CIAIAC

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report A-037/2006

Accident involving a SIKORSKY S-61N helicopter, registration EC-FJJ, on 8 July 2006, in Roque Bermejo (Tenerife – Canary Islands – Spain)

GOBIERNO DE ESPAÑA

MINISTERIO DE FOMENTO

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Foreword

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

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

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

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

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Abbreviations

00:00	Hours and minutes (time period)
00:00:00	Hours, minutes and seconds (chronological time)
00°	Geometric Degrees/Magnetic course
00°00'00"	Degrees, minutes and seconds (geographical coordinates)
00 °C	Degrees centigrade
ACC	Area Control Center
AD	Airworthiness Directive
AESA	Agencia Estatal para la Seguridad Aérea (Spain's Aviation Safety Agency)
AMM	Aircraft Maintenance Manual
AMP	Approved Maintenance Program
AOC	Air Operator's Certificate
APP	Approach Control
ATC	Air Traffic Control
ATPL	Airline Transport Pilot License
ATPL(H)	Airline Transport Pilot License (Helicopter)
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile – France's Civil Aviation Accident Investigation Authority
BIM	Blade Inspection Method – System to warn of low pressure inside the main rotor blade spars
CBIM	Cockpit Blade Inspection Method – System in the cockpit to warn of low pressure inside the main rotor blade spars
CIAIAC	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (Spanish Civil Aviation Accident and Incident Investigation Commission)
CPL(H)	Commercial Pilot License (Helicopter)
CRM	Crew Resource Management
CV	1 CV equals 0.9863 HP
CVR	Cockpit Voice Recorder
dd/mm/aaaa	Day, month, year (date)
DGAC	Dirección General de Aviación Civil (Spain's Civil Aviation Directorate General)
DMC	Daily Maintenance Check
DMR	Daily Maintenance Record
E	East
EC	European Commission
EASA	European Aviation Safety Agency – Civil Aviation Authority of the European Union
FAA	Federal Aviation Administration – Civil Aviation Authority of the United States of America
F/O	First Officer
ft	Feet
GCLA	ICAO's code for La Palma airport
GCXO	ICAO's for Tenerife North airport (Los Rodeos)
GS	Ground Speed
h	Hours
HEMS	Helicopter Emergency Medical Services
HP	Horse Power (1 HP equals 1.0139 CV)
hPa	Hectopascal(s)
IAS	Indicated Air Speed
in	Inches
INTA	"Esteban Terradas" National Institute for Aerospace Technology
JAA	Joint Aviation Authorities
JAR-FCL	Joint Aviation Requirements-Flight Crew Licensing
kg	Kilogram(s)
kt	Knot(s)
lb	Pound(s)
LT	Local time
m	Meter(s)
MBO	Manual Básico de Operaciones (Basic Operations Manual)
METAR	Routine aerodrome weather report

Abbreviations

MHz	Megahertz
MEL	Minimum Equipment List
mm	Milimeter(s)
MMEL	Master MEL
MOM	Maintenance Organization Manual
MTOW	Maximum Takeoff Weight
N	North
NM	Nautical Miles
Nr	Main rotor turn rate
NTO	Non-Technical Objection
NTSB	National Transportation Safety Board – Civil Aviation Accident Investigation Authority in the United States of America
OM	Operations Manual
P/N	Part Number
PFC	Pre-Flight (Maintenance) Check
PIC	Pilot in Command - Captain
PVM	Parte de Vuelo y Mantenimiento (Flight and Maintenance Record)
QNH	Pressure setting so that on takeoff and landing, the altimeter indicates airport altitude above sea level
RFM	Rotorcraft Flight Manual
RCC	Rescue Coordination Center
ROV	Remotely-Operated Vehicle
S	South
S/N	Serial Number
SAR	Search and Rescue services
SB (BS)	Service Bulletin
SOP’s	Standard Operating Procedures
SVA	Servicios de Vigilancia Aduanera (Border Patrol)
SWL	Low-level significant weather chart
TAF	Aerodrome forecast
TMA	Técnico en Mantenimiento de Aeronaves (Aircraft Maintenance Technician)
TWR	Control tower
UTC	Coordinated Universal Time
VBIM	Visual Blade Inspection Method – Visual indicator for system warning of low pressure inside main rotor blade spars
VFR	Visual Flight Rules
VHF	Very High Frequency
W	West
WP	Work Package

Synopsis

Owner and operator:	Helicópteros, S. A. (HELICSA)
Aircraft:	SIKORSKY S-61N
Date and time of accident:	8 July 2006; at 09:08 h[1]
Site of accident:	Roque Bermejo (Tenerife – Canary Islands – Spain)
Persons on board:	6 (two crew and four passengers)
Type of flight:	General aviation – Ferry flight
Phase of flight:	En route
Date of approval:	21 December 2010

Summary of accident

On 8 July 2006, a SIKORSKY S-61N helicopter, registration EC-FJJ, took off from La Palma Airport, located on the island of La Palma (Canary Islands, Spain), at 08:19, with two pilots and four passengers, one of whom was the mechanic assigned to maintain the helicopter, en route to Las Palmas Airport, located on the island of Grand Canary (Canary Islands, Spain).

At approximately 09:08, the aircraft fell to the sea, contacting the surface of the water at a steep downward pitch and right bank angle, in the area of Roque Bermejo, to the northeast of the island of Tenerife (Canary Islands, Spain).

An exhaustive search of the ocean surface and floor was conducted, as a result of which the bodies of five of the helicopter's occupants were recovered (the F/O's remains missing), along with a very limited portion of the aircraft wreckage, including documents, structural components and parts of the aircraft's main rotor. The main mechanical parts (engines, transmission components, etc.), the tail cone (tail rotor, transmission boxes and shafts, etc.) and other helicopter systems were not found.

The accident investigation concluded that the most likely factor that caused the helicopter to fall to the sea was the in-flight fracture of the main rotor's "black" blade.

The process that caused the failure of the blade, which evidenced signs of having failed gradually, is believed to have resulted from fatigue followed by static fracture once the fatigue crack reached a critical length.

[1] All times are local (LT) unless otherwise indicated. To obtain UTC, subtract one hour from local time.

The deficiencies detected in the application of the helicopter's maintenance and operating procedures are considered to have contributed to the accident.

A study of the aspects involving the operation and maintenance of the helicopter has revealed certain deficiencies in the application of the corresponding procedures. Likewise, the applicable regulations and technical documentation revealed aspects that merit improvement, as a result of which ten Safety Recommendations are issued.

1. FACTUAL INFORMATION

1.1. History of the flight

On 8 July 2006, a SIKORSKY S-61N helicopter, registration EC-FJJ, took off from La Palma Airport, located on the island of La Palma (Canary Islands, Spain), at 08:19, with two pilots and four passengers on board (one of whom was the mechanic assigned to maintain the helicopter), en route to Las Palmas Airport, located on the island of Grand Canary (Canary Islands, Spain).

In keeping with the flight plan filed by the crew, the aircraft was scheduled to fly under Visual Flight Rule (VFR) conditions, heading initially to the west (point W) of the Tenerife-North Airport, located on the island of Tenerife (Canary Islands, Spain), overfly it at an altitude of 1,000 ft to the east (point E) and, from that point, proceed toward the destination airport at a cruising speed of 100 kt (IAS). The flight was scheduled to last one hour and the helicopter was carrying enough fuel for three hours.

Meteorological conditions on the planned route were suitable for the helicopter's flight; despite this, the helicopter's crew did not consider the local conditions at Tenerife North Airport to be ideal for flying over the airport and, at 08:42, requested and obtained clearance from approach control at this airport to head directly to the north (point N) of the airport and circle around the northeast tip of the island of Tenerife toward point E, instead of flying over the airport.

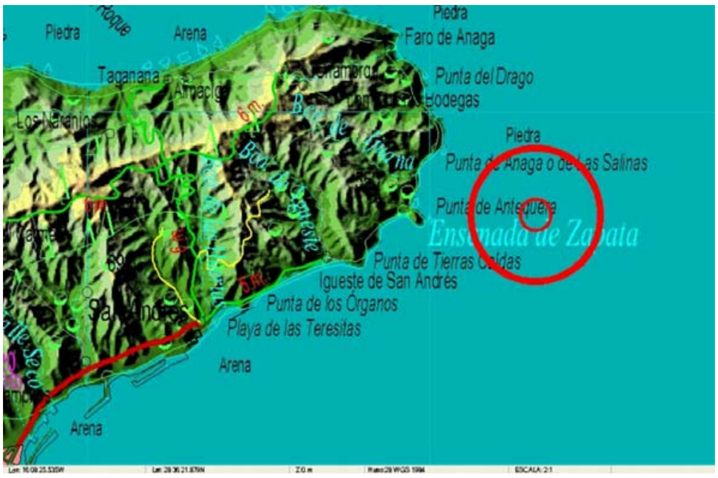

Figure 1. Area of accident

At 08:58, the crew was informed that no visual traffic had been reported around points N and E, which the crew acknowledged. Radar showed the helicopter 12 NM away from the airport flying from west to east at an altitude of 600 ft and a GS of 120 kt. At 09:00:14, its radar echo disappeared from the radar screen in an area for which there is no coverage at the altitude at which the aircraft was flying.

Ten minutes later, at 09:08:47, there was no reply from the crew when it was requested to report having reached point E. The aircraft's echo did not reappear on the radar screen.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	1 + 1 missing	4	6	
Serious				
Minor				Not applicable
None				Not applicable
TOTAL	2	4	6	

1.3. Damage to aircraft

The aircraft was totally destroyed.

1.4. Other damage

There was no other damage.

1.5. Personnel information

1.5.1. *Pilot in Command*

Age/Gender: 53 / Male

Nationality: Spanish

License: Airline Transport Pilot License - Helicopter ATPL (H)

- Issued: 27 Sep 1991
- Renewal date: 02 Aug 2005
- Expiration date: 22 Jul 2010

Last medical examination: 06 Jun 2006, valid until 15 Dec 2006

Ratings:

- SIKORSKY 61: Valid until 13 Jul 2007
- AEROSPATIALE SA365/365N: Valid until 14 Jul 2006
- Visual flight
- Firefighting: Valid until 26 Jul 2007

Total flight hours: 9,240 h

Hours on the type:

- Total: 3,020 h
- Pilot in Command: 2,365 h

Hours in previous 30 days:	35 h
Rest prior to flight:	12 h, approximately

1.5.2. *F/O*

Age/Gender:	39 / Male
Nationality:	Spanish
License:	Commercial Pilot License (Helicopter) – CPL (H) • Issued: 14 Mar 2004 • Renewal date: 22 Jun 2006 • Expiration date: 05 Mar 2011
Last medical examination:	13 Feb 2006, valid until 13 Feb 2007.
Ratings:	• BELL 212/412: Valid until 10 Feb 2007 • SIKORSKY 61: Valid until 14 May 2007 • Instrument flight (Helicopter): Valid until 10 Feb 2007
Total flight hours:	520 h
Hours on the type (F/O):	65 h
Hours in previous 30 days:	65 h
Rest prior to flight:	12 h, approximately

1.5.3. *Aircraft Maintenance Technician (TMA as per Spanish abbreviations - Mechanic)*

Age/Gender:	53 / Male
Nationality:	Spanish
Issued:	1977 (Chile's Technical License)
License (TMA - Spain):	• Issued: 1994 • Renewal date: 16 Jun 2005 • Expiration date: 16 Jun 2007
Classes:	Line Maintenance
Ratings:	BELL 212 and SIKORSKY S-61N

He had taken the HELICOPTER HOIST OPERATOR course given by HELICSA in 1995.

In the HISPACOPTER, S.L.[2] Maintenance Organization Manual, he was listed as a Part 145 Certifying Technician with the following ratings:

- Airframe: Line Maintenance: S-61N, Bell 212
- Engines: Periodic revisions of those outfitted to aircraft in the Airframe section.

1.6. Aircraft information

The SIKORSKY S-61N helicopter, certified by the FAA of the United States in 1962, is a civilian version of the SH-3 "Sea King" military helicopters developed by Sikorsky in the late 1950s for antisubmarine warfare.

It is an amphibious helicopter with a watertight shell and lateral floating devices (sponsons) to ensure its stability in water, meaning it can land on and take off from water. The main landing gear is retractable, with the legs being housed in the floats. It is designed to transport personnel (up to 30 passengers) and cargo, the latter being transportable either inside or on an external sling. Moreover, a hoist can be installed for lifting personnel or cargo onboard with the aircraft in the air. Thanks to these features, the S-61N helicopter is very widely used for ferrying people and cargo between land and off-shore oil platforms, for various types of aerial work and in search and rescue operations.

It is equipped with two General Electric CT58-140-2 engines, each capable of delivering a maximum continuous power of 1,267 CV (1,250 HP) and a maximum takeoff power of 1,420 CV (1,400 HP) at the shaft.

It has a conventional rotor configuration, with a main and tail rotor, both powered by the two engines through a transmission system and controlled by the helicopter's flight control systems.

1.6.1. *Airframe*

Manufacturer:	Sikorsky Aircraft Corporation
Model:	S-61N
Manuf. number:	61299
Year of manufacture:	1966
Registration:	EC-FJJ
Operator:	Helicópteros, S.A. (HELICSA)

[2] HISPACOPTER, S.L. is the maintenance center to which HELICSA had contracted out its line and base maintenance for its S-61N fleet. Both organizations belonged to the same group of companies.

1.6.2. *Airworthiness certificate*

Number:	3360
Type:	Normal
Category:	Large Rotorcraft
MTOW:	8,168 kg (19,000 lb)
Issue date:	07 Apr 2006
Renewal date:	07 Jul 2006
Expiration date:	06 Apr 2007

The Airworthiness certificate was initially issued on 7 April 2006, after an inspection of the helicopter, including in flight, and of its documentation. As a result of an unresolved non conformity involving the certification of the interior, a three-month grace period was granted to correct the deficiency. The validity of the Airworthiness Certificate was limited to this period, valid until 7 July 2006, to ensure compliance.

Once the non-conformity was satisfactorily resolved, an Airworthiness Certificate valid for a full year, as specified in DGAC circular 11-19B, was granted on 7 July 2006, the date on which the initial validity period expired. The new Certificate was valid from 7 April 2006 until 6 April 2007.

1.6.3. *Maintenance record*

The helicopter operator had an Approved Maintenance Program (AMP) in effect, reference AMP-S61N, for its fleet of Sikorsky S-61N helicopters. On 28 February 2006, the DGAC informed the operator of its approval of its 1st edition, dated 1 October 2005, pursuant to section M.A. 302 of Annex I (Part M), Section A Technical Requirements, Subpart C Continuous Airworthiness, of European Commission (EC) Regulation no. 2042/2003 of 20 November 2003.

In Chapter 01-02-00, Section 4 of this manual, there is a list of periodic checks (4. Maintenance Checks) that must be performed on the helicopter:

A) Preflight Check – PFC

This is a safety inspection that must be performed prior to each flight following the completion of all maintenance and as close to the departure time as possible. It is not considered part of the helicopter's maintenance program.

It is valid for eight hours of flight time for helicopters with an operational CBIM system, and for three hours of flight without said system.

B) Daily Maintenance Check – DMC

This is a general visual inspection to ensure the continuous airworthiness of the aircraft. It must be performed by a certifying TMA.

It must be performed after the day's last flight, regardless of the number of hours flown, and is valid for 24 calendar hours or 10 flight hours, whichever comes first.

C) Weekly Inspection

This is a visual inspection of the structure and related systems intended to ensure their proper state and continuous airworthiness.

D) 40-hour check (1A Check)

This is a general inspection of the structure and related systems intended to ensure their proper state and continuous airworthiness.

E) 240-hour check (2B Check)

This is a specific inspection of the function and condition of the flight controls, fuel system and critical structural areas.

F) 720-hour check (3B Check)

This is a preventive maintenance inspection of corrosion-protected components and areas of the airframe, and includes cleaning, inspecting for and protecting against corrosion.

G) 2,400-hour check (C Check)

This is an inspection of the entire primary structure, wiring and systems. Accessing the affected components requires significant effort.

H) 14,400-hour check (D Check)

This is a complete overhaul and reconditioning of the airframe, the flight control system and wire bundles to restore them to an "as-new" condition.

The 1A, 2B and 3B checks are considered line maintenance, C as base maintenance and D as overhauls.

At the time of the accident, the helicopter had a total of approximately[3] 36,260 flight hours and 45,200 total cycles.

[3] Since the data for the flights of 7 July 2006 were not recovered, the duration of those flights and the number of landings made on that day had to be estimated.

The following table shows the checks included in the maintenance program, the corresponding intervals and the compliance status on the accident helicopter:

Checks	Interval	Scheduled	
		Last	Next
Weekly	7 days	02-07-2006	09-07-2006
1A (Areas 1, 2, 3, 4, 5)	40 (+5) h[4]	36,217:40	36,257:40 (+5)
	30 days	25-06-2006	25-07-2006
2B (Area 1)	240 (+5) h	36,168:50 07-12-2005	36,408:50 (+5)
2B (Area 3)		36,168:50 07-12-2005	36,408:50 (+5)
2B (Area 4)		36,183:00 16-03-2006	36,423:00 (+5)
2B (Area 5)		36,244:55 04-07-2006	36,484:55 (+5)
3B (Area 1)	720 (+5) h	35,930:20 27-10-2004	36,650:20 (+5)
3B (Area 3)		36,035:40 26-02-2005	36,755:40 (+5)
C	2,400 (+40) h	35,985:20	38,385:20 (+40)
	3.5 años	14-01-2005	14-07-2008[5]
D	14,400 (+5) h	31,770:37	46,170:37
	15 (+1) years	28-06-1991	28-06-2007

The last technical log entry made, for July 6 2006, includes the daily maintenance check.

1.6.4. *Engines*

Manufacturer:	General Electric Company	
Position	N° 1	N° 2
Model:	CT58-140-2L	CT58-140-2
Manuf. number:	295-087C	295-165C

[4] The numbers in parentheses indicate the tolerance allowed under the Approved Maintenance Program for this aircraft.

[5] The calendar limit does not apply if the flight hour limit is not reached before 28 Jun 2007, the limit for the next "D" inspection.

Installation date:	24 Mar 2006	18 Aug 2001
Total flight hours:	20,930 (approx.)	25,025 (approx.)
Hours last overhaul:	18,889:17 h	23,786:38 h
Remaining hours:	5,960 h (approx.)	6,760 h (approx.)

1.6.5. *Main rotor blades*

Manufacturer: Sikorsky Aircraft Corporation

Model: 61170-20201-067

Position:[6]	Blue	Yellow	White
Manuf. number:	61M2737-2666	61M3165-2997	61M3483-3260
Installation date:	09-12-2003	29-12-2004	29-12-2004
Total flight hours:	9,130 (approx.)	8,188 (approx.)	7,785 (approx.)
Remaining hours:	1,470 (approx.)	2,412 (approx.)	2,815 (approx.)

Position:	Red	Black
Manuf. number:	61M3744-3532	61M3879-3653
Installation date:	17-05-2004	29-12-2004
Total flight hours:	5,925 (approx.)	6,827 (approx.)
Remaining hours:	4,675 (approx.)	3,773 (approx.)

1.6.6. *Main rotor characteristics*

The main rotor on this helicopter type has a diameter of 18.90 m (62 ft) and features five blades mounted on a rotating head to provide the necessary lift for flight.

Each blade consists of a hollow aluminum alloy spar along its leading edge, 25 aluminum pockets along the trailing edge, two aluminum sealing elements, one at the root (root cap) and one at the tip (tip cap), a steel root component where it joins the rotor head (cuff) and a stainless steel abrasion strip located along the leading edge. Each blade has a length of 8.67 m (28.44 ft) and a chord of 463.55 mm (18.25 in).

[6] So as to distinguish among the blades, each rotor head position is assigned a color, and each blade is assigned the color that corresponds to the position in which it is installed.

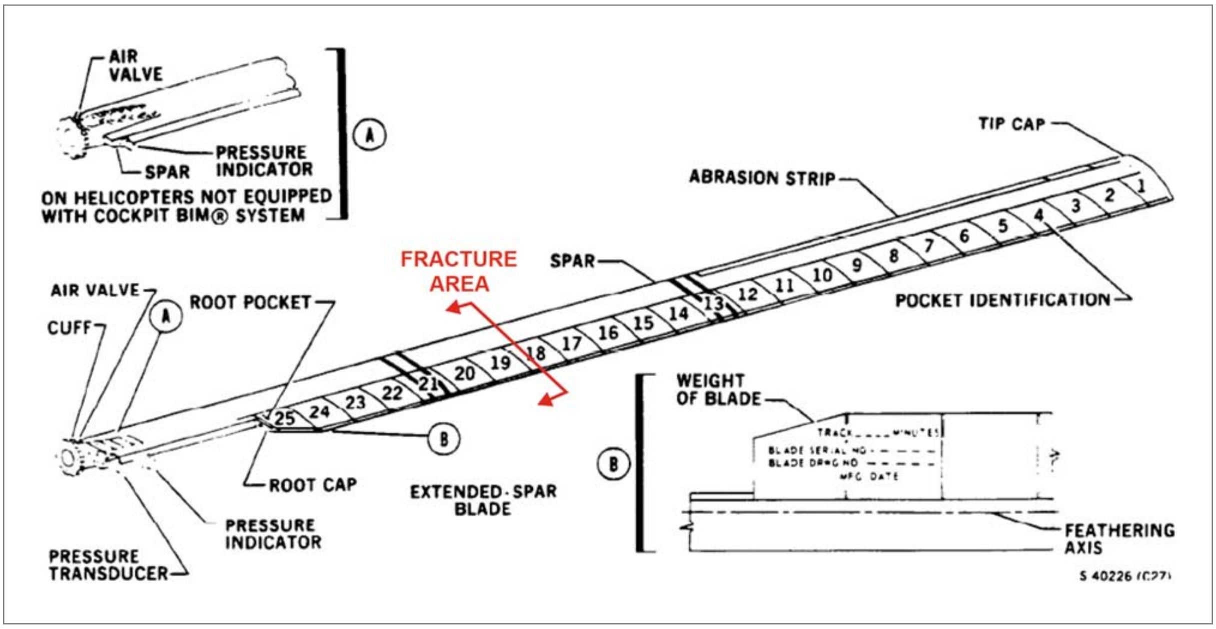

Figure 2. Diagram of a main rotor blade

The rotor spars are filled with low-pressure nitrogen. At the root of each blade there is a fill valve and a visual pressure indicator called VBIM (Visual Blade Inspection Method). In addition, this helicopter had a system called CBIM (Cockpit Blade Inspection Method), consisting of pressure sensors that provide a luminous indication in the cockpit if the nitrogen pressure in any of the blades drops below a set value with the helicopter in service.

