting safety.

2.1 Nylon Rods Failure

The nylon rods were designed to maintain the distance between the burner frame and the basket. They were not fixed to either the burner nor to the basket frame and simply fit/slide into sleeves/sockets welded to the frames.

They are usually made of nylon. While they do not play an important function during the flight, they are essential for inflation and landing.

They are non-structural items and are only replaced based on their condition. In practice, until they actually break or bend it is almost impossible to detect any fault during the periodic (100 hour or 12 month) inspections.

Based on the last metallurgical examination, the Investigation believes that, except for a small pore or internal cavity in one of the poles, no other defects in the poles were detected that could have induced or facilitated the failure. No machining irregularities (cracks or creases) were found that could have weakened the poles. The fracture of the poles (2) that were studied occurred due to a progressive and ductile mechanism (fatigue), under alternating bending stresses (bending and unbending).

The Investigation believes that the bending fatigue that failed one of the rods had resulted from side loads imposed by the burner (head panel). The fatigue crack, whether it was surface or sub-surface, could not have been detected by visual inspection.

The rods were provided by the Balloon manufacturer, but without any aviation product reference. Their material composition, strength, or storing requirements were not mentioned in the *maintenance manual*.

2.2 Pre-flight checks

Certain checks of the Balloon were required to be carried out by the Pilot just after hot inflation. As verified by the on-board video camera, the Pilot did not conduct the pre-flight checks in accordance with the *flight operation manual*.

The Pilot did not open the Balloon parachute/deflating system Velcro tabs prior to takeoff. The Pilot was seen after the takeoff attempting to open the Velcro tabs at altitude. It is very difficult to properly open the tabs of a large Ultramagic N-500 balloon in-flight, especially if the tabs are new. The Balloon's Velcro tabs had been replaced/renewed just a few days before the flight.

The pre-flight check after hot inflation also included a visual check of the burner poles and uprights to check whether any of the nylon rods were damaged, or dislocated from their sockets. It is usually easy to detect a problem as the rods are almost at pilot eye-level. It is also necessary to check whether any karabiners or flying wires are twisted. If there is damage to nylon rods the balloon must not takeoff.

The Pilot did not observe the nylon rods before takeoff and the Balloon ascended with most of the nylon rods broken, or dislocated from their sockets.

Before takeoff, the ground crew noticed that a number of nylon rods were damaged. They attempted to alert the Pilot by walking up to the basket and trying to communicate with him. However, the Pilot was focused on operating the burners and did not notice the efforts of the ground crew to attract his attention. The lack of communication prevented the ground crew from stopping the operation of the flight.

After the passengers boarded the basket, the Balloon took off at an unusually high rate of ascent (800 feet per minute) which was not in accordance with the Operator's *SOP.*

2.3 Heat and Dryness

In the United Arab Emirates, the balloons are operated in a unique environment. Normally, balloons are operated in the desert where the environment is very dry with high temperatures.

The temperature can frequently reach over 50 degrees centigrade during the summer months inside the hanger where the balloons are stored. Nylon is hygroscopic, which means that it absorbs humidity and also can dry out. It may become brittle over time.

As part of the required A-check (pre-flight), the Ultramagic N-500 pilot should check (among other items) that the burner nylon rods are in a serviceable condition. The rods are line replaceable items. In most situations, especially with smaller balloons where the burner frame is not already rigged, the pilot will 'rig' the balloon at the take-off site by lifting in and securing the fuel cylinders, fitting the nylon rods, burner frame and basket cables and then hooking up the envelope.

If one (or more) of the burner nylon rods is unserviceable then the pilot should replace it with a serviceable item (assuming that one was available) prior to inflation and takeoff. If one is unserviceable during hot inflation, then this should be replaced prior to continuing with the takeoff.

According to the Balloon's log, the Operator carried out a B-check (100 hour interval) less than two weeks before the Accident, the nylon rods would have been inspected in detail and would have been replaced if found cracked or badly distorted (according to the manufacturer's *maintenance manual*).

2.4 Human Factors

According to the *Operator flight manual*, in case of emergency, the pilot lights must be switched off prior to touchdown. On the Accident flight, the Pilot did not switch off the pilot lights, which sustained the flame when the Pilot inadvertently activated the burners.