1.7. Meteorological information

1.7.1. *Information provided to the crew*

According to the information provided by Spain's National Weather Institute prior to the flight, the helicopter crew requested the weather information available at the La Palma Airport Weather Office. They were provided with the following:

- Bulletin with the aerodrome weather forecasts (TAF) for Canary Island airports.
- Bulletin with the routine weather reports (METAR) for Canary Island airports.
- Wind and temperature charts for flight levels 050, 100 and 180.
- Significant low level weather chart (SWL).

1.7.2. *Prevailing conditions*

The weather conditions along the planned route were suitable for the flight in question. The sky was generally overcast with low clouds with bases around 3,500 ft and moderate winds from the north to northeast, gusting strongly near mountainous areas. Tenerife North Airport was overcast with winds out of the northwest at 16 kt and gusting up to 28 kt. The relative humidity was 85% and the temperature was 18 °C.

The Meteosat 8 high-resolution satellite images showed the formation of weak to moderate mountain waves to lee of the Anaga range, which is located at the northeastern tip of the island of Tenerife in a southwest to northeast orientation. Out at sea this gave rise to updrafts and downdrafts to the south of this range off the island's northeast coast.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The aircraft's crew maintained communications with the following ATC facilities:

- La Palma Airport Control Tower (GCLA TWR) on a frequency of 118.90 MHz, between 08.07:32 and 08.22:07.
- Canaries Area Control Center (Canarias ACC – GCNB) on a frequency of 126.10 MHz, between 08.22:23 and 08.41:31.
- Tenerife North Airport Approach Control (GCXO APP) on a frequency of 124.80 MHz, between 08.41:47 and 08.58:07.

The content of these communications is described below:

1.9.1. *Communications with the La Palma Airport Control Tower*

Communications with this facility began at 08:07:32, when the aircraft requested permission to start up its engines, which was granted. They were also provided with the available weather information.

At 08:14:39, the crew of the helicopter reported they were ready and they were given instructions for takeoff and departure to Las Palmas.

The aircraft was cleared for takeoff at 08:18:56 and transferred to the Canaries Area Control Center at 08:22:07 as it flew over point E at an altitude of 1,000 ft.

1.9.2. *Communications with the Canaries Area Control Center*

Shortly after being transferred, at 08:22:23, the helicopter crew established contact with this facility. They were told they were in radar contact, after which the crew reported its intentions as per the flight plan they had filed. They were asked to report when they were 10 NM away from Tenerife North airport, which they acknowledged.

At 08:41:31, it was the ATC facility that contacted the aircraft to transfer it to the Tenerife North Airport Approach Control.

1.9.3. *Communications with Tenerife North Airport Approach Control*

The aircraft contacted this station at 08:41:47. Once they were notified that there was no visual traffic reported along its route, of the runway in use and the QNH at the airport, they were instructed to report point W. At that time, the crew requested to proceed directly to point N and circle around the northeast of the island of Tenerife. They were authorized to do so, at which point the crew confirmed they were on course to point N.

At 08:58:07, the crew was told there was no visual traffic reported between points N and E, which they acknowledged.

Ten minutes later, at 09:08:47, there was no response when the crew was contacted to report having reached point E.

1.10. Aerodrome information

Not applicable.

1.11. Flight recorders

1.11.1. *Cockpit Voice Recorder (CVR)*

The helicopter was equipped with a Fairchild A-100 CVR, part number (P/N) 93-A100-31, serial number (S/N) 6699, housed in the aft section of the fuselage.

This device records on four channels and is able to continuously record the sounds corresponding to at least the last 30 minutes of aircraft operation.

As noted in 1.15, this component was still in its place when the wreckage recovered on the day of the accident was taken to the port. After verifying that it had suffered no apparent damage, it was removed and preserved submerged in fresh water.

The information recorded on this device was extracted at the recorder laboratory of the Bureau d'Enquetes et d'Analyses pour la Securité de l'Aviation Civile (BEA), the organization responsible for investigating civil aviation incidents and accidents in France. Four channels of sound lasting 32:12 minutes were recovered and transferred to commercial media for subsequent transcription, study and analysis.

Three of the channels had recorded the sounds from the:

- Area microphone.
- Microphone and headset for the Pilot in Command's seat
- Microphone and headset for the F/O's seat.

The last channel was blank since the helicopter was not wired to record sounds on it.

1.11.1.1. Conversations and sounds recorded on the CVR

The conversations and sounds recorded on the CVR were played back and transcribed at the offices of Spain's Civil Aviation Accident and Incident Investigation Commission (CIAIAC) by commission personnel, aided by two specialists from the helicopter operator's S-61N fleet. Once the CVR was transcribed, it was synchronized with the communications and radar track recorded at the various ATC facilities involved in the flight.

The recording started at 08:35:13, sixteen minutes after takeoff from La Palma Airport, and ended at 09:07:25, when the equipment stopped functioning, most likely as a consequence of the helicopter's impact against the ocean surface.

The channel associated with the area microphone had sounds from the aircraft's engines and mechanical components. The conversations and sounds from within the cockpit could not be heard on it.

The channels associated with the microphones and headsets of the Pilot in Command and the F/O had the same conversations and sounds, captured by different microphones. The quality of the recordings was sufficiently good in both that it was possible to listen to them without first having to process the audio.

These channels contained the conversations maintained between the two crew members, the mechanic and one of the passengers, as well as the communications with ATC by this and other aircraft. Generally, there was nothing out of the ordinary until, 4.5 seconds before the end of the recording, the background noise increased significantly. This noise continued until the end and prevented the remaining cockpit conversations and sounds from being heard.

Finally, as regards possible technical problems with the aircraft, it is worth noting that at 08:41:27, the Pilot in Command said, "See, we have a BIM PRESS"[7]. No one replied and no comments were made in this regard for the remainder of the flight.

1.11.1.2. Spectral analysis of the CVR recording

The frequencies of the noises recorded on the CVR were analyzed so as to identify which rotating helicopter components could have caused them and to determine their operating conditions based on any possible variations in their associated frequencies. One of the studies was conducted at the flight recorder laboratory of the National Transportation Safety Board (NTSB), the agency responsible for investigating incidents and accidents involving different means of transportation in the United States, with help from the aircraft manufacturer. The results of this study in terms of the characteristics of the recording, the frequencies identified and their variations were confirmed by another conducted at the Criminal Services Acoustics and Imaging Department of Spain's Civil Guard.

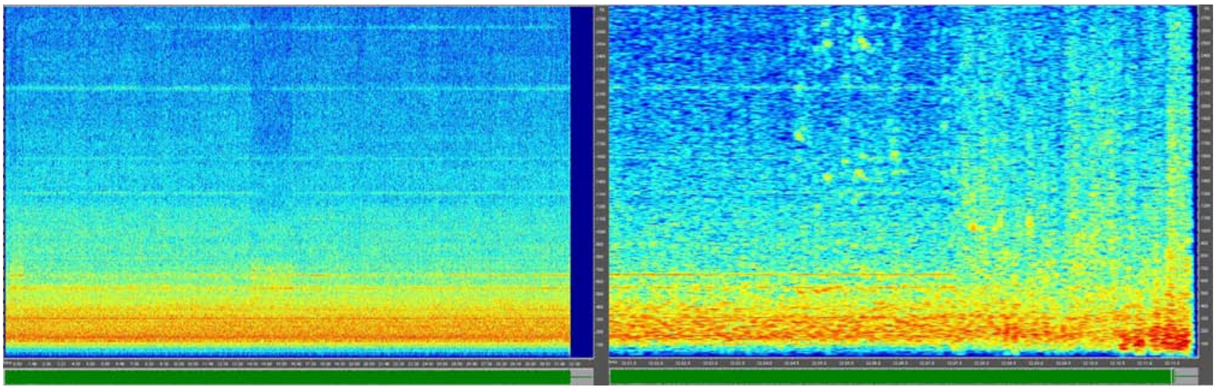

Figure 3. Spectrum of area channel, complete and last 11 seconds

On the channel associated with the area microphone, it was possible to identify the frequencies and harmonics corresponding to the aircraft's alternating current and those generated by the rotation under normal operating conditions of the following components:

- Tail rotor.
- Power turbine tachometer generators.
- High-speed transmission shaft
- Hydraulic pump.
- Meshing of main rotor mast with the planetary gear on the main transmission.

[7] Indication of a low nitrogen pressure inside at least one of the main rotor blades.

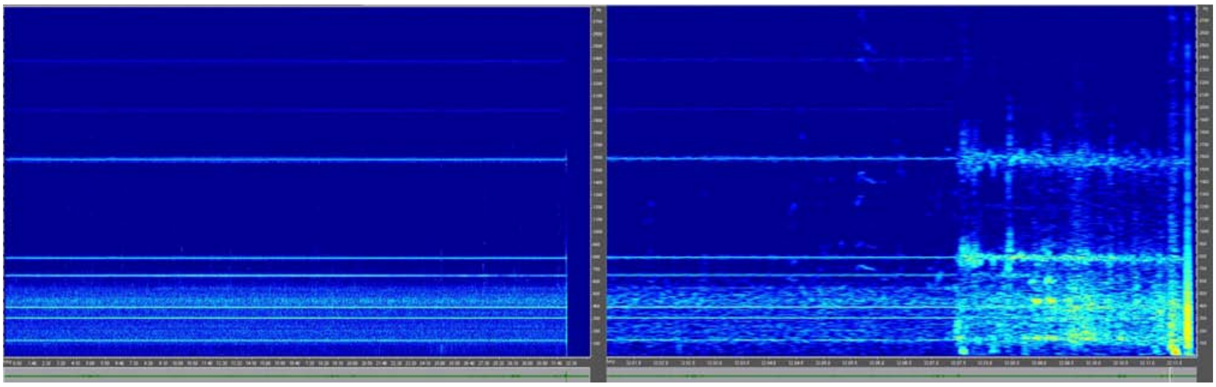

Figure 4. Spectrum of blank channel, complete and last 11 seconds

These signals remained constant throughout the flight until, as with the conversations and other sounds, they suddenly disappeared 4.5 seconds from the end of the recording as the background noise increased and persisted until the conclusion of the recording. Under these conditions, it was impossible to establish whether any of the helicopter's primary mechanical components failed.

The spectrum of the blank channel was also analyzed at the NTSB's laboratory to look for the frequencies associated with electrical noise. Practically the same frequencies and variations were found as were present in the area microphone. The fact that frequencies corresponding to acoustic signals, such as that produced by the turning of the gear on the main rotor mast, were found on a channel that was not designed to record them, though unusual, does occur with relative frequency and is explained as the result of electronic coupling or interference induced by the rotation of these components in those cables routed next to them.

The study of the last 4.5 seconds of this channel also yielded no valid information to establish the possibility of a failure in one of the helicopter's primary mechanical components.

1.12. Wreckage and impact information

1.12.1. *Helicopter debris found and recovered*

As detailed in 1.15, floating debris was found on the same day of the accident and recovered. The debris included the aft section of the fuselage and structural components from the lower center section of the fuselage.

As a result of the search conducted between 1 and 8 September 2006, light components were found on the sea bottom from every area of the fuselage that had not been previously recovered (except the tail section), along with parts from four of the five main rotor blades and some of the helicopter's documentation.

Figure 5. Wreckage recovered, at the port in Tenerife

The debris recovered can be grouped into three categories: documentation, structure and main rotor blades. Each is considered in turn below.

1.12.1.1. Documentation

The Daily Maintenance Record (DMR) was found and recovered from the ocean floor. Inside were the operator's documents, but only four of the daily logs were found, folded into four pieces, corresponding to the flights made on 6 July 2006 between the airports of Jerez and Las Palmas. The rest, due to the characteristics of the paper and to the length of time submerged, disintegrated when the book was moved in the water as it was being recovered.

The log that was recovered only makes mention of an anomaly noted by the mechanic on the pre-flight inspection performed in Jerez, a fault in the radar transceiver, which was replaced.

1.12.1.2. Structure

As already indicated, components were recovered on the very day of the accident, including the aft section of the fuselage and structural elements from the lower center section of the fuselage.

Figure 6. Debris found on ocean floor

In addition, light elements were found on the ocean floor from every one of the helicopter fuselage sections that was not previously recovered, except for the tail section.

1.12.1.3. Main rotor blades

All of the segments found for four of the five main rotor blades correspond to the part closest to the union of the respective blade with the rotor head.

With regard to the sections that exhibited the fractures, three of them showed breaks of similar characteristics at both ends, all of them having detached from the rotor head due to fractures in the blades in a section close to the union with the rotor head. The fourth had broken from its rotor head attachment due to the breaking of the fastening bolts. Of the three aforementioned blades, the first two fragments were recovered and measured approximately 4.5 and 5.5 m. The third fragment was not recovered. The fourth, belonging to the fourth blade, measured some 3.8 m.

Figure 7. Recovered main rotor blades

It was noted that the breaks in the first two spar segments were of a static nature. Due to their similar characteristics, judging by the images captured by the ROV (Remote Operated Vehicle), it is believed that

Figure 8. Ends of the “black” blade segment recovered

the third unrecovered fragment also fractured statically. As a result, it is thought that these three blades broke as the result of the large energy applied as they impacted the water.

As for the spar from the fourth blade segment, the break in the single fracture area showed characteristics of having started progressively.

The diagram in Figure 2 indicates the position of this fracture area, located in pocket no. 18, 112.3 mm away from the edge adjoining it to no. 19.

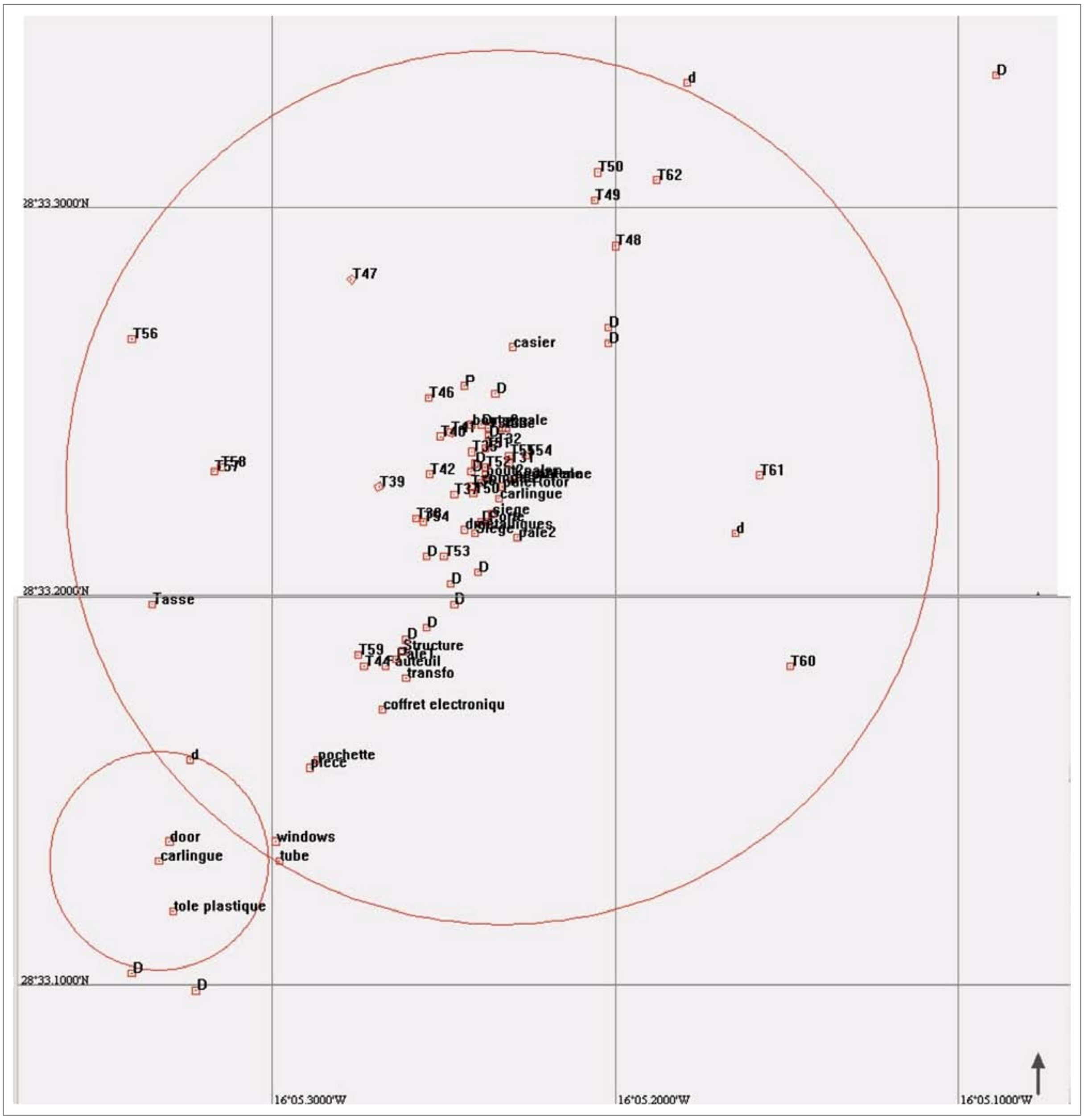

Figure 9. Debris field on ocean floor

1.12.2. *Impact of the helicopter with the water*

The fractures found on the aft section of the helicopter fuselage and the structural elements from the lower central portion of the fuselage indicate that the helicopter contacted the water surface at very pronounced high pitch and right bank angles.

The aft break present in this section also indicates that the tail detached from the fuselage as a single piece, bending first to the right, then twisting left around the helicopter's longitudinal axis before finally falling vertically.

Finally, the light fragments found on the sea floor from all the areas of the fuselage not previously recovered, except for the tail section, attest to the violent nature of the aircraft's impact with the water surface, as a result of which the structure of the cockpit and of the forward and central sections of the fuselage practically disintegrated.

1.13. Medical and pathological information

1.13.1. *Pilot in Command*

Only the upper part of the Pilot in Command's remains was recovered, completely severed at the abdomen below the navel.

In addition to this disseverance, the body exhibited a violent frontal contusion of the head and face, as well as a partial anterior cut on the thorax from the upper right shoulder to the bottom of the left armpit that included both the skin as well as anatomical structures of the thoracic cavity.

The autopsy report on the body of the aircraft's Pilot in Command concluded that the cause of death was traumatic shock resulting from injuries that could have been produced by a frontal contusion, as well as from the cutting effect of the helicopter blades which severed the body in two places, a partial anterior cut of the thorax and a complete disseverance below the navel.

1.13.2. *Passengers*

The autopsy reports on the bodies of the aircraft's four passengers concluded that they died from traumatic shock resulting from injuries consistent with a high-altitude fall and a severe frontal impact.

1.14. Fire

There was no fire.

1.15. Survival aspects

1.15.1. *Search and rescue*

The helicopter's last radio contact took place at 08:58:07 with Tenerife North Airport approach. At that time, radar showed the helicopter 12 NM north of the airport flying from west to east at an altitude of 600 ft and a speed of 120 kt. At 09:00:14, its echo disappeared from the radar display in an area with no radar coverage at said altitude. It did not reappear.

Ten minutes later, at 09:08:47, the helicopter crew was contacted by the same ATC facility to report reaching point E, to which there was no reply. The same thing happened when a new contact attempt was made at 09:10:34. When no reply was received, efforts were made on other frequencies and by asking other aircraft to relay the message, with the same result.

In light of this situation, and in keeping with established procedures, approach control at Tenerife North Airport asked other ATC facilities if they had any news about the helicopter. The reply was negative.

1.15.1.1. Search conducted by Search and Rescue (SAR) services

The Canaries Rescue Coordination Center (RCC) was first notified by radio of the loss of contact with the aircraft and of its delay in reaching its destination at 09:37. Coincident with this notification were reports received from various aircraft control communications facilities that they had picked up a signal from an emergency beacon.

The first concrete information about the helicopter was received at 10:13 at the control center of the Port of Tenerife, when a pleasure craft reported having heard another vessel on the radio report that a helicopter had gone into the water in the area of Las Manchas, to the northeast of the island of Tenerife, and that it was heading in that direction.

At that time, air and surface units were dispatched to the area. The helicopter wreckage and some of its occupants were located shortly afterwards, with rescue efforts starting at around 10:30.

The floating remains of three of the passengers were found first, along with the aft section of the helicopter fuselage with an inflated life raft inside. The three bodies were recovered and taken immediately to land, while the section of fuselage was secured to keep it from sinking and then inspected by divers, who found the mechanic's body inside. This section was later taken to the Port of Tenerife.

Of note is the fact that the CVR housing in the aft section of the fuselage was in its proper place when the wreckage arrived at the port. After checking it for obvious signs of damage, it was removed and preserved submerged in fresh water to avoid, to the extent possible, corrosion caused by sea water.

During the day of the accident, more parts of the wreckage were found, along with the body of the Pilot in Command late in the afternoon, which was located and recovered at around 19:30.

The search conducted by SAR services lasted until 14 July, and covered an area along the east coast of the island of Tenerife. The remains of the F/O could not be found, and he was declared missing.

In an effort to complement the units deployed in the efforts to locate the aircraft and the F/O, the helicopter operator contracted the services of an oceanographic vessel equipped with a multibeam sonar, side scan sonar and surface-guided video submersible to a maximum depth of 300 m, as well as of an airplane equipped to conduct surface searches.

To the extent permitted by weather conditions, and in coordination with SAR services, these resources were deployed between 10 and 20 July.

In addition to the aft section of the fuselage, of particular note among the additional helicopter components recovered are the following:

- The main landing gear, the left leg of which was recovered with its corresponding float.
- A piece of the lower center part of the fuselage, which included the part containing the floor of the cabin.
- A portion of the cabin floor.
- Two radio beacons.
- A life jacket.
- Personal effects of the occupants.

All of these remains were also taken to the Port of Tenerife. All of the remains recovered were subsequently placed in storage at Tenerife North Airport.

1.15.1.2. Search for the main helicopter wreckage

In light of the unsuccessful search for the helicopter wreckage, and in the interest of furthering the technical investigation of the accident, it was decided to search for the

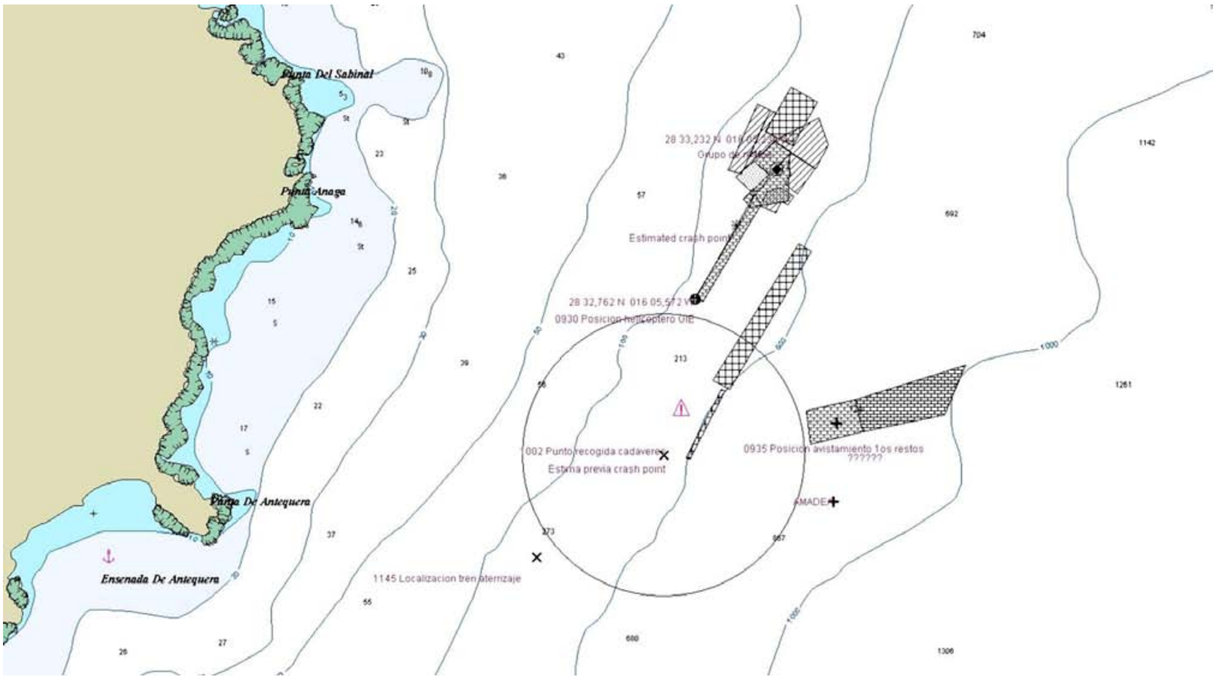

Figure 10. Search areas

submerged remains by using means suitable to the depths of the water in which the accident took place.

This search was conducted under the supervision of the CIAIAC between 1 and 8 September 2006, using a ship equipped with a remotely-operated vehicle (ROV), side-scan sonar and search and recording equipment capable of operating at depths of up to 1,000 m.

Due to the topography and the characteristics of the ocean floor in the area, the side-scan sonar proved ineffective in the search, which had to be conducted exclusively with the ROV.

As for the search areas involved, it was decided to start in the vicinity of where the eyewitness reported having seen the helicopter fall to the water, with depths of between 700 and 900 m. No wreckage of any type was found.

A second search area was defined based on the locations where the bodies of the passengers and the aft section of the helicopter fuselage were found, with depths of between 630 and 955 m. The results of this search were also negative.

A third area, determined by the location of where the aircraft's remains were first found on the surface, with depths of between 700 and 1,000 m, yielded some debris from the helicopter, distributed over an approximate area of 500 × 350 m, on 4 September.

Among this debris were four main rotor blade segments and the aircraft's Daily Maintenance Record (DMR). Apart from these items, the remains found generally consisted of light components from the aircraft, especially the entire outer skin of the fuselage, and elements from inside the cabin and from windows from every area of the helicopter fuselage not previously recovered.

All of the components were found in the time between the discovery of this debris and the 6th. They were documented and filmed, and a sketch was made showing their positions. Recovered were three of the blade segments, the DMR and a bag with personal effects.

Once these tasks were completed, the search was continued during the evening of the 6th and then on 7 and 8 September over a wider area. Nothing else was found, meaning that the heavier helicopter components, such as mechanical components or the tail, are not available. It was also not possible to find the remains of the F/O.

1.15.2. *Survival aspects*

Given the characteristics of the helicopter's impact with the water, its occupants had no possibility of survival.

1.16. Tests and research

1.16.1. *Inspection of aircraft wreckage*

As detailed in 1.15.1.1, floating debris from the helicopter was recovered on the day of the accident, including the aft section of the helicopter's fuselage and structural components from the lower central section of the fuselage.

These were taken to the Port of Tenerife, were they were identified and catalogued. The damage noted on each was documented and related to that observed on other parts. This study allowed for a determination that all of the fractures and deformations found had resulted from a severe impact with the water and that, at the time of impact, the helicopter had significant pitch and right bank angles.

Likewise, as indicated in 1.15.1.2, during the search conducted between 1 and 8 September 2006, four main rotor blade segments and light components from the helicopter's fuselage were found on the ocean floor. All of these remains were documented and three of the blade segments were recovered.

A study of the video documentation obtained during the search concluded that the light components found belonged to all of the fuselage areas not previously recovered, except for the tail section.

Both the debris found on the day of the accident and which had been initially taken to the Port of Tenerife, and the three blade segments recovered from the ocean floor, were stored in a hangar at Tenerife North Airport.

A 100-mm long section of spar was cut from a blade segment corresponding to the helicopter's "black" blade, and which included the fracture section that showed signs of a progressive failure. This section was sent for analysis to the laboratories of the Metallic Materials Division of the "Esteban Terradas" National Institute for Aerospace Technology (INTA). The NTSB of the USA later requested to be sent this piece, which it was, for the purpose of conducting additional studies at its laboratories in collaboration with the helicopter manufacturer.

1.16.2. *Study of the fracture area in the main rotor "black" blade*

1.16.2.1. Study conducted at INTA

A study of the characteristics exhibited by the fracture section of the "black" blade spar was conducted at the "Esteban Terradas" National Institute for Aerospace Technology (INTA).

In general, the entire surface of this segment was corroded as a result of having been submerged in sea water for some two months.

Referring to the diagram in Figure 11, four clearly separate areas were evident in the fracture surface:

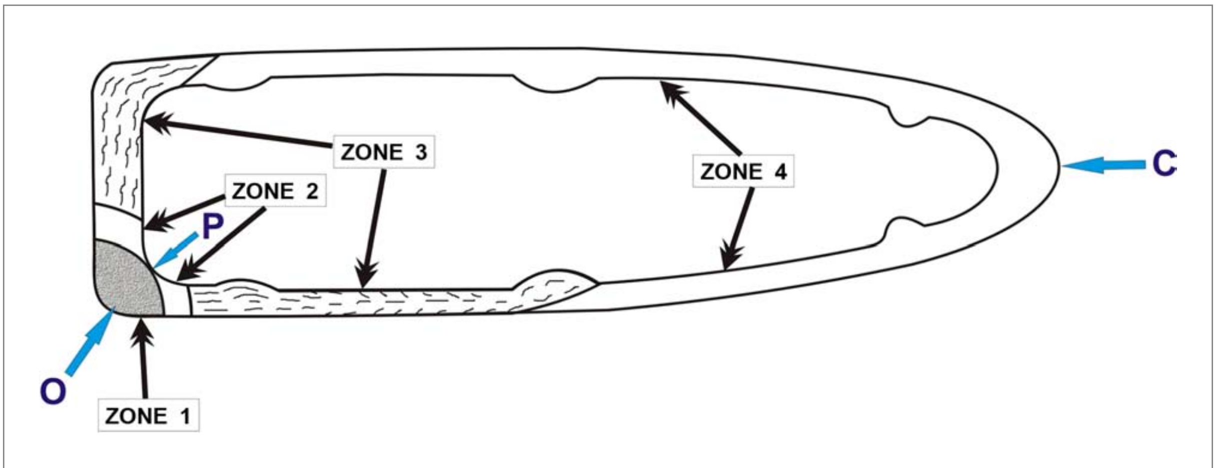

Figure 11. Fracture surface zones

- Zone 1:

  Exhibited clear indications of a progressive break, originating at O, and caused by fatigue.

  The external surface of the spar around O was highly corroded, more so than the rest of the fracture surface, which impeded the gathering of more data as to the origin of the fatigue process.

- Zone 2:

  Exhibited macrofractographic characteristics that did not allow for a determination of the fracture micromechanism. It also displayed microfractographic features consistent with ductile failure produced by a tensile static overload.

- Zone 3:

  This zone had a directional rough texture that displayed macrofractographic features typical of brittle fracture due to a tensile static overload and microfractographic features typical of ductile failure due to a tensile static overload. These features indicate that the fracture in this zone resulted from a tensile static overload applied at a very high speed (with or without impact effect).

- Zone 4:

  Comprised of two C-shaped 45° bevels. It exhibited small thickness sheets, typical characteristics of ductile failure produced by a tensile static overload.

As a result of this study, it was determined that the break in this section of blade initiated along the lower part of the rear spar wall (point O in the diagram of Figure 11), propagated via a fatigue mechanism and developed and failed due to a tensile static overload.

The zone exhibiting signs of a progressive failure caused by a fatigue mechanism extended over approximately 5% of the blade section’s surface and affected practically the entirety of the spar wall thickness. On the edge that opened toward the inside of the blade there was a strip of material about 1 mm thick, corresponding to the fracture exit lip (point P in the diagram of Figure 11).

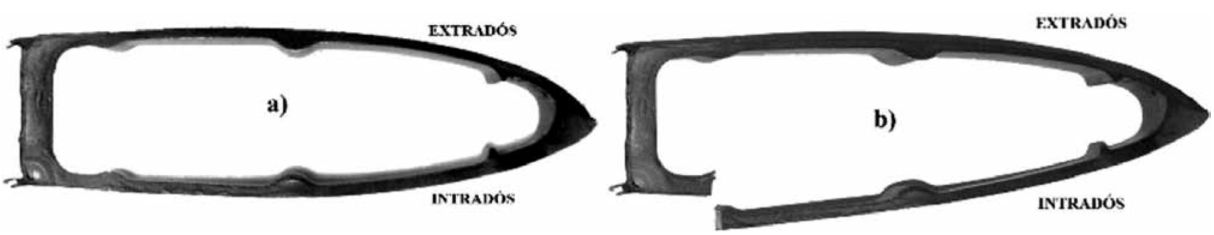

Figure 12. Fracture section before and after the cut

As for the initiation of the fatigue fracture, it took place in an area whose surface had flattened during the crack propagation and subsequently undergone an oxidation-corrosion process, over a limited area, which masked any information concerning the existence of a possible process prior to the corrosion. This process, very localized, could have contributed to the initiation of the fatigue process.

As for the material used to manufacture the blade spar, it was verified to have been a struded EN AW 6061 T6-treated aluminum alloy, in compliance with the manufacturer's specifications. The material's state did not exhibit any abnormalities, with the exception of residual stress detected in the perpendicular plane along the length of the blade when it was cut to obtain the samples (see photographs in Figure 12). These stresses could not have affected the fracture, which resulted from forces that were parallel to the length of the blade.

1.16.2.2. NTSB analysis

The characteristics present in the fracture section from the "black" spar blade were studied at the NTSB Materials Laboratory with the aid of a representative from the Sikorsky Aircraft Corporation.

In this study, it was noted that a portion of the fracture surface on the spar's trailing edge exhibited relatively flat characteristics along a plane perpendicular to its longitudinal axis, characteristics which were consistent with a fatigue crack. There were lines along which the fracture stopped, also consistent with a fatigue crack, originating at the lower corner of the spar's trailing edge, as shown in Figure 13. These typical fatigue fracture features extended to the top and forward to the dashed lines shown in the figure.

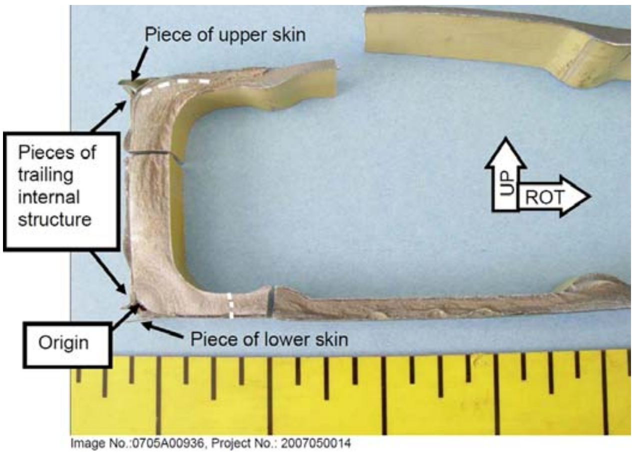

Figure 13. Extent of fatigue fracture limits

The bellow image of Figure 14 shows the fracture initiation point in detail. The origin was situated at approximately the halfway point of the arc that joined the rear and lower spar surfaces. Epoxy was found on the spar surface and although there was a large void next to the origin, there was epoxy between the void and the spar surface. As can be seen in the right image of Figure 15, once the epoxy was removed from the area where the fracture initiated, a corrosion pit was found, surrounded by material that was of a darker color than the rest of the surface.

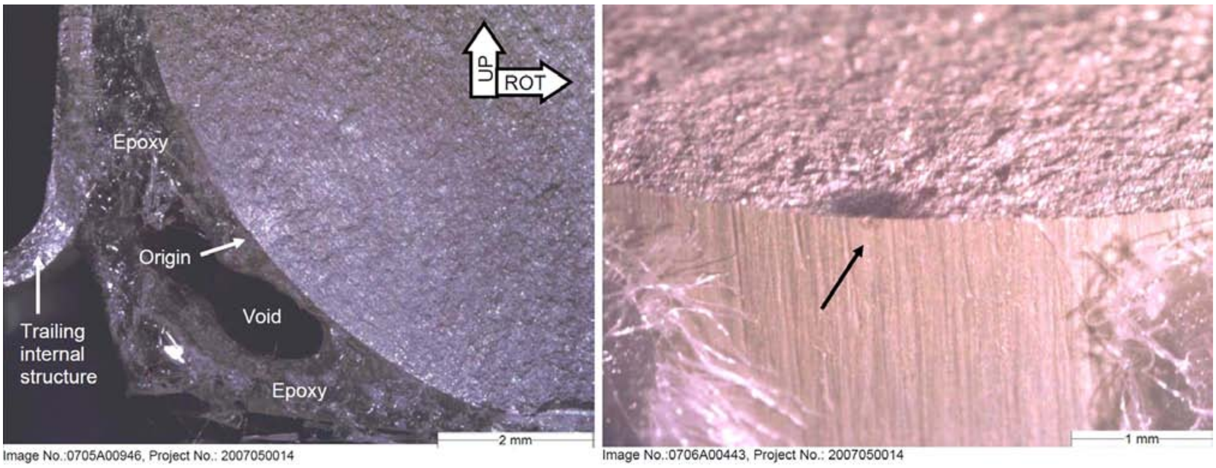

Figure 14. Fracture initiation point

To examine the microstructure of the area of origin, the piece was cut as shown in the left image of Figure 15 and prepared for analysis. As is evident in the center and right images in this figure, although no anomalies were found along the plane cut by the fracture surface, a small corrosion pit was found next to it, as well as another one further away.

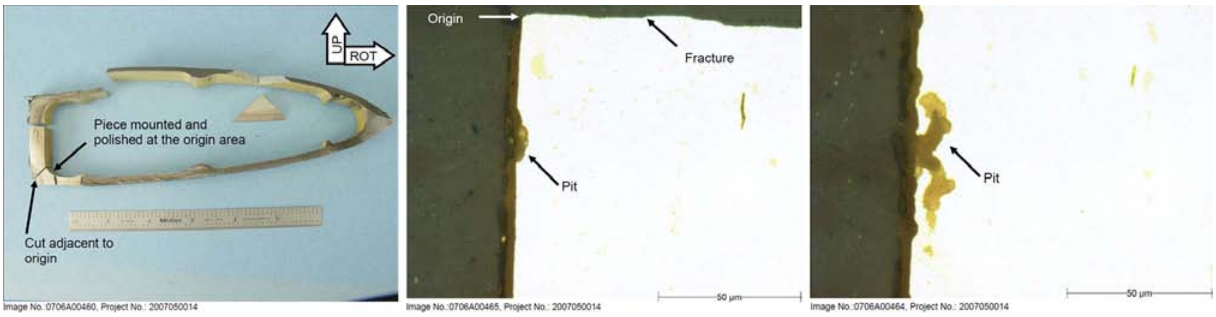

Figure 15. Analysis of fracture initiation point

The results of this study generally support the idea that the fatigue process started in a small corrosion pit that would not have been detectable under normal conditions, unless the crack propagated to the extent that it could have been detected via the BIM system. No manufacturing defects or marks produced by tools used during maintenance activities were detected in the material.

1.16.2.3. Discrepancies between the two studies

In light of the discrepancies in the findings of the two studies as to the extent to which the fracture had propagated due to a fatigue mechanism, the NTSB was requested to confirm whether its laboratory found any microfractographic fatigue characteristics in that part of the fracture section that its study concluded had propagated via this mechanism, and which the INTA study concluded had propagated due to a high velocity static overload.

The NTSB laboratory replied that the extent of the area that exhibited fatigue fracture characteristics, shown in Figure 13, was based on macroscopic features, which included a banding pattern[8] and a fracture plane that was perpendicular to the spar surface. The banding pattern in particular is a clear indication of progressive growth under cyclic loading. No microscopic features were observed that clearly indicated stops in the propagation, though these features could have been masked by the corrosion observed on the surface.

The NTSB added that the fact that the crack propagation had been more rapid in the regions identified as zones 2 and 3 in the INTA report is evidenced by the increased banding in the fracture, but that a banding pattern is not consistent with a static overload. Certain microscopic characteristics in these zones apparently did result from a static overload, which at times propagated relatively quickly. There can be regions of rapid fracture with static overload characteristics separated by bands of slower growth with typical fatigue characteristics.

INTA was consulted once more and stood by its initial conclusions, insisting on the need to find areas with microfractographic fatigue characteristics in order to be able to determine that the fracture had propagated due to a fatigue mechanism.

This criterion was transmitted to the NTSB, which expressed its disagreement with INTA's findings. What is more, it amplified its initial study with an addendum on a microfractographic analysis conducted on a piece of the fracture section corresponding to the aft spar wall and that included parts from zones 1, 2 and 3 on the INTA report. Figure 16 depicts a photograph of this piece, showing those points where the microscopic photographs were taken and on which the study are based.

This study revealed microfractographic features consistent with a fracture resulting from a fatigue mechanism under relatively high stress intensity, in aluminum alloys, though specific fatigue characteristics were not found. The study also stated that oxidation, corrosion or mechanical damage could conceal these characteristics, and concluded that the fracture characteristics in this region were not consistent with a static overload, but were instead consistent with a brittle fracture mechanism, such as fatigue.

INTA was consulted once again. It replied that, from a macrofractographic standpoint, a fracture along a plane perpendicular to the blade's longitudinal axis is not, in and of

[8] The term "banding pattern" is used in the NTSB report, and corresponds to the description "directional rough texture" in the INTA report.

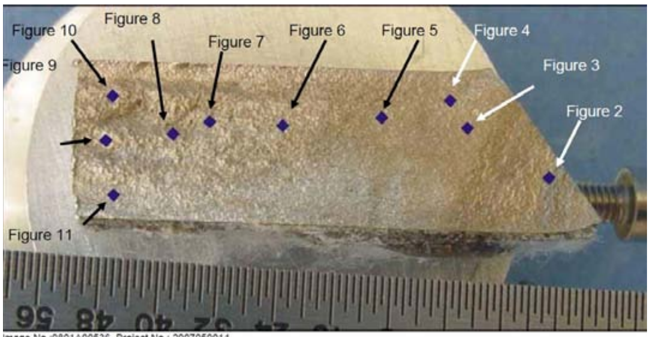

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Figure 16. Fracture section on which additional study was conducted

itself, indicative of a fatigue fracture. Numerous references can be found in the literature in which a fracture that is initiated and propagated by a fatigue mechanism in a plane that is perpendicular to the forces that cause the fracture, at a given moment will quickly propagate from a static overload along the same fracture plane.