The Pilot maintained the pilot lights active because he was not aware of the fractured nylon rods, damage to which, had he been aware of it, required him to apply an emergency procedure, the first step of which was switching the pilot lights 'off'. The Pilot's awareness about the burner frame collapse was adversely affected because he did not know about the possible frame fracture during the inflation phase in spite of an abnormal audible sound coming from the nylon rods that could have been attributed to their damaged state.

When the Balloon started to tilt after landing, the burner frame collapsed, and the Pilot attempted to hold on by grabbing the burner handle by both hands causing inadvertent activation of the liquid valve and a high flow of gas to the burners. The fuel-fed fire burned the Pilot's face and the envelope while the basket was tilting upside down with the all passengers and the Pilot on-board.

A video captured by the Go-pro camera fixed to the Balloon, showed the ground crew attempting to alert the Pilot about the fractured nylon rods, but his attention was not attracted as his attention was fully concentrated on operating the burners.

The Investigation did not find any fatigue issues that could have adversely affected the Pilot's performance. The Pilot was well-rested, and had returned from a holiday with his family two days before the Accident.

As per the Operator's policy, Ultramagic N-500 pilots could only operate one flight per day. Consequently, fatigue was not an issue in this occurrence.

The ground crew was aware of the failure of the nylon rods during the hot inflation and they attempted to stop the operation of the flight as the Pilot was performing the pre-flight check tasks. However, the communication with the Pilot was improper as attempted by the ground crew due to loud noise and the fact that the Pilot's attention was focused on preflight activities.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this Accident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the conclusions heading:

- **Findings.** Statements of all significant conditions, events or circumstances in this Accident. The findings are significant steps in this Accident sequence but they are not always causal or indicate deficiencies.
- **Causes.** Actions, omissions, events, conditions, or a combination thereof, which led to this Accident.
- **Contributing factors.** Actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 Findings relevant to the Balloon

(a) The Balloon was certified, equipped, and maintained in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Balloon was not airworthy since the nylon rods failed during hot inflation before the takeoff.

(c) The Balloon landed upright and tipped onto its side after sliding along the ground.

(d) After the Balloon came to a stop, and prior to disembarkation of the passengers, the Pilot lost his balance and grabbed the burner handle with both hands causing inadvertent activation of the burners and the basket tipped upside down.

(e) The Balloon sustained fire damage because of the Accident.

3.2.2 Findings relevant to the Pilot

(a) The Pilot was licensed and qualified for the flight in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Pilot carried out pre-flight check not in accordance to the *flight manual* and the Operator's *SOP.*

(c) The Pilot performed the takeoff when the Balloon was not airworthy.

(d) The Pilot performed the takeoff without opening the Velcro tabs.

(e) The Pilot performed the landing with the pilot lights on, which was against the Operator's policy.

(f) The Pilot did not notice the warning communication attempted by the ground crew prior to takeoff.

3.2.3 Findings relevant to flight operations

(a) The landing position was briefed in accordance with the Operator's *operations manual* and *SOP*, and the manufacturer's *flight manual*.

3.3 Causes

The Air Accident Investigation Sector determines that the cause of the Accident was the existence of fractures on some poles of the nylon rods, which occurred during the hot inflation phase. The nylon rods fractured resulting in their failing to adequately support the burner frame.

This caused, after landing, the collapse of the burner frame and caused the basket to tilt upside down with the all passengers and the Pilot on-board.

3.4 Contributing Factors to the Accident

The Air Accident Investigation Sector identifies the following contributing factors to the Accident:

(a) The Pilot performed the takeoff with most of the nylon rods fractured or bent.

(b) Failed communication between ground crew Pilot during pre-takeoff.

(c) Pilot lights remained active during the landing.

(d) Before landing, the Pilot failed to switch off the pilot lights and grabbed the burner handle by both hands causing inadvertent activation of the liquid valve.

3. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in part 3 of this Report. The Air Accident Investigation Sector expects that all safety issues identified by the Investigation are addressed by the concerned organizations.

4.2 Final Report Safety Recommendations

The Air Accident Investigation Sector recommends that:

4.2.1 Balloon Adventure Emirates

SR15/2018

Improve communication procedures between the pilots and the ground crew.

SR16/2018

During internal training and the annual flight check, emphasize the importance of the pre-flight check, and the requirement as to when to turn off the pilot lights.

4.2.2 The General Civil Aviation Authority of the United Arab Emirates,

SR17/2018

Consider a red and green flag system for the ground crew to clearly indicate to the pilot that the balloon is considered serviceable for takeoff.

This Report is issued by:

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