In this particular case, there were no macroscopically detectable faint curving crack arrest, indicative of a progressive advance of the fracture, along the entire fracture surface situated perpendicularly to the blade's longitudinal axis, with the exception of zone 1, where the fracture originated.

Zone 3 exhibited directional banding that, in light of the constant geometry and thickness of the piece and condition of the loads that resulted in the fracture of the blade, can only be attributed to a change in fracture mechanism. Said mechanism persisted until the change in thickness of the piece originated a fracture surface along differently angled planes with respect to the piece's longitudinal axis. Moreover, the appearance, starting in this section, of small exit lips angled at 45°, which are much more evident in the portion corresponding to the upper part of the spar, point to a static overload fracture.

From a microfractographic standpoint, the fracture surface, as received, showed considerable generalized corrosion, meaning that the extent to which the surface had deteriorated as a result of the corrosion that had taken place while submerged under water, combined with the mechanical deterioration, greatly hindered any observation of the original fracture area, which could have been completely covered by a layer of corrosion products, and that only the relief of this layer was noticeable.

Along the entire fracture surface, which was oriented perpendicular to the blade's longitudinal axis, there were no signs of microfractographic fatigue characteristics except for zone 1, where the fracture originated. While this could have been due to the intense corrosion evident on the surface, it was possible to distinguish clear microfractographic plastic deformation characteristics in numerous areas of this fracture segment. The NTSB's own expanded study included an image that showed features typically associated with a final fracture caused by a static overload.

Despite the discrepancies between the two studies, they agree in concluding that the fracture process resulted from a fatigue phenomenon that led to static fracture when the fatigue crack reached its critical length.

1.16.3. *Detachment of the "black" blade from the main rotor head*

As noted in 1.6.7, the main rotor blades are rooted in a steel component, the cuff, through which they are attached to the rotor head. This component is joined to the spar root by ten through bolts.

The photographs in Figure 17 show how parts of the bolts remained in eight of the bolt holes in the "black" blade.

Figure 17. Top and bottom view of the "black" blade root

The ends of the bolt segments, which were still in their housings, showed signs of shear fracture resulting from the relative displacement between the two components that held the blade to the cuff.

The marks found on the upper and lower surfaces of the blade root indicate that this relative displacement was produced by a deceleration of the blade with respect to the rotor head, which caused the ends of the bolts to shear and the blade to detach from its housing.

1.16.4. *Radar trace*

The information provided by ATC included data and diagrams of the helicopter's path as detected by radar stations that provided coverage along the route: Taborno, on the island of Tenerife, and La Palma, on the island by the same name.

The aircraft was first detected shortly after takeoff, at 08:19:52, as it was climbing east of La Palma Airport at an altitude of some 300 ft and a speed of 50 kt. Its last recorded

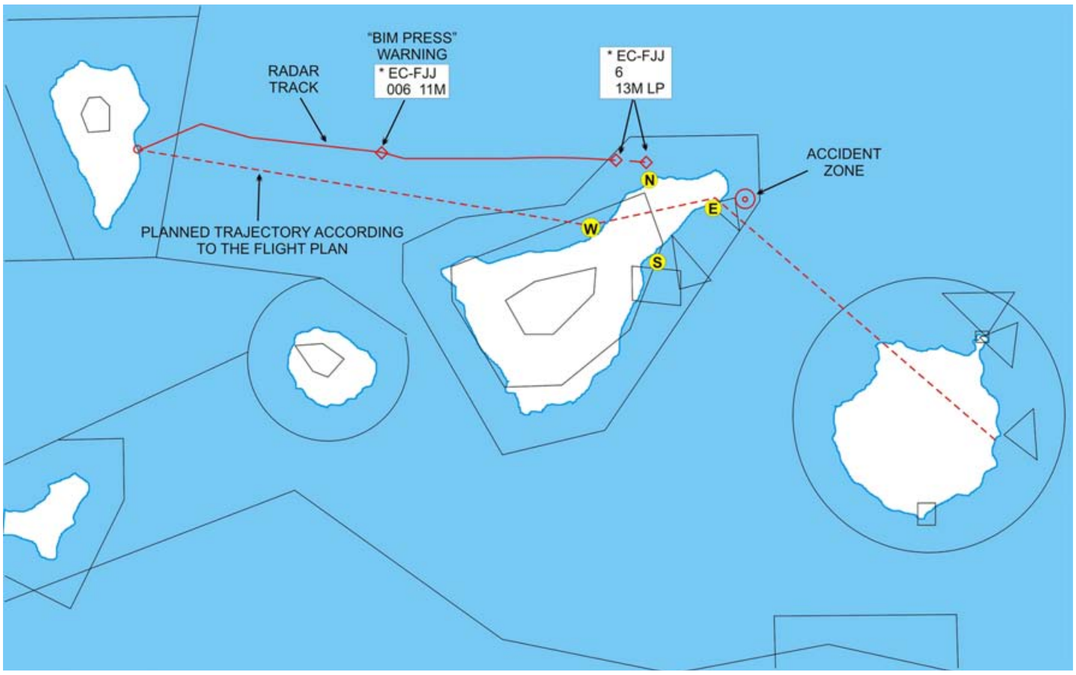

Figure 18. Radar trace

position was detected at 09:00:00, when the aircraft was north of Tenerife North Airport flying from west to east above the ocean at an approximate altitude of 600 ft and a speed of 120 kt.

The information available did not allow for an exact determination of the helicopter's final trajectory nor of the exact time of the accident, since none of the radars tracking its signal provided coverage of the area at the altitude being flown by the aircraft.

It was possible to determine, however, the aircraft's position at 08:41:27, when the CVR recorded the Pilot in Command say, "See, we have a BIM PRESS". This position was at coordinates 28°37'13"N 17°01'57"W, practically halfway between the La Palma and Tenerife North airports. At that moment, the helicopter was flying at an approximate altitude of 600 ft and a speed of 110 kt, conditions that were maintained over practically the entire recorded trajectory.

It should be noted that the speeds measured by radar are referenced to the surface of the terrain, or water, as the case may be (Ground Speed - GS).

1.17. Organizational and management information

1.17.1. *The aircraft operator*

The company that operated the aircraft, HELICOPTEROS, S.A. (HELICSA), was founded in 1965 and is Spain's oldest helicopter operator. It began its activity by providing agricultural and firefighting services. In 1972 it started providing services to off-shore oil platforms and in 1991 it started providing maritime rescue services (SASEMAR from its initials in Spanish) under contract to Spain's Ministry of Development.

In 2006 the company was an autonomous subsidiary of the INAER business group. It is now called INAER HELICOPTEROS OFF-SHORE, S.A.U., and its services include Search and Rescue, border patrol and assistance to off-shore oil platforms.

At the time of the accident, HELICSA had an Air Operator's Certificate (AOC) and an Authorization for Aerial Work that included the accident helicopter. Said authorization allowed work involving fire prevention and firefighting, among other activities.

The Line and Base Maintenance for its fleet of Sikorsky S-61N helicopters was contracted out to HISPACOPTER, S.L., an EASA Part 145 approved maintenance center that belonged to the same group of companies as the operator.

At the time of the accident, the company was operating a fleet of five Sikorsky S-61N helicopters.

1.17.2. *Operational organization*

1.17.2.1. Operator's structure

In keeping with the requirements of the Operations Manual in use on the date of the accident (MBO, 2nd Edition, Revision 1, approved by the DGAC on 16 November 2004), the overall structure of the operator consisted of the Quality and Flight Security Departments on one side, and the Operations, Technical and Financial and Commercial Departments on the other, all reporting to the General Manager's office. The Operational and Technical Departments reported to the Financial Department.

The Operations Department included an office (responsible for technical documentation) and the Training Department on one side, and the Search and Rescue (SAR), Off-shore Oil Platform, Border Patrol (SVA) and Emergency Medical (HEMS) Services Department in both the Canary Islands and the mainland, on the other.

The Technical Department, in turn, consisted of the Technical Office (responsible for managing airworthiness), and the Line and Base Maintenance Departments, the workshops and the Planning and Logistics Department, which did the maintenance and belonged to the Part 145 Maintenance Organization.

As for the Quality Department, it was responsible for the Quality System adopted by the company and included the Quality Assurance for the Operations and Technical Departments. Within the Part-145 Maintenance Organization, it was part of the Technical Office.

1.17.2.2. The crews

The crews report to the Operations Department and their functions are coordinated via the operator's Operating Bases.

In general, the minimum helicopter crew consists of a pilot in command (PIC) and a F/O and, if required, a Line Mechanic, a Hoist Operator and any required Rescue/Diving personnel.

In the case at hand, the helicopter had been used for transporting firefighting crews to fires on the island of La Palma. As a result, the helicopter had been assigned a crew of two pilots and a line maintenance mechanic.

In accordance with the specifications of its Operations Manual, Chapter 1, Section 1.4, the duties and obligations of the captain (PIC) included "Exercising the authority and accepting the responsibilities relative to the aircraft and its operation and crew, to the passengers and cargo, to the freight and mail from the time the crew takes command of the aircraft in preparation for the flight until, upon completion, the above are delivered to any competent authority or to a representative of the aircraft operator". He is also "responsible for ensuring the operation of the aircraft is in accordance with the Company's MBO, air traffic regulations and aviation regulations" and "for the conduct of the flight, those decisions involving any risk or requiring actions outside of this MBO or air traffic regulations not being delegable to any other crew member".

Similarly, Section 1.5.2 of said manual specified that the duties and obligations of the Line Mechanic consisted of "the set of activities corresponding to the pre- and post-flight inspections, refueling as indicated by the PIC, in-flight repairs, arrangement of passengers and/or cargo and all those assigned in the MOM".

The mechanic did not have any duties assigned on the accident flight, meaning the minimum crew consisted of the pilot in command (PIC) and the F/O, with the mechanic traveling as a passenger.

1.17.2.3. Operational Control

In its Operations Manual, Chapter 2, Section 2.4, the operator defines Operational Control as "the authority exercised with respect to the initiation, continuation, deviation or termination of a flight", through which "the authority of the Operations Director is extended as it relates to the conduct of flights".

Two "tiers" are established for this purpose:

a) Base Manager and
b) Aircraft captain,

such that "any incident that takes place during the conduct of an operation must be handled by the lower of the two tiers possessing:

a) Authorized attributes,
b) Resources for executing the decision."

1.17.2.4. Pilot training

In its Operations Manual, Chapter 5, Section 5.4, the operator specifies the training criteria (obtaining and maintaining the type and company ratings) for its personnel, training that is provided in accordance with the criteria established in the Training Manual (Part D of the OM), which was approved pursuant to the applicable regulation on the date of the accident, namely "*ORDER FOM/381/2004,* of 4 November, on the adoption of the joint aviation requirements for flight crew licensing (JAR-FCL) regarding the conditions for the performance of the functions of civil helicopter pilots".

In reference to the S-61N crews, the training was provided by the company itself. Since no simulator for this helicopter was available at Helicsa, the simulator training portions were completed through the Norwegian company CHC Helicopter Services.

The training program applicable to the pilots of the operator's S-61N fleet was specified in its Training Manual, Appendix 2, Annex S61N, "PRACTICAL S 61 N TRAINING – OBTAINING THE TYPE RATING – MULTIENGINE MULTI-PILOT HELICOPTERS". This program matched the one in "Appendix 2 to JAR-FCL 2.240 & 2.295 – Contents of the skill test and proficiency check for multi-pilot helicopter type rating and ATPL".

In keeping with the requirements of this program, it was necessary to hold practical training and demonstrate proficiency on every aspect therein, both for certain required items as well as for a number of items selected from among those listed in one section. The check for item "3.4 Abnormal and emergency procedures" indicated that "A minimum of three items from those included in 3.4.1 to 3.5 inclusive must be selected".

1.17.2.4.1. Crew Resource Management (CRM) Training

On the date of the accident, the operator of the accident aircraft did not provide Crew Resource Management (CRM) training to its pilots. Such training was not mandatory for helicopter operators in Spain and the company did not have a CRM program.

The regulation now in effect, JAR-OPS 3, which does require this type of training, was published in Spain on 21 March 2007 via "ROYAL DECREE 279/2007 of 23 February, which specifies the requirements for the conduct of commercial air transport operations by civil helicopters", and went into effect six months following its publication.

This regulation, however, specifies that CRM training is not applicable to, among others, helicopters performing SAR services or on firefighting flights (JAR-OPS 3.001 Applicability), meaning that the operator's S-61N fleet was expressly excluded from compliance. The helicopters that take part in these types of operations are considered to be aircraft of the State.

1.17.2.4.2. Agricultural Pilot Rating

As noted in 1.17.2.2, the helicopter was being used to transport firefighting crews on the island of La Palma and had been assigned a crew consisting of two pilots and a line maintenance mechanic.

Of the two pilots assigned, the Pilot in Command was verified to have held an Agricultural Pilot Rating, while the F/O did not. Although this had no effect on the accident flight in and of itself, it could have affected the operations to which the helicopter had been assigned.

The operator replied as follows when asked about this:

- Except in the case of the S-61N, the company's remaining helicopters are certified to fly under VFR conditions with a minimum crew of one pilot. This, combined with the fact that the training necessary for obtaining the Agricultural Pilot Rating does not consider multi-pilot operations, is why none of the company's F/Os hold such a rating.
- Additionally, in keeping with company procedures, the F/O never engaged in firefighting actions, which were always carried out by the Pilot in Command.
- Moreover, in the case at hand, the helicopter's operation was only supposed to ferry crews and not engage directly in firefighting operations.
- That is why only the Captain was required to hold an Agricultural Pilot Rating to comply with the demands of the helicopter's intended operations.

The applicable regulation on the date of the accident states:

- ROYAL DECREE 1684/2000 of 6 October, establishing the agricultural pilot rating:

  Article 1. Implementation of the agricultural pilot rating.

  1. The agricultural pilot rating is hereby implemented. This rating shall be required for holders of airplane or helicopter pilot licenses to exercise the duties involved in air operations of an agricultural nature in Spain.

  ...

Article 2. Activities of an agricultural nature.

Pursuant to Section 1 of the preceding article, the following are considered air activities of an agricultural nature:

...

i) Firefighting in forests, fields or pastures.

j) Surveillance of forest areas while loaded or unloaded for a first attack or with remote sensors.

...

Article 4. Requirements for obtaining a rating.

1. Other general requirements notwithstanding, an applicant for an agricultural pilot rating must demonstrate compliance with the following requirements:

...

b) Have flown a minimum of 300 hours as a pilot.

...

There is no reference in this order to the operations conducted with aircraft that are certified to operate with a minimum crew of more than one pilot.

- Civil Aviation Directorate General (DGAC) RESOLUTION of 5 July 2002, modified by the DGAC RESOLUTION of 14 August 2002, which established the specific operating procedures for aerial and agricultural work. Annex 1:

  B. Flight crew.

  1. Anyone carrying out the duties of a crew member onboard an aircraft performing aerial work or agricultural activities must hold the following:

  ...

  c) Valid agricultural pilot rating (as applicable).

  ...

  There is no reference in this order to the operations conducted with aircraft that are certified to operate with a minimum crew of more than one pilot.

To which have been added:

- ORDER FOM/395/2007 of 13 January, which regulates the training process for the agricultural pilot rating:

Article 2. Accreditation of the requirements for obtaining an agricultural pilot rating.

1. Prior to taking the course, applicants shall accredit:

...

b) Having flown at least three hundred hours as the pilot in command or an airplane or helicopter...

There is no reference in this order to the operations conducted with aircraft that are certified to operate with a minimum crew of more than one pilot.

1.17.2.5. The Aircraft Technical Records

The operator has a document, called the Flight and Maintenance Record (PVM in Spanish), that reflects the aircraft's technical and operational conditions for each flight made. Up to eight flights can be logged in each document, which is specific to each helicopter and features three copies, which are sent to the Operations Department, the Technical Department and one copy which is kept in the aircraft as part of its documentation.

In the Operations Manual, Chapter 8, Section 8.1.9, the operator includes the instructions for the TMA (responsible for the maintenance) and PIC for filling out this record. In general, the following tasks are assigned to each:

a) Maintenance technician:

- Before the flight: record and sign for the condition of the aircraft, log the refueling data and how much fuel is in the tanks, record the performance of the pre-flight check and certify it with a signature, code and license number, and annotate the data for the aircraft and engines.
- After the flight(s) and at the end of the day: record the aircraft and engine data, ensuring that they match those annotated by the PIC in the relevant books; annotate the actions taken in response to any defects noted by the PIC and, if appropriate, fill out the associated discrepancy report. Once completed, fax the report to the Technical Office, located at the company's central services.

b) Helicopter pilot:

- Before the flight: check for and sign that the condition of the aircraft is as recorded and signed for by the TMA. If the PIC refueled the aircraft and did the pre-flight inspection, he must fill out the associated boxes.
- After the flight(s) and at the end of the day: record the data for the crew members, including, if any, the mechanic, hoist operator and rescue personnel. Annotate the information for the number of flights made, the aircraft and

engines, and defects noted, if any. Once complete, fax the report to the Operations Office, located at the company's central services.

On a weekly basis, the base managers are responsible for sending to central services the copies of the reports addressed to the Operations and Technical Departments.

1.17.2.6. Admitting passengers onboard

In its Operations Manual, Chapter 8, Section 8.2.2.2, the operator establishes the criteria for the embarking of passengers on commercial passenger flights.

Said manual does not specify the criteria for admitting passengers who are not part of the crew on those operations not involving commercial air transport.

In general, the operator applies Circular 03/90 of 7 November 1990 on the "Authorization of persons onboard", and sent by the Operations Department to all the bases, which states:

> Once more, you are reminded that on helicopters operated by HELICSA, whether owned by us or another company, only the following personnel are authorized onboard:
>
> 1. Company employees directly involved with the operation.
> 2. Clients involved in the operation and/or persons duly authorized by the client's representative or delegate.
>
> **"Permitting anyone onboard who is not in one of these groups is strictly prohibited".**
>
> The Captain of the aircraft is responsible for observing and enforcing these regulations.

Although, as indicated in the last paragraph of 1.17.2.4.1, the regulations in JAR-OPS 3 were not applicable on the date of the accident, nor are they currently applicable to the operator's S-61N fleet, it should be noted that *Appendix 1 to JAR-OPS 3.1045 Content of Operations Manual* establishes the criteria for allowing passengers onboard, and states that the operator shall ensure that Section 8.7 of its Operations Manual contains the procedures and limitations for non-commercial flights, to include the type of personnel that can be carried on such flights.

> "8.7 Non-commercial flights. Procedures and limitations for:
>
> (a) Training flights;

(b) Test flights;
(c) Delivery flights;
(d) Ferry flights;
(e) Demonstration flights; and
(f) Positioning flights, including the kind of persons who may be carried on such flights."

Said regulation has no characteristics nor the procedures and limitations corresponding to each, leaving it to the judgment of the Operator, which proposes the Operations Manual and to the Aviation Authority, which approves it.

Likewise, in the AESA's "PROCEDURE FOR OBTAINING AUTHORIZATION FOR CONDUCTING AERIAL WORK (AIRPLANES OR HELICOPTERS)", approved in March 2009 and currently in effect, it appears as "ANNEX 2. Contents of the Operations Manual for Aerial Work" (MO-T.A. Rev. 01/09). Its structure is similar to that shown in the figure in "Appendix 1 to JAR-OPS 3.1045 Operations Manual Contents"). This aspect is considered in Section 8.6 Non-commercial Flights, in the same terms as in this regulation.

For reference, the contents of the section involving this topic are shown below, taken from the Inaer Helicopters Operations Manual, currently in effect:

"8.8 NON-PAYING FLIGHTS: PROCEDURES AND LIMITATIONS

The Company engages in flights that are not billed to third parties and which, by their characteristics, as called "Non-Commercial Flights". These are:

- Training flights.
- Test flights.
- Delivery flights.
- Ferry flights.
- Demonstration flights.
- Positioning flights.

Anyone authorized to be onboard during these flights is subject to the following restrictions. Those persons onboard who are not company employees must be logged in the transportation manifest that the Captain must fill out prior to each flight.

8.8.1. *Training flights*

Training flights are conducted to train crews on a helicopter type at the conclusion of the theory course for said helicopter type. This type of flight will also be conducted to renew type ratings or to train pilots on a specific type of operation.

This category may also include those flights conducted to inspect and check the extent of the skills, training and competency of the crews.

Only the crew in training and its authorized instructors/examiners shall be authorized onboard the aircraft for this type of flight.

8.8.2. *Test flights*

Test flights are conducted to check the airworthiness of an aircraft and the proper operation of its systems. This category includes flights to certify the aircraft for the issuance or renewal of its Airworthiness Certificate and which are required by the Aviation Authority.

Only the technical crew (minimum flight crew) and as many technicians as are necessary, as well as those persons assigned by the Aviation Authority, if any, shall be allowed onboard during this type of flight.

8.8.3. *Delivery flight*

If any type of test flight is necessary for the acceptance or delivery of an aircraft, the stipulations of 8.8.2 shall apply.

Only the technical crew (minimum flight crew) and as many technicians as are necessary, as well as those persons that may be assigned by the Company and/or Client for acceptance of the aircraft, shall be allowed onboard during this type of flight.

8.8.4. *Ferry flight*

The purpose of these flights is to move a helicopter that has a malfunction that does not keep it from flying to another place for repair. This category includes those flights made to import a helicopter.

Only the technical crew (minimum flight crew) and a minimum complement of technicians, if required, shall be allowed onboard during this type of flight.

8.8.5. *Demonstration flights*

These flights are made to show current or future clients the characteristics and performance of a helicopter model applied to a specific operation.

Only the minimum required crew and those persons expressly authorized by the Operations Manager, if any, shall be allowed onboard during this type of flight.

8.8.6. *Positioning flights*

These flights are made to transfer the helicopter to a location to perform a service or, once the service has been rendered, to return it to a point determined by the Company.

Only the minimum required crew and those persons expressly authorized by the Captain and the Operations Manager, if any, shall be allowed onboard during this type of flight.

1.17.2.7. Regulations applicable to Operations organizations

1.17.2.7.1. Regulations applicable at the time of the accident

As noted in 1.17.1, on the date of the accident the helicopter involved in it was included in the Operator's Air Operator's Certificate (AOC) and in its Aerial Work Authorization. At that time, and from an operational standpoint, the national regulations of a general nature and the relevant operating procedures were applicable to the helicopter:

- Air Traffic Regulations
- Civil Aviation Directorate General (DGAC) RESOLUTION of 5 July 2002, modified by the DGAC RESOLUTION of 14 August 2002, which established the specific operating procedures for aerial and agricultural work.
- The DGAC's procedure for obtaining authorization for the conduct of Aerial Work.
- Crews:

  — JAR FCL – 2 (Helicopter Crews) and 3 (Medical Requirements).
  — Operating Circular 16 B (flight time limits).
  — R.D. 1684/2000, of 6 October, which implements the agricultural pilot rating.

1.17.2.7.2. Currently applicable regulations

As indicated in the last paragraphs of 1.17.2.4.1, in general terms, the currently applicable regulation is JAR-OPS 3, which was published in Spain on 21 March 2007 by way of "ROYAL DECREE 279/2007 of 23 February, on the requirements for the conduct of commercial air transport operations by civil helicopters", which went into effect six months after publication.

Within this regulation, "JAR-OPS 3.035 Quality System" and "JAR-OPS 3.037 Accident Prevention and Flight Safety Programmes" specify that the operator shall implement the corresponding systems and programs, under the supervision of the quality manager, as well as the requirements with which they must comply.

Nevertheless, as already indicated, this regulation specifies that it is not applicable to, among others, helicopters engaged in SAR or firefighting services *(JAR-OPS 3.001 Applicability),* meaning the operator's S-61N fleet is expressly exempt from compliance. Thus, these types of operations are still subject to those national regulations of a general nature and the relevant operating procedures currently in effect:

- Air Traffic Regulations
- ROYAL DECREE 1762/2007 of 28 December, which specifies the requirements for the master minimum equipment list and the minimum equipment list for civil aircraft used for commercial air transport or for aerial work.[9]
- Civil Aviation Directorate General (DGAC) RESOLUTION of 5 July 2002, modified by the DGAC RESOLUTION of 14 August 2002, which established the specific operating procedures for aerial and agricultural work.
- The DGAC's procedure for obtaining authorization for the conduct of Aerial Work.
- Crews:

  — JAR –FCL Part 3
  — Operating Circular 16 B (flight time limits).
  — R.D. 1684/2000, of 6 October, which implements the agricultural pilot rating.
  — ORDER FOM/395/2007 of 13 February which regulates the training process for the agricultural pilot rating.

1.17.3. *The Maintenance organization*

1.17.3.1. Maintenance Structure

As stated in 1.17.1, the operator contracted its Line and Base Maintenance for its Sikorsky S-61N fleet of helicopters to a Part-145 approved maintenance center belonging to the same business group.

In the Maintenance Organization Manual valid on the day of the accident (MOM - Edition 0, Revision 2, approved by the DGAC on 29 June 2005), for S-61N type helicopters, it states that Line Maintenance includes every inspection below level C (those performed every 2,400 flight hours or 3.5 years, whichever comes first) specified in the Approved Maintenance Program (AMP), and that Base Maintenance includes the replacement of major components, being considered as such those whose replacement requires the availability of a crane/hoist and/or jacks.

In accordance with the procedures established by the operator, each helicopter is assigned a Certifying TMA who is type qualified on the S-61N, whose job is to perform the line inspections envisaged in the AMP necessary for placing the helicopter in service

[9] Incorporates amendment 1 adopted by the Joint Aviation Authorities (JAA) on 1 August 2005.

as specified in Part 145. These include the Daily Maintenance Check (DMC) and the Pre-Flight Check (PFC).

The MOM defines the Base Maintenance Supervisors at permanent S-61N locations, to whom the Certifying TMAs assigned to the various helicopters report. At the remaining bases, the Base Maintenance Supervisor is the TMA assigned to each helicopter.

The Base Maintenance Supervisors report, organizationally and functionally, and in terms of everything involving helicopter line maintenance, to a Fleet Manager. The Fleet Managers for the various helicopter types report to a single Maintenance Manager, who reports to a Part 145 Technical Director (within the operator's structure)/Manager (within the operator's integrated maintenance structure).

1.17.3.2. Control of Aircraft Technical Records

Below is a textual reproduction of part 2-2.14 of the MOM, which specifies the different elements that comprise a helicopter's technical records and the procedures for its control:

2.14.- CONTROL OF TECHNICAL RECORDS.

The technical records essential to maintenance are:

- Aircraft log Book
- Engine log Book
- Equipment log Card
- Status List
- Work Package

Only the Certifying Personnel listed in Appendix A.1 are authorized to make any annotations or entries in the aircraft, engine or equipment log books.

The control procedures are as follows:

A) CONTROL OF AIRCRAFT AND ENGINE BOOKS AND EQUIPMENT LOG CARDS

- Once a maintenance or repair job is finished, the Fleet or Workshop Manager (Base Maintenance Supervisor at the bases) gathers the necessary data for completing the technical records, checking them thoroughly for accuracy before making the entries in these records.
- The Fleet or Workshop Manager (Base Maintenance Supervisor at the bases) makes the entries in the corresponding records, validating them with his signature and personal stamp.

- These documents are given to Technical Office personnel for review and for the drafting, using these data, of the maintenance or repair report.
- Finally, the Fleet or Workshop Manager (Base Maintenance Supervisor) does a final check of all the technical records before they become part of the aircraft's required documentation.

B) CONTROL OF THE STATUS LIST

The Status List is maintained by Technical Office personnel in coordination with the relevant Fleet Manager through the Maintenance Center's software, whose features are described in APPENDIX A.6 to this Manual.

The only references for maintaining these Status Lists are the Maintenance Manuals and Maintenance Programs of the various Manufacturers.

Updating a Manufacturer's documentation can involve revising the Status Lists for those affected aircraft that are undergoing maintenance or repair at the Center or at the Bases.

Technical Office personnel shall be responsible for applying said updates when preparing the Status Lists in accordance with the above procedure.

C) WORK PACKAGES

These are a set of documents and records associated with maintenance tasks. The documents comprising the Work Package (WP) are grouped in two different ways, depending on whether the documents involve line or base maintenance jobs.

- The line Work Package includes all those documents and records associated with line maintenance tasks included in the line release to service (H8 Form).
- The base Work Package includes all those documents and records associated with base maintenance tasks included in the line release to service (H49 Form).

The Work Package is prepared, performed and filed as described in the following sub-sections.

C.1) Line "Work Package":

Generated directly at the line maintenance base, where the line maintenance tasks are performed according to the maintenance logs and the changes according to the status lists.

The above jobs are placed in service in the H8 Form (DMR - index of line work packages).

Once the H8 Form is closed out, they are sent by the Base Maintenance Supervisor to the main Maintenance Center[10].

Once at the Maintenance Center, the line work package is temporarily filed at the Technical Office once the work is verified and processed. As the records become obsolete, they become part of the permanent records (general archive at the Maintenance Center). These records are kept for at least two years under lock and key to avoid tampering and in a fire, flooding and theft proof location (metallic containers) as per AMC 145-55 (c) (1).

The line work packages are filed as follows:

- The H8 Forms (DMR) are filed in a cabinet, grouped by helicopter, to create an index of releases to service and maintenance documents and records.
- The inspection books are filed in another cabinet chronologically by helicopter.
- The component replacements/ cards are filed in the aircraft's Log Book. If the component does not have a component card, the card is included in the line work package index (H8 Form).
- Once the work order is processed and filed, the work package is closed out. Processing a work package involves:

  — Updating the Status List.
  — Updating the helicopter cards.
  — Updating the engine cards.
  — Updating the helicopter and engine hours.
  — Updating the master AD's.
  — Updating the master SB's.
  — Updating the master modifications.
  — Updating master helicopter and engine inspections.

C.2) Base Work Package:

Generated directly at the Maintenance Center when the Fleet Manager opens a work order (see procedure, Section 2.10.3).

Once the job is complete, the Fleet Manager records the release to service by logging it in the H49 Form.

The Technical Office generates the base work package based on all the associated documents, records and the H49 release to service, and includes:

[10] The document corresponding to the Daily Maintenance Record (DMR) is similar to that for the Flight and Maintenance Record (PVM). It includes three copies, one for the Operations Department, one for the Technical Department and one which is kept on the aircraft. The copies of the DMR must likewise be sent to the two departments to which they are sent under the same criteria as the PVM (see 1.17.2.5 – The Aircraft Technical Records.

- H49 release to service.
- Inspection log books.
- Master list of Airworthiness Directives and Service Bulletins at start and finish of inspection.
- Master updated helicopter inspection list.
- Additional job sheets.
- DGAC notices, communications.

All of this documentation is compiled in a single book (the base work package) that is filed in the Technical Office. As the records become obsolete, they become part of the permanent records (Maintenance Center General Archives). These records are kept for at least two years under lock and key to avoid tampering and in a fire, flooding and theft proof location (metallic containers) as per AMC 145-55 (c) (1).

The component records (Log cards, Form one, cards) are to be filed in the same way as the line work package.

When the work package is closed by the Technical Office, it must be processed in the same way as specified for the line work package.

1.17.3.3. Regulations applicable to maintenance organizations

1.17.3.3.1. Regulations applicable at the time of the accident

As indicated in 1.17.1, on the date of the accident the helicopter involved in it was included in the Air Operator's Certificate (AOC). At that time, from a maintenance standpoint, it was subject to *Commission Regulation (EC) 2042/2003 of 20 November 2003, on the continuous airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.*

This regulation establishes the requirements for continuous airworthiness (Part M - Annex I to the Regulation), for the approval of maintenance organizations (Part 145 - Annex II to the Regulation), for certifying personnel (Part 66 - Annex III to the Regulation) and for training organizations (Part 147 - Annex IV to the Regulation).

Of note in this regulation is *M.B. 303 Aircraft Continuous Airworthiness Monitoring*, which specifies the criteria to be followed by the Authority in this regard, and *145.A.65 Safety and quality policy, maintenance procedures and quality system*, which specifies the criteria to be followed by the organization and the requirements they must fulfill.

1.17.3.3.2. Currently applicable regulations

In general terms, the currently applicable regulation is *Commission Regulation (EC) 2042/2003 of 20 November 2003, on the continuous airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks*, modified by *Commission Regulation (EC) 1056/2008 of 27 October 2008*.

Nevertheless, *Regulation (EC) no. 216/2008 of the European Parliament and of the Council, of 20 February 2008, on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC*, modified by Regulation (EC) No. 1108/2009 of the EUROPEAN PARLIAMENT AND OF THE COUNCIL, of 21 October 2009, amending *Regulation (EC) No 216/2008 in the field of aerodromes, air traffic management and air navigation services and repealing Directive 2006/23/EC* specifies that the regulation "shall not apply when products, parts, appliances, personnel and organisations referred to in paragraph 1, letters a) and b) are engaged in military, customs, police, search and rescue, firefighting, coastguard or similar services. The Member States shall undertake to ensure that such services have due regard as far as practicable to the objectives of this Regulation" (Article 1, Scope, Section 2). As a result, the operator's S-61N fleet was also exempt from complying with Regulation 2042/2003. Still applicable were national regulations of a general nature currently in effect.

1.17.4. *The operating bases*

Due to the wide geographic area in which its activities are normally carried out, the operator has a Central Base, where it is headquartered, and several permanent Operating Bases throughout Spain. When it provides services in areas beyond the reach of these bases, it sets up temporary bases in suitable locations.

In its Operations Manual, the operator considers its Operating Bases as satellites for its client operations. They are intended to adapt more readily to local conditions and to have their own facilities, equipment and resources. They require combining central coordination with decentralized daily oversight.

Each base is under the supervision of a Base Manager, who must oversee all the aspects related to its activities in coordination with the central units. These aspects include personnel, financial and material resources, flight activities and line maintenance and client relations.

To perform the tasks assigned, the bases have fixed and temporary personnel. The fixed staff is stationed there permanently, while the temporary personnel is assigned based directly on the number of helicopters at the base and is comprised, in general, by the personnel assigned to operate and maintain each helicopter.

Within this context, the Operating Bases provide coordination between central services and the supervisors in the field for the operation and maintenance of the helicopters. The logistical support and necessary resources are provided so that operations can be performed under suitable conditions.

In general, temporary bases have the helicopters and operations and maintenance personnel, along with the resources required for everyday tasks. Coordination with central services can be either direct or through the nearest operating base.

1.18. Additional information

1.18.1. *History of the "black" blade and VBIM/CBIM warnings*

1.18.1.1. History of the blade

The blade was manufactured by Sikorsky, P/N 61170-20201-067 and S/N 61M-3879-3653. It was first mounted on the accident helicopter as the "blue" blade on 22/09/2000 when the helicopter had 34,638:25 flight hours. It was not reinstalled on any other aircraft. The blade had 5,301:03 flight hours at the time and had been repaired and inspected by the manufacturer on 20/06/2000.

On 03/07/2001, with 5,585:08 flight hours and 34,922:30 aircraft hours, a low nitrogen pressure warning was received that cleared after ten minutes of flight time. On the ground the warning was confirmed to have been associated with the "blue" blade, which was recharged with nitrogen. On 12/07/2001, with 5,604:33 flight hours and 34,941:55 aircraft hours, a warning was detected on the ground during a pre-flight check. The blade was removed. Maintenance checks detected a small leak in the seat of the visual indicator. Since the necessary material was not available, the replacement was deferred and the blade was installed again on the helicopter. When the necessary material became available, on 18/08/2001, with 5,682:33 flight hours and 35,019:55 hours on the aircraft, the repair was made, the deferment was lifted and the blade placed in service.

Subsequently, on 10/10/2002, the blade was removed due to a nitrogen leak with 6,018:08 flight hours and 35,355:30 hours on the aircraft. It was repaired at the operator's maintenance center on 27/12/2002 and reinstalled on the helicopter, now as the "black" blade, on 27/01/2003 with 35,451:10 hours on the aircraft. The repair consisted of replacing the CBIM transducer and the nitrogen fill valve and performing a leak check. Both the blade repair and its subsequent reinstallation on the helicopter were performed by the mechanic who perished in the accident.

During the performance of a C inspection of the helicopter at ASTEC Helicopter Services (Norway), corrosion was detected in various parts of the blade, as a result of which it was removed on 01/12/2004 with 6,552:18 flight hours and 35,985:20 aircraft hours. Once repaired and inspected, it was reinstalled on the aircraft on 29/12/2004. The blade remained on the aircraft until the day of the accident.

As for periodic maintenance, checks of the nitrogen pressure of the helicopter's main rotor blades were made on 31/07/2005 and 25/01/2006 with 36,104:10 and 36,179:55 flight hours on the aircraft and 6,671:08 and 6,746:53 flight hours on the blade, respectively. On both occasions the pressure in all the blades was within tolerance and the blades were refilled to the maximum pressure value allowed by the manufacturer for in-service blades.

1.18.1.2. Recent VBIM/CBIM warnings

There is only one recorded instance in the records for the "black" blade installed on the helicopter of a VBIM/CBIM warning occurring after those that led to its removal, on 10/10/2002, and subsequent repair, on 27/12/2002. It occurred on 14/06/2005 when, while performing the daily maintenance check, the mechanic noted that the VBIM for the blade indicated a low nitrogen pressure. As a result, after ensuring that the pressure was within the refill limits, he proceeded to refill it.

It has also been confirmed that a main rotor blade low nitrogen pressure warning was received in the cockpit on 26/06/2006 at Jerez Airport while starting the engines on the helicopter. Once the engines were stopped, the warning was confirmed to have emanated from the "black" blade. This event was not logged in the relevant Flight and Maintenance Record (PVM), and subsequent actions resulting from this event were not noted in the Daily Maintenance Records (DMR) nor in the corresponding forms.

The helicopter was preparing to take off for Ceuta, to service the Ceuta-Malaga passenger route, with two pilots, a mechanic and a mechanic's assistant onboard. Previously, on 25/06/2006, the required maintenance had been performed to place the aircraft in service. This included a 1A inspection. There were 36,217:40 flight hours on the aircraft and 6,784:38 hours on the "black" blade at the time.

Once the blade with the low nitrogen pressure warning was identified, the mechanic performed the procedure defined in the Operator's Maintenance Manual to return the blade to service. Since the equipment needed to check and recharge the nitrogen on the main rotor blades was not available at the base in Jerez, he instead used a sufficiently precise low-pressure manometer to check the blade pressure.

The equipment needed to check and recharge the nitrogen in the main rotor blades was sent to Ceuta, where it arrived on 28/06/2006. That same day the nitrogen pressure on the main rotor blades was checked. There were 6791:53 flight hours on the "black" blade and 36,224:55 on the helicopter.

On 04/07/2006, the helicopter returned to Jerez Airport. The mechanic assigned to support its operation in Ceuta repeated the check in Jerez before the helicopter was delivered to La Palma. There were 6,811:53 flight hours on the "black" blade and 36,244:55 on the helicopter

As noted earlier, this event was not logged in the helicopter's Daily Maintenance Record (DMR), nor were the associated forms for checking the nitrogen pressure in the main rotor blades filled out.

Conversations between the mechanic assigned to the helicopter to support its operations in La Palma, and who was flying in it as a passenger at the time of the accident, and the company's operating base at Las Palmas Airport, as well as information provided by people who were present and who helped in these tasks, revealed that there had been in-flight CBIM warnings on the two days prior to the accident. What is more, as noted in the last paragraph of 4.2.1, the Pilot in Command of the helicopter also commented during the accident flight that the warning was lit.

The first of these warnings came in on 06/07/2006 during the Agadir (Morocco) - Las Palmas leg of a positioning flight between Jerez Airport and La Palma Airport. The aircraft had taken off from Agadir shortly after 13:00, with 36,253:15 flight hours (6,820:13 h on the "black" blade). After landing at Las Palmas Airport, the VBIM was used to verify that the warning was from the blade in question and that its nitrogen pressure was within the limits for refilling, which was done. Once the operations scheduled for that base were completed, which included reconfiguring the seats inside the helicopter, the flight continued to La Palma Airport. The necessary components were taken to monitor the "black" blade.

The next day the spare parts needed to change out the affected components were sent from the maintenance base at Las Palmas Airport to La Palma Airport, in case the mechanic assigned to the helicopter deemed it necessary.

The second warning came in on the evening of 07/07/2006, at the end of the last reconnaissance flight carried out that day around the island of La Palma intended to familiarize the crew assigned to the helicopter with their firefighting duties. Once verified via the VBIM that the warning was for the same blade and that there was a nitrogen leak from the seat of the fill valve, the mechanic proceeded to replace the valve and the seal installed on the blade with new ones, but the leak persisted.

After trying different combinations of the new parts and the old and obtaining the same result, he installed the combination that resulted in the smallest leak and, after checking with the operating base in Las Palmas, decided, along with the pilots, to move the helicopter to said base on the next day so that more conclusive leak tests could be performed.

As already indicated, the CBIM light illuminated for the last time on 08/07/2006 during the helicopter's ferry flight to Las Palmas Airport and on which the accident took place. The aircraft had some 36260 flight hours and the "black" blade 6827.

The following table provides a chronological listing of every event involving the "black" blade, from its repair and inspection by the manufacturer and its installation on this helicopter in the year 2000, until the accident.

Order	Date hours (TT)	Event	Activity	Remarks
1	20/06/2000 5,301:03		Repaired at Sikorsky.	
2	22/09/2000 5,301:03	Blade in warehouse. Available	Installed on helicopter ("blue" blade).	
3	03/07/2001 5,585:08	**CBIM warning in flight.** Clears after 10 minutes	Placed in service.	
	12/07/2001 5,604:33	**VBIM warning during pre-flight**	• Removed. • Leak test. • Deferred. • Placed in service. • Installed.	
	18/08/2001 5,682:33	Necessary parts received	• Repair. • Deferment lifted. • Placed in service.	Tracking. Not repeated.
4	10/10/2002 6,018:08	**VBIM warning during pre-flight**	Removed.	
	27/12/2002 6,018:08	Blade in warehouse. Not available	• Repair. • Placed in service.	
	27/01/2003 6,018:08	Blade in warehouse. Available	• Installed on helicopter ("black" blade)	Tracking. Not repeated.
5	01/12/2004 6,552:18	Corrosion detected during C inspection	Removed.	
	29/12/2004 6,552:18	In workshop	• Repair. • Installed on helicopter ("black" blade)	
6	14/06/2005 6,653:48	**VBIM warning during pre-flight**	Placed in service.	Tracking. Not repeated.
7	31/07/2005 6,671:08	Scheduled	Periodic pressure check.	Result SAT.

Order	Date hours (TT)	Event	Activity	Remarks
8	25/01/2006 6,746:53	Scheduled	Periodic pressure check.	Result SAT.
9	26/06/2006 6,784:38	**CBIM warning on start-up**	Placed in service (alternative procedure).	In Jerez (not logged).
	28/06/2006 6,791:53	Proper tool received	Pressure check.	In Ceuta (not logged).
	04/07/2006 6,811:53	Scheduled	Pressure check.	In Jerez (not logged).
10	06/07/2006 ≈ 6,822	**CBIM warning in flight** (Agadir-Las Palmas)	Placed in service.	In Las Palmas.
	07/07/2006 ≈ 6,826	**CBIM warning in flight**	• Partial repair. • Placed in service.	In La Palma.
	08/07/2006 ≈ 6,827	**CBIM warning in flight**	Ferry flight.	Accident flight (CVR)

1.18.2. *BIM warnings caused by cracks in blades. Manufacturer's records*

Based on a summary of metallurgical inspections of a little over 100 BIM warning events produced by cracks in the spars of main rotor blades in S-61 and H-3 helicopters, and on the detailed analysis of 10 metallurgical inspections done on blades that were removed due to BIM warnings, Sikorsky, the helicopter manufacturer, which performed these inspections, reported that, based on its experience, the cracks that typically caused these warnings covered approximately 5% of the blade's cross-section. In 5 cases they covered a little over 10% of the cross-section and in another 14 cases they covered just over 6%. No catastrophic failures were recorded in any.

1.18.3. *Helicopter Flight Manual*

In its Operations Manual (OM), the Operator specified that the manufacturer's Rotorcraft Flight Manual (RFM) was being used as the Helicopter Flight Manual (Part 'B' of the OM).

1.18.3.1. Emergency procedures

Section 3 of the Helicopter Flight Manual contains the Abnormal and Emergency Procedures, and has the procedure associated with the luminous indication displayed in the cockpit in the event of a drop in nitrogen pressure in any of the blades below a certain setpoint (CBIM):

"ILLUMINATION OF OPTIONAL COCKPIT BIM WARNING LIGHT:

If the BIM PRESS warning light goes on in flight, do as follows:

1. Reduce airspeed to 90 knots IAS.
2. Establish and continue operation at 104% Nr.
3. Land at nearest suitable landing area.

Note

After landing do not start rotor until cause has been determined and corrected."

The Operator also had checklists for the crews to use during flights, which included the normal and emergency procedures, along with the tasks assigned to each crew member. The one associated with the CBIM stated:

«BIM WARNING

Indications:

BIM PRESS + MASTER CAUTION

ACTIONS:

NR...104%
Indicated Airspeed..90 kts

Descend to below 1,000 ft is possible.

LAND AS SOON AS PRACTICABLE (Within TWO hours)»

These actions could be carried out by any crew member.

1.18.3.2. Emergency terms for landings

Section 3 of the Helicopter Flight Manual, which contains the Abnormal and Emergency Procedures, employs the following terms to indicate the degree of landing urgency:

- LAND IMMEDIATELY.
- LAND AS SOON AS POSSIBLE (if over land) / NEAREST SAFE LANDING SITE (if over water).
- LAND AT THE NEAREST SUITABLE LANDING AREA.

Since the definitions for these terms are not found in this manual, the flight manuals for other helicopters were consulted. In them, the following terms and definitions were found:

- LAND IMMEDIATELY: Land without delay.
- LAND AS SOON AS POSSIBLE: Land without delay at nearest suitable area (i.e., open field) at which a safe approach and landing is reasonably assured.
- LAND AS SOON AS PRACTICABLE: Duration of flight and landing site are at discretion of pilot. Extended flight beyond nearest approved landing area is not recommended.

Also, the following definitions were included in the Operator's checklists for the emergency procedures:

- LAND - DITCH IMMEDIATELY: Land immediately.
- LAND AS SOON AS POSSIBLE (ASAP): Land at the nearest site at which a safe landing can be made.
- LAND AS SOON AS PRACTICABLE: Extended flight is not recommended. The landing site and the duration of the flight are at the discretion of the pilot.

In manuals and checklists translated into Spanish, the following terms and definitions were found:

- LAND IMMEDIATELY: Land without delay.
- LAND AS SOON AS POSSIBLE: Start the procedure required to land without delay at the nearest available site.
- LAND AS SOON AS PRACTICABLE: Maneuver so as to reach the nearest aerodrome, heliport or suitable site.

1.18.4. *Helicopter Maintenance Manual*

The helicopter was maintained in accordance with the requirements of the manufacturer's Maintenance Manual: "Sikorsky Aircraft S-61N Maintenance Manual SA 4045-80", dated 15 July 1969. The last update to the manual prior to the accident had been added on 15 August 2005.

Chapter 65-11-0 includes a Troubleshooting Chart, along with the procedures for inspecting and replacing components associated with the pressurized spars of the helicopter's main rotor blades.

Likewise, in Chapters 65-11-1 to 4 are the descriptions of and maintenance practices applicable to the components installed in each blade, namely the pressure indicators (BIM), fill valves, pressure transducers (CBIM - discussed in more detail in Chapter 65-64-1) and the static eliminators installed on the tips of the blades.

Appendix A includes the parts of this manual that are of relevance to the aspects addressed in this section.

1.18.4.1. Pressure indicator

There is a pressure indicator installed in the rear spar wall on each blade, near where it is joined to the rotor head. This indicator shows the service conditions for the blade as they pertain to the nitrogen pressure within it.

The indicator has a rigid transparent cover through which the indication, which can be a combination of two colors, black and white or yellow and red, can be seen. Its operation is exactly the same regardless of the color combination shown.

The indication is based on a comparison between a reference pressure inside the indicator, compensated for temperature changes, and the pressure inside the blade spar. When the pressure inside the spar is within the allowed limits, the indicator displays white or yellow, indicating the blade is operable. It the pressure falls outside the minimum allowed limits, the indicator shows three red or black stripes, meaning the blade's condition is unsafe. The amount of red or black displayed depends on the pressure inside the blade.

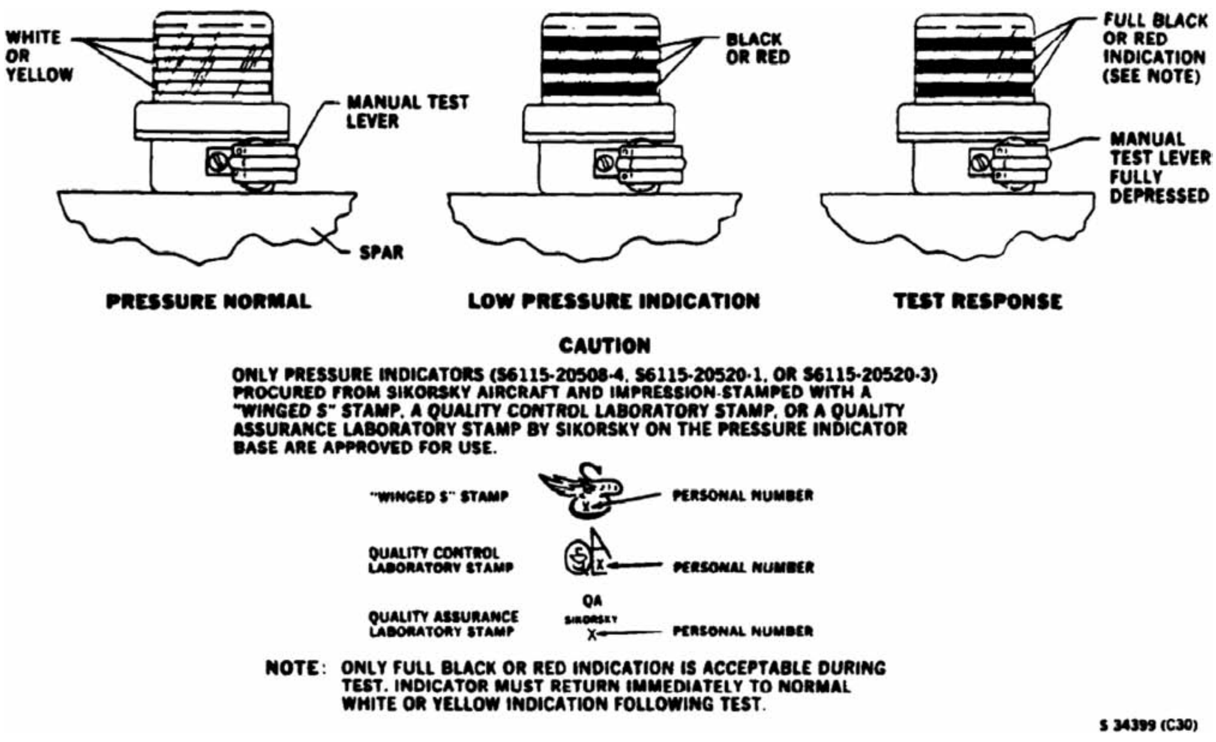

Figure 19. BIM indicator

The proper operation of the indicator's internal mechanism can be checked by pressing a test lever at the base of the indicator. After the check, the indicator reseats automatically when the lever is released.

As for this system's indications, a warning is provided in Chapter 65-11 of the Maintenance Manual that states the following:

> Any blade for which the pressure indicator shows any red or black indication, or whose pressure transducer results in a luminous CBIM warning, must be removed from service until the cause of the unsafe (red or black) indication or of the warning light is found and corrected. If either the indicator or the transducer are not working properly, they must be replaced, but only if the pressure inside the blade spar is within allowable limits.

1.18.4.2. Troubleshooting Chart for a pressurized spar

Appendix A shows the Troubleshooting Chart and associated procedures for a pressurized blade spar, as taken from Chapter 65 of the Helicopter Maintenance Manual.

First, two preliminary cautions are given. They read as follows:

- If a blade has any incident involving its pressure indicator (BIM), all of the procedures specified in the fault tree must be performed before any other repairs are made.
- When a blade that has had an unsafe pressure indicator (BIM) reading has been repaired in accordance with the instructions in this manual, that blade must not be repaired again as the result of a new unsafe indication if the second indication occurs within 30 flight hours of the first[11]. If this happens, the blade must be sent to the manufacturer for repair.

Broadly speaking, the fault tree is based on a check of the BIM indication, either visual (periodic or as a consequence of a CBIM warning) or by checking the indicator itself.

If an unsafe indication is observed, the pressure inside the spar must be measured. If it is within the allowable margins, the indicator must be replaced and the blade returned to service; if it is not, the spar must be pressurized and the various installed components, as well as the spar itself, checked for leaks from fatigue cracking. It should be noted that this operation must be performed with the ends of the blade supported on two stands and a weight applied to the middle so as to open the fatigue cracks, meaning the blade must first be removed from the helicopter.

[11] This means that the blade must be monitored during 30 flight hours before being returned to service for good.

If leaks are detected (loss of pressure) and the source cannot be clearly identified, the blade must be sent to the manufacturer for repair. If the source of the leak can be clearly identified and corrected, it must be done in accordance with applicable procedures.

Once the leak in the various components installed in the blade is corrected, a leak test of the spar must be performed. If the result is not satisfactory, the blade must be sent to the manufacturer for repair; if it is, a last check must be made before the blade is returned to service.

If the result of this last check is unsatisfactory, the blade must be sent to the manufacturer for repair.

1.18.4.3. Additional specific operator instructions

The aircraft operator had a set of instructions, adopted from the previous operator, called "Additional Instructions Specific to the Maintenance Manual", designed to complement the instructions contained in the manufacturer's AMM.

Included in these instructions was one for the system to warn of low nitrogen pressure inside the main rotor blades called AHS – 0540 "MAIN ROTOR BLADE, BIM WARNING TROUBLESHOOTING", which has been included as Appendix F.

This instruction, added to chapter 65-11 of the helicopter's Maintenance Manual, to be inserted opposite page 101 in said manual, specifies a calendar limit of 10 days for the 30 flight hours mentioned in the AMM. It also adds an additional monitoring period during which the nitrogen in the spar cannot be refilled for 100 flight hours or 30 days, whichever comes first, before it can be returned to service for good. It also states that the blade must be sent to a workshop instead of the manufacturer.

1.18.5. *Handling of malfunctions by operator*

The process that, in accordance with the procedures contained in the Operations and Maintenance Organization Manuals, was used in the event that a malfunction was detected during scheduled inspections is shown below:

A malfunction occurs and:

a) Is detected by the crew:

- The crew makes the PVM entry, and
- The line TMA notes it in the DMR.

b) Is detected by the line TMA:

- The line TMA notes it in the DMR.

Possible actions the line TMA can take at the location of the helicopter:

1. If immediately repaired:

   - Place the helicopter in service. Log it in the DMR and PVM and cross-reference both documents.
   - The helicopter can fly without restrictions.

2. If not immediately repaired:

   - Can be deferred in accordance with the Minimum Equipment List (MEL)[12]:

     — Deferred in accordance with the MEL. Note it in the DMR, PVM and deferred item list.
     — Track as required and repair as soon as possible, within the time limit specified in the MEL.
     — The helicopter can fly with the restrictions specified in the MEL.

   - Cannot be deferred in accordance with the MEL:

     — Can be deferred in accordance with the manufacturer's maintenance and/or repair manuals:

       – Deferred in accordance with the applicable document. Log it in the DMR, the PVM and the deferred item list.
       – Track as required and repair as soon as possible, within the time limit specified in the applicable documents.
       – The helicopter can fly with the restrictions specified in the applicable documents.

     — Cannot be deferred in accordance with the manufacturer's maintenance and/or repair manuals

       – The helicopter remains out of service until repaired.
       – Apply the procedures specified in the Organization Maintenance Manual.

[12] In the case of the S-61N fleet, the operator used the Master Minimum Equipment List (MMEL) approved by the FAA for this helicopter type.

If he deems it appropriate, the line TMA can make technical inquiries of the Maintenance Base Manager, if at a permanent base, and the Fleet Manager and Maintenance Manager.

If the limitations exceed the limits specified in the manufacturer's Maintenance Manual, inquiries must be made on a case by case basis through the operator's and/or maintenance facility's Engineering Department to the manufacturer's Engineering Department, which will issue a document[13] with its recommendations.

Once the issue has been studied internally and the viability to request a ferry flight from the Authority is evaluated, the operator's Technical Office can request the corresponding AESA Flight Safety Office a Permit to Flight specific for that malfunction. Said permit must specify the route to be followed and alternate landing sites, the minimum crew and the applicable flight conditions. Only essential crew members are allowed onboard during this type of flight to move the helicopter to a maintenance center. No passengers of any type are allowed onboard.

1.18.6. *Airworthiness considerations*

This section addresses the actions taken by the helicopter manufacturer and by the competent airworthiness authorities of the United States (FAA - Federal Aviation Administration) and the European Union (EASA - European Aviation Safety Agency) as a result of this accident.

1.18.6.1. Sikorsky Aircraft Corporation

On 20 October 2006, the helicopter manufacturer issued Sikorsky Safety Advisory SSA-S61-06-002, included as Appendix B.

This document states that a CBIM warning or an unsafe BIM indication can be indicative of a crack in the blade, and that the applicable flight and maintenance manuals specify the procedures to be followed in this event.

The advisory also includes a warning that if established procedures are not followed, spar damage in the main rotor blades could remain undetected, and that the failure of a blade will result in a loss of control of the helicopter with the subsequent loss of life and property.

[13] Normally, though not necessarily, called an NTO (Non-Technical Objection).

As a corrective action, operation and maintenance personnel are reminded to rigorously observe and adhere to all the procedures, warnings and notices published in the applicable manuals.

1.18.6.2. FAA – Federal Aviation Administration

On 19 April 2007, the FAA issued Special Airworthiness Information Bulletin SAIB NE-07-30, which is included as Appendix C along with FAA Airworthiness Directives (AD) 74-20-07 R5 and 85-18-05 R2, to which it makes reference. This type of document is issued for information purposes only, as noted in the text of the bulletin.

This document refers to the visual pressure indicating system inside the blade and states that the document is being issued following reports of a fatigue crack on a blade recovered from a fatal accident involving an S-61 helicopter, corresponding to this accident.

By way of background, it references FAA Airworthiness Directives 74-20-07 R5 and 85-18-05 R2, which specify the time periods for inspecting the pressure indications inside the main rotor blades and the associated BIM and CBIM components, if applicable. It also mentions that AD 74-20-07 R5 requires that each blade which has triggered a BIM indication or activated the CBIM be considered unsafe and unsuitable for flying operations until the cause of the indication or warning is determined and corrected in accordance with the procedures established in Sikorsky Service Bulletin (SB) No. 61B15-6P or any subsequent version approved by the FAA (or Maintenance Manuals SA 4045-80 and SA 4045-101). In fact, on the date of the accident, revision number 17 of the Service Bulletin (SB 61B15-6Q), dated 22 May 1986, was in effect, and had been included in the applicable Maintenance Manual (SA 4045-80) by revision 34 of 30 June 1986.

Finally, it also refers to Sikorsky Safety Advisory SSA-S61-06-002

It should be noted that the Troubleshooting Chart for a pressurized spar, shown in page 13 of Service Bulletin (SB) 61B15-6Q and included as Appendix D, states that once an unsafe indication is received, or the result of the indicator check is unsatisfactory, the blade must be removed before the pressure inside the spar is measured. As noted in the last paragraph of 1.18.4.1, the Maintenance Manual specifies that the blade must be removed from service.

1.18.6.3. EASA – European Aviation Safety Agency

On 22 May 2007, the EASA issued Safety Information Notice No. 2007-13, included as Appendix E.

This document makes reference to FAA Special Airworthiness Information Bulletin SAIB NE-07-30, a copy of which is attached. It states that FAA Airworthiness Directives 74-20-07 R5 and 85-18-05 R2 are applicable to all S-61N helicopters registered in European Union member states, and endorses the FAA's recommendations.

1.18.6.4. Implementation by the Operator

Over the course of the investigation, it was verified that the helicopter Operator had implemented the inspection procedures established in FAA Airworthiness Directives 74-20-07 R5 and 85-18-05 R2 into its Sikorsky S-61N fleet, as well as those specified in Maintenance Manual SA 4045-80 involving the actions to take for unsafe BIM indications or CBIM warnings.

1.18.7. *Eyewitness statements*

The helicopter's fall to the water was observed by a person who was on a boat, fishing, to the north of the Anaga lighthouse, some 3 NM away from the coast. An interview was conducted with this person, the highlights of which presented below.

On the day of the accident, he saw a helicopter emerge from Roque Bermejo, some three or four NM away from his position, between 09:00 and 09:05, flying in the direction of Las Palmas. The sky was overcast and dark gray, and the horizon was hazy. The wind was from the northeast and the seas were choppy. Although he could not estimate its altitude, he thought the helicopter was flying relatively low since it remained below the clouds. At no time was he able to hear it above the noise of his own boat's engine.

As he was looking at it, he saw how, in a matter of seconds, the helicopter rotated backwards and rose slightly before nosediving while on an approximate course of 180º with respect to its original heading. It fell in the sea to the east-southeast of his position, some 3 NM away from land.

When asked about the direction of the turn made by the aircraft, he replied that he did not know if it had been to the right, all the while motioning several times with his hand to the right.

He proceeded to the area where he had seen it fall but did not find anything. He thought it had sunk and, after searching for it for about 15 to 20 minutes without finding it and not knowing how to react, continued fishing. Although he could hear an occasional message, both his VHF radio and his mobile phone were out of signal range.

About 15 minutes after resuming his fishing activities, he heard a ship on a marine band calling the Port of Tenerife control center and reporting something about a helicopter accident. It was then that, after several attempts, he was able to obtain a signal and call the 112 emergency number, where he was informed that they were already aware of the accident.

Shortly afterwards more ships arrived in the area and search and rescue efforts were initiated.

1.19. Useful or effective investigation techniques

Not used.

2. ANALYSIS

2.1. Events of the flight

2.1.1. *Overview*

The Sikorsky S-61N, registration EC-FJJ, had arrived on 6 July 2006 to La Palma Airport from Jerez Airport to take part in firefighting activities. On the Agadir-Las Palmas segment of this positioning flight, a low nitrogen pressure warning had come in for the main rotor blades, which, once on the ground, was determined to have come from the "black" blade. The pressure inside this blade was verified to be within the refill limits, and so was refilled with nitrogen before the helicopter completed the last planned leg of its flight.

Late the next day, at the end of the last flight made over the course of the day on the island of La Palma, the warning was repeated. Once on the ground, it was verified to have come from the same blade, and also that there was a nitrogen leak on the fill valve seat. The valve and its associated seal were replaced with new ones, but the leak persisted. After several different combinations of new and old components gave the same result, the mechanic assigned to the helicopter installed the combination that resulted in the smallest leak and, after consulting with the operating base at Las Palmas, decided, with the pilots' consent, to move the aircraft to said base the next day so as to subject the blade to more conclusive leak tests.

That is why, on 8 July 2006, the helicopter was flying from La Palma Airport to Las Palmas Airport with two pilots and four passengers onboard. One of the passengers was the mechanic assigned to perform line maintenance on the helicopter. In accordance with the flight plan filed by the crew, they planned to make a VFR flight, heading initially to point W of Tenerife North Airport, overfly it at an altitude of 1,000 ft toward point E, and then head directly for the destination airport. The flight was scheduled to last one hour and the helicopter had sufficient fuel for a three-hour flight.

In general, the weather conditions along the scheduled route were adequate for the flight as planned; nevertheless, the helicopter crew thought that the local conditions at Tenerife North Airport were not conducive to an overfly and, at 08:42, requested and was granted clearance to head directly to the airport's point N and circle the island of Tenerife around the northeast to point E instead of flying over the airport.

At 08:58:07, as the helicopter was flying from west to east 12 NM north of the airport, at an altitude of 600 ft and a speed of 120 kt, the crew was informed that no visual traffic had been reported between points N and E, which it acknowledged. At 09:00:14, its echo disappeared from the radar screen in an area that has no radar coverage at the aircraft's flight level. It did not reappear.

After the helicopter crew was requested on two occasions to report reaching point E without a reply, and then trying on other frequencies and using other aircraft in the area to relay the message, all with the same result, and after receiving a negative reply from other ATC facilities consulted, the Canaries Rescue Coordination Center (RCC) was radioed to inform them of the loss of contact with the aircraft and of its delay in arriving at its destination. Coincident with this notification were reports received from various aircraft control communications facilities that they had picked up the signal from an emergency beacon.

The first concrete information about the area in which the helicopter had fallen was received at 10:13, at which time air and surface units were dispatched to the area. The helicopter wreckage and some of its occupants were located shortly afterwards, with rescue efforts starting at around 10:30.

2.1.2. *Helicopter flight path*

As noted in 1.16.4, information is available on the helicopter's path as detected by radar stations and corresponding to the approximately 40 minutes of flight time that elapsed between the takeoff from La Palma Airport and the loss of contact at a position near point N of Tenerife North Airport.

Figure 18 shows how the aircraft followed a path to the north that was nearly parallel to its planned route until it requested, and was granted, clearance to circle around the northeast side of the island of Tenerife instead of overflying Tenerife North Airport, at which moment it proceeded directly to point N of said airport on a west to east trajectory. While on this path it maintained a ground speed of 110 to 120 kt. Considering that, according to the available weather information, the wind was moderate and variable in direction from the N and NW, it can be deduced that its indicated airspeed was slightly above the 100 kt called for in the flight plan.

Although the information available gives no exact indication of the helicopter's final trajectory, if the request made by the crew and the corresponding clearance from ATC are considered, along with the fact that the accident took place in an area located to the north of Tenerife North Airport's point E, it is likely that the aircraft circled the island to the northeast to point E, in keeping with its planned route.

2.1.3. *Impact with the water*

On the same day of the accident, the aft fuselage section of the helicopter and structural elements from the lower central part of the fuselage were recovered. Their analysis allowed investigators to determine that all of the damage and fractures found had been caused as a result of a very violent impact with the water and that, at the time of impact, the helicopter was in a very pronounced dive and right bank angle.

This confirms what was presented in 1.18.5 concerning the interview of the fisherman who had witnessed the helicopter's fall to the water. When asked about the turn it made before falling, he doubted whether it had been to the right, though his gestures seemed to confirm this.

The parts from the light components from all the fuselage areas not recovered earlier, except for the tail section, and which were found on the ocean floor during the search operations conducted between 1 and 8 September 2006, also point to the extremely violent nature of the impact between the aircraft and the surface of the water, as a consequence of which the cockpit and the front and central parts of the fuselage practically disintegrated.

This allows one to conclude that the helicopter contacted the water violently with an abnormal attitude and, probably, out of control. Moreover, at the time of impact with the surface of the water, the aircraft's structure was intact.

These characteristics do not correspond to those of a direct impact of a helicopter with the water along its line of flight, meaning that the possibility that the aircraft could have lost altitude gradually so as not be perceived by the crew to the point where it impacted the surface of the ocean and crashed, can be ruled out.

2.2. Aspects involving the helicopter

2.2.1. *Mechanical characteristics of the helicopter*

The helicopter had a conventional configuration, with two engines directly coupled to a main gearbox through which they supply power to the main rotor, the tail rotor and to all associated systems. The main rotor's rotational axis (mast) meshes directly with the main gearbox, while the tail rotor is meshed via two lines and two gearboxes. The aircraft's systems can receive the energy they require to operate either by being directly coupled to the gearbox, or through other systems.

A configuration such as this one means that an anomaly in any component that is coupled, either directly or via other intermediate elements, to the main gearbox can be transmitted to the remaining components in sequence and with a delay that will depend, basically, on the distance between them and on the presence of any intermediate components.

As for the main rotor blades, they are filled with low-pressure nitrogen, which not only aids in detecting cracks through the CBIM/VBIM system, but has the added benefit of preventing corrosion by keeping an inert atmosphere. The nitrogen, then, impedes or delays the appearance of corrosion inside the spar, which could then lead to cracks that would propagate from the inside out and would be difficult to detect through normal procedures before they reached the outer surface. Additionally, the CBIM/VBIM systems outfitted on the helicopter produce warnings in the event that the pressure reaches a certain value below which outside air can find its way inside the spar. As for the operation of these systems, it is worth repeating that a warning of the former is taken as an unsafe indication and could come from any of the blades, which one remaining unknown until after the helicopter lands and the blades are checked using the second system. It should also be noted that a nitrogen leak in a blade can result from the loss of the seal around the joint of an element that is coupled to it (fill valve, BIM indicator, CBIM transducer or sealing elements at the tip or root of the blade). A leak can also result from cracks in the spar walls that, in addition, can alter its structural characteristics.

2.2.2. *Wreckage recovered and structural failure*

Debris belonging to the helicopter fuselage structure was located and recovered, as were pieces from the main rotor blades.

The aft section of the helicopter's fuselage was recovered from the surface. It had been kept afloat by a life raft that had inflated inside it. The CVR housing was in this section of fuselage and in its proper position, which allowed for the recovery of this component. Also found was a portion of the lower center part of the fuselage, which included the associated part of the passenger cabin floor, another part of the cabin floor and the main landing gear.

The search for submerged wreckage was made possible by the availability of the proper equipment for operating at the depths present in the area of the accident, although due to the topography and characteristics of the ocean floor in the area, only a limited number of remains were recovered. In fact, only pieces of light components from all of the parts of the fuselage not recovered on the surface were located, except from the tail section, as well as four main rotor blade segments (of which three were recovered). These segments were from the end of the blade closest to the union with the main rotor head. All were recovered in an area with depths ranging from 700 to 1,000 m, and scattered over an approximate surface area of 500 by 350 m.

A study of the fuselage components allowed for a determination of the conditions under which the helicopter impacted the water, as described in 2.1.3.

A study of two of the blade segments recovered, and which exhibited similar fractures (between them and with the segment that was documented, but not recovered), corresponding to three of the blades, concluded that the fractures were probably produced by the high-energy impact of the blades against the surface of the water.

A study of the fourth blade segment, corresponding to the fourth blade and identified as belonging to the helicopter's "black" blade, showed, first, that it detached from the component that affixed it to the rotor head when the bolts that held it in place broke; and second, that the only fracture segment it had showed characteristics of having initiated progressively. The results of the analyses conducted on this segment are analyzed later.

No additional helicopter components were found. Specifically, the remaining mechanical parts (engines, transmission components, etc.) and the tail cone (tail rotor, transmission gearboxes and axles, etc.) were not recovered, nor were any of the systems that could have provided valuable information about the general state of the aircraft at the moment it impacted the ocean surface.

Not recovered either were the main rotor head and one of the blades. Of three blades, the root and most of the length towards its tip was not available, nor was most of the length, toward the tip, of the fourth blade. In other words, the main rotor components needed to perform a complete study of the conditions at the time of impact for each of the blades were not available, nor were the segments containing the other sides of the fractures (counter-fractures) that were studied, an analysis of which could have determined the characteristics of the loads that resulted in the fracture.

As a result of the above, the investigation of the aircraft wreckage was restricted to the study of the components available, though some conclusions regarding the possible causes of the accident were able to be drawn.

2.2.3. *Helicopter maintenance*

A study of the maintenance documentation for the helicopter and its components reveals that they had been maintained in accordance with the approved maintenance plan and the requirements of the applicable documentation, though the last maintenance activities involving the "black" blade were not in accordance with approved procedures.

As described in 1.18.1.2, on 26/06/2006, while starting the helicopter's engines, a low nitrogen pressure warning was received for the main rotor blades that, once the engines were stopped, were verified to have come from the "black" main rotor blade. At that time said blade had 6784:38 flight hours and the helicopter had 36217:40.

The mechanic performed the procedure defined in the Additional Specific Instruction of the Maintenance Manual, no. AHS-0549, complementary to the manufacturer's Maintenance Manual and described in 1.18.4.3., for placing the blade in service. Since the equipment needed to check and recharge the nitrogen in the main rotor blades was not available, he instead used a low-pressure manometer that was accurate enough to enable him to check the pressure in the blade.

When the equipment needed to check and recharge the nitrogen in the rotor blades became available, on 28/06/2006, he checked the nitrogen pressure in the main rotor blades. The “black” blade had 6,791:53 flight hours and the helicopter 36,224:55. On 04/07/2006, he performed the check once more, with 6,811:53 flight hours on the “black” blade and 36,244:55 on the helicopter.

This event and the checks of the nitrogen pressure in the main rotor blades were not logged in the appropriate flight and maintenance documents, as they should have been.

Moreover, as described in 1.18.1.2, the CBIM had produced in-flight warnings on the two days prior to the accident. In two of those cases, the VBIM was used to confirm that the warning had come from the “black” blade. In the first case, the nitrogen pressure inside the blade was confirmed to be within refill limits, so the blade was refilled with nitrogen and returned to operation. In the second, a nitrogen leak was detected in the seat of the fill valve that could not be fully corrected, which is why it was decided to move the helicopter to Las Palmas Airport on the next day.

As regards the first warning, in keeping with the instructions in the helicopter’s Maintenance Manual described in 1.18.4, the blade should have been removed from service until the cause of the warning was positively identified and corrected. Then, once returned to service, it should have been monitored until 30 flight hours or 10 days had elapsed, whichever came first. In accordance with the instruction used, the blade should have been also monitored until 100 flight hours or 30 days had elapsed, whichever came first.

As for the second warning, it took place after 10 days and approximately 38 flight hours had elapsed, which, as per the helicopter’s Maintenance Manual, should have been treated as a new event. In keeping with the operator’s procedures, the blade should have been replaced and sent to the workshop.

Finally, there was the third warning, which took place some 4 flight hours later, that is, within the 30 flight hours following the second event, meaning that the blade should have been replaced for good since no other maintenance option was available for said blade at its location, regardless of whether or not the criteria in the manufacturer’s Maintenance Manual or in the operator’s procedures were applied.

Besides these considerations regarding the events that took place, the last paragraph in 1.18.4.2 highlights how the applicable manufacturer Maintenance Manual (SA 4045-80) specifies that the blade must be removed from service under certain conditions. According to the Troubleshooting Chart shown in said manual, the first measurement of the pressure inside the spar can be taken with the blade mounted on the helicopter, as long as the helicopter and its components are not in service during the measurement. The Additional Specific Instruction to the Maintenance Manual, no. AHS-0540, and applied by the operator states as much. The Troubleshooting Chart for a pressurized spar that is shown in the Service Bulletin (SB 61B15-6Q), however, specifies that once an unsafe indication is received, or the result of the indicator test is unsatisfactory, the blade must be removed from helicopter before the pressure inside the spar is measured. In light of this, said Service Bulletin is not considered to have been properly incorporated into the Maintenance Manual. If that is not the case, the reason for the difference should be justified.

2.3. Fracture of the "black" main rotor blade

2.3.1. *Characteristics of fracture section*

In 1.16.2, the results of the studies conducted by INTA and by the NTSB were presented regarding the characteristics exhibited by the fracture section of the "black" main rotor blade spar.

Both studies agree that the fracture originated in the lower aft wall of the blade spar and propagated through a fatigue mechanism which led to a static overload. They differ, however, on the mechanism by which the fracture developed in the zones labeled 2 and 3 in the INTA report (see Figure 12).

Focusing our attention on the features exhibited by the fracture in these zones (2 and 3) of the fracture section, both studies describe similar surface characteristics, especially in zone 3, which shows, from a macrofractographic standpoint, a fracture surface on a plane perpendicular to the direction of the forces that resulted in the fracture and a directional rough texture (INTA), or a banding pattern (NTSB), and from a microfractographic standpoint, features typical of plastic deformation in numerous areas and the absence of fatigue characteristics.

The discrepancies arise when interpreting the results. While in the INTA study these characteristics are thought to indicate that the fracture in this area resulted from a tensile static overload applied at a high speed (impact or near-impact loads), the NTSB interpretation is that the banding pattern is not consistent with a static overload and, although certain microscopic features in these zones are apparently indicative of a tensile static overload, and sometimes of relatively rapid progressive growth, there can be rapid fracture regions with features typical of static overload separated by more slowly growing bands with features typical of fatigue.

In practice, and in light of the findings of both studies, the fracture in zones 2 and 3 is regarded as exhibiting characteristics of rapid growth under cyclic loading.

Both studies reveal that the fracture was caused by a fatigue phenomenon that culminated in a final application of strong loads which the section was incapable of withstanding, resulting in its fracture.

2.3.2. *Significance of VBIM/CBIM system warnings*

The zone exhibiting characteristics of a progressive fatigue fracture (zone 1 in figure 12) affects practically the entire thickness of the spar wall, except for the exit lip of the fracture toward the inside of the blade (point P in Figure 12), measuring approximately 1 mm in thickness and which coincides with the boundary between zones 1 and 2 of the fracture section. Based on the information provided by the manufacturer and included in 1.18.6, the size of the opening may have been sufficient to cause a nitrogen leak that would have been detectable by the CBIM/VBIM system over a relatively long period of time.

On the other hand, as described in the above section, the fracture in zones 2 and 3 also exhibited rapid growth characteristics produced over a small number of cycles. In this case, the size of the opening would be sufficient to produce a leak that would be detectable by the CBIM/VBIM system over a relatively short period of time.

Consequently, the possibility exists that the low pressure warnings for the nitrogen inside the blades and which took place in the two days prior to the accident were due to leaks through this opening. It is likely that the warning issued some 26 minutes before the accident was due to a leak through this opening.

2.3.3. *Possible effect on accident*

The findings of the two studies disagree as to the extent of the zone that exhibited fatigue-induced progressive fracture characteristics, though the results obtained underscore the presence of a zone with slow growth characteristics (zone 1 in Figure 12) and others with more rapid growth (zones 2 and 3 in the same figure). In either case, however, the proportion of the total surface area of the blade affected by the progressive fracture does not, in and of itself, conclusively prove that the fatigue process triggered the fracture of the blade; nor does it rule out the fact that, due to the change in the blade's structural characteristics (basically a change from a closed to an open section and a change in the positions of center of gravity or of shear), the blade could have fractured in this area due to the debilitating effects of said changes.

Also, as described in 1.16.3, the blade segment found had detached from the main rotor head as the result of the relative displacement of the spar with respect to the component used to attach it to the rotor head. This relative displacement took place due to the deceleration of the blade with respect to the rotor head, which caused the fastening bolts to shear, followed by the separation and ejection of the blade root from its housing. The deceleration of the blade with respect to the rotor hear suggests the possibility of the blade impacting the water.

Also, as described in 1.11.1.2, the CVR recording revealed that the frequencies and harmonics generated by the rotation of the components coupled to the engines and to the main gearbox, as well as of the gearbox itself and of the tail rotor, indicated normal conditions. At any rate, the signal remained constant throughout the flight until, 4.5 seconds before the end of the recording, it disappeared instantly, drowned out by a significant increase in the background noise that persisted until the end of the recording. Under these conditions, it was impossible to establish the likelihood of a possible failure in one of the helicopter's main mechanical components, much less of a sequence of failures.

To summarize the analysis presented in 2.3.1 and 2 and in previous paragraphs, it can be concluded that, on the one hand, a determination of the cause-effect relationship between the helicopter's impact with the water and the fracture of the "black" main rotor blade could not be established; and, on the other, that it is likely that the CBIM warnings of low nitrogen pressure inside the blade spars received prior to the accident were caused by leaks through the opening from the inside of the spar in the area with the progressive fracture and caused by the fatigue mechanism found in that section, as well as by the leaks detected at the seat of the fill valve.

2.4. Crew actions

2.4.1. *General considerations*

According to all available information, it is believed that the crew was aware that there were nitrogen leaks in the "black" main rotor blade and that these had caused the in-flight CBIM warnings that had been received during the two previous days. In fact, the flight to Las Palmas Airport had been agreed upon with the mechanic in order to subject said blade to more conclusive leak tests.

What is more, in light of the argument presented in 2.2.3, said blade should have been replaced permanently, there being no other maintenance option available where the blade was located. This means that the helicopter, with this blade installed, did not satisfy the maintenance conditions required to conduct a positioning flight without any restrictions.

Therefore, it is believed that the characteristics of the flight were such that it should been conducted as a ferry flight once the relevant Permit to Flight had been requested and obtained and, as such, should have had the relevant restrictions applied to it in terms of the passengers allowed on board. As indicated in 1.17.2.6, in its Operations Manual the operator did not establish any criteria in this regard for non-commercial flights, and in its Circular 03/90 leaves everything to the Captain's discretion.

2.4.2. *Considerations on BIM WARNING procedure*

As regards the procedure associated with the CBIM warnings and discussed in 1.18.2.1, first, it was noted that the operator used the expression "LAND AS SOON AS

PRACTICABLE (Within TWO hours)", defining this as "Extended flight is not recommended. The landing site and the duration of the flight are at the discretion of the pilot" and quantifying the maximum duration of the flight, while the manufacturer used the expression "Land at nearest suitable landing area" without defining this.

In light of the information presented in 1.18.2.2, it is thought that the BIM WARNING procedure included in the operator's checklists was consistent with that for "ILLUMINATION OF OPTIONAL BIM WARNING LIGHT" found in the Helicopter Flight Manual. This indicates, moreover, that the helicopter manufacturer regarded that this type of warning would be produced far enough ahead of a possible blade failure to allow the flight to continue until the nearest suitable landing facility. The same applies to the operator, which established a flight time limit that would allow, in the case of flying over water, reaching a suitable landing area without directly requiring a water landing.

In any case, when faced with a BIM WARNING, this operator's crews must use the procedure dictated by the operator and perform the following four actions:

- Main rotor turn rate (Nr): 104%
- Indicated airspeed (IAS): 90 kt
- Descend below 1000 ft, if possible.
- Land as soon as practicable, within two hours.

2.4.3. *Information obtained from the Cockpit Voice Recorder (CVR)*

As noted in 1.11.1.1, at 08:41:27 the statement "See, we have a BIM PRESS" was recorded on the CVR, spoken by the Pilot in Command. There were no replies nor were any comments made in this regard for the duration of the flight.

In addition, as described in 1.11.1.2, the CVR recording revealed that the frequencies and harmonics generated by the rotation of the components coupled to the engines and to the main gearbox, as well as of the gearbox itself and of the tail rotor, indicated normal conditions. These signals remained constant over practically the entire flight. Specifically, they did not change immediately after 08:41:27.

Keeping in mind that all of these components are directly or indirectly coupled to each other and to the main rotor, this indicates that there were no variations in the main rotor turn rate, as a consequence of which no actions were taken following the warning.

2.4.4. *Information obtained from radar trace*

When the statement "See, we have a BIM PRESS" was recorded on the CVR, as spoken by the Pilot in Command, the radar trace for the helicopter's flight indicated that they were at a position corresponding to coordinates 28°37’13”N 17°01’57”W, practically halfway between the La Palma and Tenerife North airports. At the time they were flying at an approximate altitude of 600 ft and a ground speed of 110 kt (indicated airspeed slightly above 100 kt, as explained in 2.1.2), conditions that were maintained for practically the entire recorded flight path.

In these conditions, actions should have been taken to reduce the helicopter’s indicated airspeed to 90 kt. As for the altitude, since the helicopter was already below 1,000 ft, no actions were necessary in this regard.

2.4.5. *Compliance with established procedure*

Continuing with the last of the four actions envisaged in the established procedure (Land as soon as practicable, within two hours), once the BIM WARNING was received, the crew continued with the intended flight plan.

In regard to this action, and bearing in mind that the helicopter had taken off and was engaged in a positioning flight that met all of the requirements for a ferry flight, even though Las Palmas Airport was about 40 minutes away by air at the time the in-flight warning was received, within the limit established by the operator, both the Tenerife North and La Palma airports were approximately 20 minutes away from their location. The flight plan should therefore have been modified and the crew should have headed for one of these two airports

It may be concluded, based on the considerations presented in the above paragraph, as well as in the previous sections, that the crew did not execute the emergency procedure as written in the operator’s checklists for the case of a BIM WARNING luminous indication in the cockpit, and resulting from a drop in the nitrogen pressure in one of the blades below the setpoint.

Moreover, as noted in 2.4.1, the crew knew that there were nitrogen leaks in the “black” main rotor blade and that these leaks had caused the in-flight CBIM system warnings that had been received the two previous days. In fact, the flight to Las Palmas was being conducted so as to subject this blade to more conclusive leak tests. This environment, in which the origin of a warning was thought to be known and not to pose a threat to the aircraft or its occupants, was conducive to the crew ignoring a warning and not carrying out the corresponding emergency procedure.

Based on the premise that adherence to Standard Operating Procedures (SOPs) constitutes a guarantee of safety to operations, the fact that a procedure is not performed is, in and of itself, sufficiently serious, and made even more so in this case by the inability to correctly identify the origin of the warnings while in flight.

Taking into consideration above deviations from the SOPs and up to this point, it does not seem appropriate to consider any aspect of the Crew Resource Management (CRM).

2.5. Organization of the aircraft operator

The organization of the helicopter operator by the date of the accident is described in 1.17, with an emphasis on its structure, the chain of command and applicable procedures. Particular attention is paid to those aspects directly related to operations and maintenance, to the handling of the aircraft's technical records and to the established operational control criteria.

In general, each helicopter is assigned a crew based on the type of operation in which it is to be used, such that it can be completely self-reliant while performing its mission. These crews include a line mechanic with the ratings required to perform both scheduled and any other specific maintenance as required, in addition to other tasks that may be assigned depending on the type of operation. Each helicopter's pilots and mechanic report to their respective commands (operational and technical), which are coordinated through the operating base where the aircraft is stationed, or by the nearest operating base if assigned to a temporary base.

In light of this arrangement, it is normal for decisions to be made in the field and acted on accordingly, with or without prior approval, and that these decisions be communicated later. This allows for fast and flexible operations. The tradeoff is that the supervision of these activities will, in general, be reactive in nature; that is, the organization acts once the situation has already played out and been resolved according to the criteria of each of the individuals involved in it.

These criteria will, in general, be uniform when they involve actions taken in common situations, whether routine or not. However, in specific situations that arise much less frequently, each individual may have different criteria based on their own experience, which could result in actions being taken that are outside established procedures without any effective supervision on the part of the organization.

In the case at hand, this last point is evidenced in two ways: on the part of the mechanic, by not removing the "black" blade from service when it should have been, and on the part of the crew, by agreeing with the mechanic to perform, and then performing, the flight, and by ignoring the BIM WARNING procedure when this indication was received.

This highlights the need to establish procedures that allow the organization to have a proactive supervision such that, when faced with unique situations, actions outside established procedures can be anticipated and the necessary means put in place to prevent them.

2.6. Considerations of the applicable regulations

2.6.1. *Regulation applicable to Maintenance and Operations organizations*

In 1.17.2.7 and 1.17.3.3, the regulations applicable both now and at the time of the accident to Operations and Maintenance organizations are discussed in general terms. Emphasis is placed on certain aspects of these regulations that are considered pertinent to this case, and the specific reasons as to why the current regulation does not apply to the accident helicopter operator's S-61N fleet are discussed.

The application of the regulation currently in effect provides significant improvements, especially as it relates to the supervision of activities by the Authority and by the companies themselves, to accident prevention and operational safety and to any quality systems in place or that should be implemented.

In this particular case, and in light of the considerations presented in 2.5, it is believed that the implementation of regulations with these characteristics would contribute decisively to the establishment of a proactive supervisory culture at the helicopter operator, both as it relates to operational aspects as well as to the maintenance of its aircraft.

Likewise, as regards the passengers allowed onboard, if an operator has an Operations Manual that is written and approved according to requirements similar to those established in Appendix 1 to JAR-OPS 3.1045, its crews should have specific criteria available to them for determining the characteristics of any non-commercial flights they make and for applying the relevant restrictions to each type of flight.

2.6.2. *Agricultural Pilot Rating*

In terms of the crew training required, the accident helicopter was assigned to firefighting tasks and, as noted in 1.17.2.4.2, the F/O who perished in the accident was not in possession of an Agricultural Pilot Rating, as required by the regulation in effect at the time of the accident and currently. In 1.17.2.4.2 the applicable regulation was discussed, along with the reasons why the operator believes that the F/O was not required to have one, on the one hand, as well as why the applicable regulation does not take into account multi-pilot operations, on the other.

In light of the regulation applicable to both firefighting activities and to the requirements for pilots to obtain the corresponding rating, the regulation does not consider those operations involving aircraft certified to fly with a minimum crew of more than one pilot.

In terms of the requirements for pilots to obtain the associated rating, it should be noted that on the date of the accident, the requirement was "to have flown, as a pilot, a minimum of 300 flight hours", while the current requirement is "to have flown at least three-hundred flight hours as pilot in command of an airplane or helicopter". This requirement could have been satisfied by a F/O on the date of the accident, even including his experience on other types of aircraft, though today he would only have satisfied this requirement if he had flown as Pilot in Command on other aircraft types.

Keeping in mind that firefighting operations are often conducted with more than one pilot in helicopters certified to fly with a minimum crew of one pilot, it is believed that it would be worthwhile to include multi-pilot operations in the regulation applicable to this activity type.

2.7. Injuries sustained by the helicopter occupants

2.7.1. *Injuries sustained by the Pilot in Command*

The autopsy report on the body of the aircraft's Pilot in Command states that he died from traumatic shock caused by injuries that could have resulted from a frontal contusion, as well as from the cutting effect of the helicopter blades, which severed the body in two places, causing a partial anterior cut of the thorax and a complete disseverance below the navel.

Bearing in mind that in this helicopter type the Pilot in Command occupies the right hand seat and that the main rotor blades turn counter-clockwise as seen from above, if the main rotor blades did penetrate the cabin and strike the Pilot in Command, they would have produced cuts from the back to the front and from right to left, and not anterior cuts.

The complete disseverance present below the navel is, however, consistent with one produced by the ventral segment of the harness as a consequence of a frontal impact of the aircraft with the surface of the water at a very high pitch angle, as happened in this case. As for the partial anterior cut of the thorax, this could have been produced by the impact of an undetermined object located in the front part of the helicopter cabin.

2.7.2. *Injuries sustained by the passengers*

The injuries sustained by the passengers are consistent with the fall of the helicopter and its violent impact with the water.

3. CONCLUSIONS

3.1. Findings

A) The helicopter crew was properly qualified, adequately experienced and physically fit. Their licenses were in good standing.
B) The helicopter had valid Airworthiness and Registration Certificates.
C) The helicopter was conducting a flight between the La Palma and Las Palmas airports for the purpose of subjecting one of its blades to a leak test. Onboard were two crew and four passengers, including the mechanic responsible for its line maintenance.
D) The characteristics of the flight were such that it should only have been made as a ferry flight once the relevant Permit to Flight had been filed and approved, and with the corresponding restrictions.
E) Forty-six minutes into the flight, the helicopter fell to the sea and impacted the surface of the water at high pitch and right bank angles.
F) The bodies of the Pilot in Command and of the four passengers were recovered. The F/O remains missing.
G) An exhaustive search of the ocean surface and floor for the helicopter wreckage was conducted. The results of the latter were very limited due to the characteristics of the ocean floor in the area. Even though a very limited amount of debris from the helicopter was recovered, its study revealed some conclusions regarding the possible causes of the accident.
H) Among the components recovered was a spar segment from the "black" main rotor blade. One of its ends showed signs of a progressive fracture stemming from a fatigue phenomenon. In particular, the analyses conducted on the fracture section of the "black" blade allowed investigators to determine that the blade fractured prior to the impact with the water.
I) The CVR installed in the helicopter was recovered and its contents extracted, transcribed and spectrally analyzed.
J) On one of the CVR recordings, the Pilot in Command can be heard saying, "See, we have a BIM PRESS" twenty-two minutes into the flight.
K) A spectral analysis of the CVR recordings did not reveal any anomalies in the operation of those helicopter components whose spectrum could be identified.
L) In the two days prior to the accident, in-flight CBIM warnings had been received notifying of low nitrogen pressure inside the main rotor blades. The origin of these warnings had been traced to the "black" main rotor blade.
M) Previously, 10 days and some 38 flight hours before the first of the warnings referred to in the point above, a CBIM warning had been received while starting the helicopter's engines. This event and the maintenance actions that followed as a result were not logged in the flight (PVM) or maintenance (DMR) documents, as they should have been.
N) In accordance with the helicopter's Maintenance Manual and the operator's procedures, the "black" blade should have been removed service and removed from the helicopter.

O) With this blade installed, the helicopter did not satisfy the maintenance requirements for an unrestricted positioning flight.
P) The crew did not carry out the emergency procedure required for a BIM WARNING of the CBIM system installed in the helicopter.
Q) The procedures established by the operator to supervise operations and maintenance activities are considered to be of a clearly reactive nature. Procedures should be implemented that allow the organization to adopt a proactive supervisory stance.
R) It would be prudent to develop national regulations that ensure adequate equivalent requirements for those operations and aircraft to which the general regulations currently in effect are not applicable.

3.2. Causes

The helicopter was conducting a flight when it fell to the sea and violently impacted the water in an abnormal, and probably out of control, attitude. The most probable cause for the fall was the in-flight fracture of the “black” main rotor blade.

The blade fracture process, which evidenced characteristics consistent with a progressive failure, was initiated by a fatigue phenomenon that was followed by a final static fracture when the fatigue crack reached its critical length.

The deficiencies detected in the application of the helicopter’s maintenance and operating procedures are considered to have contributed to the accident.

4. SAFETY RECOMMENDATIONS

4.1. Maintenance procedures

Over the course of the investigation it was discovered that three CBIM warnings had been received in the cockpit indicating a low nitrogen pressure inside the main rotor blades. The VBIM system was used to confirm that the source of the warnings had been the "black" blade.

As noted in 2.2.3, in the first case no entries were made in the flight (PVM) or maintenance (DMR) documents, as should have been the case, regarding the event or the maintenance actions taken as a result of the warning. Since practically all of the helicopter's documentation was lost in the accident, it is not known whether the entries associated with the two other cases had been made. In any case, if they had been made, the relevant sheets had not been faxed to the company's central services on a daily basis, as required by their procedures.

Given the importance from a maintenance standpoint of being able to track the progress of a malfunction, and considering that in this case the necessary steps were not taken to allow for effective tracking, the following Safety Recommendation is issued:

Recommendation no. 17/10. The helicopter operator should make changes and improvements to its organization as required to ensure that the necessary and essential tracking of malfunctions is achieved by way of proper log entries in the corresponding flight (PVM) and maintenance (DMR) documents, that said documents are submitted to the department responsible for their tracking and that said department monitors the progress of these documents.

4.2. Non-commercial flights

Over the course of the investigation it was discovered that the operator's Operations Manual did not include the definitions for the various types of non-commercial flights its helicopters could make, nor the criteria for allowing passengers onboard said flights.

It was verified, however, that "Appendix 1 to JAR-OPS 3.1045, Content of Operations Manual", lists criteria for allowing passengers onboard, namely, that the operator shall ensure that Section 8.7 of its Operations Manual contains the procedures and limitations for non-commercial flights, including the type of personnel that can be transported on each flight.

Based on the contents of the last paragraph in 2.6, in the sense that if an operator has an Operations Manual that is written and approved in keeping with requirements similar to those specified in Appendix 1 to JAR-OPS 3.1045, its crews will have available specific criteria for determining the characteristics of any non-commercial flights they make and be able to apply the relevant restrictions to each, the following Safety Recommendations are issued:

Recommendation no. 18/10. The helicopter **operator** should include procedures and limitations for non-commercial flights in its Operations Manual, to include the type of passenger that can be transported on each flight, in terms similar to those used in Appendix 1 to JAR-OPS 3.1045.

Recommendation no. 19/10. Spain's **Aviation Safety Agency (AESA)** should ensure that the Operations Manual of this operator in particular, and of every operator in general, include procedures and limitations for non-commercial flights, including the type of passenger that can be transported on each, in terms similar to those used in Appendix 1 to JAR-OPS 3.1045.

Recommendation no. 20/10. Spain's **Civil Aviation Directorate General (DGAC)** should consider the possibility of drafting regulations applicable to Spain and which require that all Operations Manuals involving any activity required by this document include procedures and limitations for non-commercial flights, including the type of passenger that can be transported on each, in terms similar to those used in Appendix 1 to JAR-OPS 3.1045.

4.3. Applicable regulations

Over the course of the investigation, it was noted that the regulations currently applicable in Spain to Operations and Maintenance organizations (JAR-OPS 3 and the EC Regulations specified in 1.17.3.3) are, in general, not applicable to a group of activities that include SAR and firefighting services, meaning that the operator's S-61N fleet is exempt from its requirements.

It was noted, however, that the application of these regulations would provide significant improvements, especially as they relate to the supervision of activities by the Authority and by the companies themselves, in terms of accident prevention and operational safety and of any quality systems in place or that should be implemented.

Additionally, the last paragraph in 2.5 highlighted the need for the operator to establish procedures that allow the organization to adopt a stance of proactive supervision such that, when confronted with isolated situations, events outside of established procedures can be anticipated and the necessary resources implemented to avoid them.

Based on the contents of the second-to-last paragraph in 2.6, in the sense that the implementation of a regulation with these characteristics would contribute decisively to the establishment of a proactive supervisory culture at the helicopter operator, both as it pertains to the operation and to the maintenance of its aircraft, the following Safety Recommendations are issued:

Recommendation no. 21/10. The helicopter operator should establish criteria in its Operations and Maintenance Manuals that are generally similar to those specified in the applicable Spanish regulations for Operations and Maintenance organizations (JAR-OPS 3 and the EC Regulations referred to in 1.17.3.3), at least as they relate to the supervision of activities by the organizations themselves, to accident prevention and operational safety, and to any quality systems in place or that should be implemented.

Recommendation no. 22/10. Spain's Aviation Safety Agency (AESA) should ensure that operators in general, and this one in particular, include criteria in their Operations and Maintenance manuals that are generally similar to those specified in Spanish regulations applicable to Operations and Maintenance organizations (JAR-OPS 3 and the CE Regulations referred to in 1.17.3.3), at least as they relate to the supervision of activities by the organizations themselves, to accident prevention and operational safety, and to any quality systems in place or that should be implemented.

Recommendation no. 23/10. Spain's Civil Aviation Directorate General (DGAC) should consider the possibility of enacting regulations, applicable in Spain to those activities that are excluded from regulations that are generally and normally applicable to Operations and Maintenance organizations (JAR-OPS 3 and the CE Regulations referred to in 1.17.3.3), such that all civil aviation activities are carried out on similar terms, at least as they relate to the supervision of activities by the Authority and by the organizations themselves, to accident prevention and operational safety, and to any quality systems in place or that should be implemented.

4.4. Agricultural Pilot Rating

The investigation revealed that the regulation applicable to aerial work, which include agricultural activities, and to the agricultural pilot rating, does not include any reference to operations performed with aircraft certified to operate with a minimum crew of more than one pilot nor to their crew members.

ORDER FOM/397/2007, of 13 February, which regulates the training process for the agricultural pilot rating, specifies, among other requirements, that applicants must certify having completed at least three-hundred flight hours as the pilot in command of an airplane or helicopter prior to taking the corresponding course.

Based on the contents of the last two paragraphs in 2.6.2, in the sense that a pilot with a rating of F/O's, for an aircraft type certified to operate with a minimum crew of more than one pilot could only obtain an Agricultural Pilot Rating after having flown as a Pilot in Command in aircraft of other types; and considering the fact that firefighting operations frequently involve more than one pilot in helicopters certified to operate with a minimum crew of one pilot, the following Safety Recommendation is issued:

Recommendation no. 24/10. Spain's **Civil Aviation Directorate General (DGAC)** should consider the possibility of modifying existing regulations or of drafting new regulations applicable to aerial work and the agricultural pilot rating such that said regulations include multi-pilot operations, whether they involve aircraft certified to be flown by a minimum crew of more than on pilot or by just one pilot.

4.5. Manufacturer's maintenance documentation

The investigation revealed that there is a discrepancy in the helicopter manufacturer's maintenance documentation in effect on the date of the accident involving the main rotor blades; specifically, between revision 17 of Service Bulletin 61B15-6Q, dated 22 May 1986, and the applicable maintenance manual (SA 40405-80), in which said revision was included by way of revision 34, dated 30 June 1986.

As noted in the last paragraph in 1.18.4.1, there is a warning in Chapter 65-11 of the helicopter's Maintenance Manual that states the following:

> Any blade for which the pressure indicator shows any red or black indication, or whose pressure transducer gives a luminous CBIM warning, **must be removed from service** until the cause of the unsafe (red or black) indication or of the warning light is found and corrected. If the indicator or transducer are not working properly, they must be replaced, but only if the pressure inside the blade spar is within allowable limits.

The Troubleshooting Chart for the pressurized spar, included in Appendix A, does not require that the blade be removed from the helicopter. Instead, the sections referenced in the various notes must be consulted to see that once an unsafe pressure indication is received or the result of the indicator check is unsatisfactory, the pressure inside the spar must be measured. If the result is within established margins, the indicator must be replaced and the blade returned to service; if it is not, the spar must be pressurized and its installed components checked for leaks. It is this operation that must be performed with the blade removed.

In contrast, as noted in the last paragraph in 1.18.6.2, the Troubleshooting Chart for a pressurized spar that is shown in page 13 of Service Bulletin 61B15-6Q, and which is included as Appendix D, states that once an unsafe indication is received, or the result of the indicator test is unsatisfactory, **the blade must be removed before measuring the pressure inside the spar.** As mentioned in the preceding paragraph, the Maintenance Manual states that the blade must be removed from service.

Additionally, among the comments provided by the manufacturer of the accident helicopter, the technical report sent to the United States pursuant to the requirements of Annex 13 to the International Convention on Civil Aviation (ICAO), is one expressing its disagreement with the possibility that the blade could have been considered to have been removed from service during the helicopter's stopover at the Las Palmas Airport. As stated by the manufacturer: **It was not removed from the aircraft,** the leak was not corrected and the blade was not repaired or checked in accordance with the maintenance manual, meaning it cannot be regarded as being out of service.

Based on the argument in the last paragraph in 2.2.3, which includes statements based on which the conclusion is drawn that said Service Bulletin is not properly incorporated in the Maintenance Manual and establishes that if this is not the case, the purpose for said difference must be justified, the following Safety Recommendations are issued:

Recommendation no. 25/10. The helicopter manufacturer, Sikorsky Aircraft Corporation, should modify the helicopter Maintenance Manual (AMM), reference SA 4045-80, so that it accurately reflect the contents of Service Bulletin (SB) 61B15-6Q, or a subsequent revision, if any, so as to delete the discrepancy that exists with respect to the need to remove the blade or remove it from service before performing certain tasks specified in the Troubleshooting Chart for a pressurized main rotor blade spar.

In the event that the manufacturer considers the incorporation to be adequate as is, it should justify the reason for said difference.

Recommendation no 26/10. The helicopter certifying authority, the United States Federal Aviation Administration (FAA), should ensure that the helicopter manufacturer modify the helicopter's Maintenance Manual (AMM), reference SA 4045-80, so that it accurately reflect the contents of Service Bulletin (SB) 61B15-6Q, or a subsequent revision, if any, so as to delete the discrepancy that exists with respect to the need to remove the blade or remove it from service before performing certain tasks specified in the Troubleshooting Chart for a pressurized main rotor blade spar.

In the event that the manufacturer consider the incorporation to be adequate as it is, the FAA should ensure that such is actually the case.

APPENDICES

APPENDIX A
Excerpt from Maintenance Manual: Sikorsky Aircraft S-61N Maintenance Manual. SA 4045-80

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S-61N MAINTENANCE MANUAL, SA 4045-80

ROTARY WING BLADES - TROUBLE SHOOTING

1. General.

Rotary wing blade trouble is indicated by low-frequency vibration in the helicopter structure. Damage to a blade may change its aerodynamic profile, its weight, or its balance. These changes cause the affected blade to behave differently from others. Undamaged blades that are out-of-track will have the same effect. These blade conditions throw the rotary wing out of balance, causing a beat-per-rotor revolution (low-frequency vibration). Low-frequency vibration in the helicopter is also caused by rotary wing head troubles, or by fuselage failure (especially at main gear box mounts). Rotary-wing-blade trouble shooting is aimed at pin-pointing trouble to blades, or eliminating them as a cause. When it is determined that blades are not responsible, trouble shooting should be continued in conjunction with the rotary-wing-head trouble shooting chart. To localize trouble, check the helicopter for vibration with the primary hydraulic system turned off. Consult the pilot's flight report for indication of location and cause of vibration. The primary symptom of rotary-wing-blade malfunction is low-frequency vibration. For probable causes of and remedies for rotary-wing-blade malfunction, see figure 101.

CAUTION: NO ADJUSTMENT IS PERMITTED TO CORRECT AERODYNAMIC OR DYNAMIC (CHORD-WISE) UNBALANCE. BLADES THAT ARE OUT OF BALANCE MUST BE RETURNED TO SIKORSKY AIRCRAFT FOR REBALANCING.

2. Pressurized Spar.

CAUTION: IF A BLADE HAS HAD ANY TROUBLE WITH ITS BIM (PRESSURIZED SPAR) FEATURE, ALL TROUBLE SHOOTING PROCEDURES GIVEN HEREIN MUST BE COMPLETED BEFORE DOING ANY OTHER REPAIR.

CAUTION: WHEN A BLADE THAT HAS AN UNSAFE INDICATION ON ITS BIM PRESSURE INDICATOR HAS BEEN REPAIRED IN ACCORDANCE WITH THE INSTRUCTIONS IN THIS MANUAL, THAT BLADE MUST NOT BE REPAIRED AGAIN FOR A SECOND UNSAFE INDICATION IF THE SECOND UNSAFE INDICATION OCCURS WITHIN 30 FLIGHT HOURS OF THE FIRST. SHOULD THIS HAPPEN, FORWARD THE BLADE TO SIKORSKY AIRCRAFT.

NOTE: If helicopter is equipped with cockpit BIM system, refer to Trouble Shooting, 65-64-0, for trouble shooting procedures that apply to that system.

NOTE: If a blade is to be returned to Sikorsky Aircraft, it must have with it a statement that describes accurately the specific maintenance action or actions that have been taken and what was originally wrong with blade to require these actions. Statement should include spar pressure that existed when blade was shipped and specific reason for returning blade to Sikorsky Aircraft. If applicable, blade should be marked to identify it as having had an unsafe BIM indication.

A. If pressure indicator shows any black or red color, determine cause of unsafe indication before any further flight. Follow procedures in figure 102 to determine cause and to make correct disposition of blade.

B. To check spar pressure, refer to Checking Spar Pressure, Inspection/Check.

C. To test for a leak at air valve, pressure indicator, pressure transducer, root end plate seal, or cuff/spar bolts, refer to Test Components for Leakage, Testing Pressurized Spar for Leakage, Adjustment/Test.

D. To do a spar leakage test, refer to Spar Leakage Test, Testing Pressurized Spar for Leakage, Adjustment/Test.

E. To do a return-to-service aircraft test, refer to Return-to-Service Aircraft Test, Testing Pressurized Spar for Leakage, Adjustment/Test.

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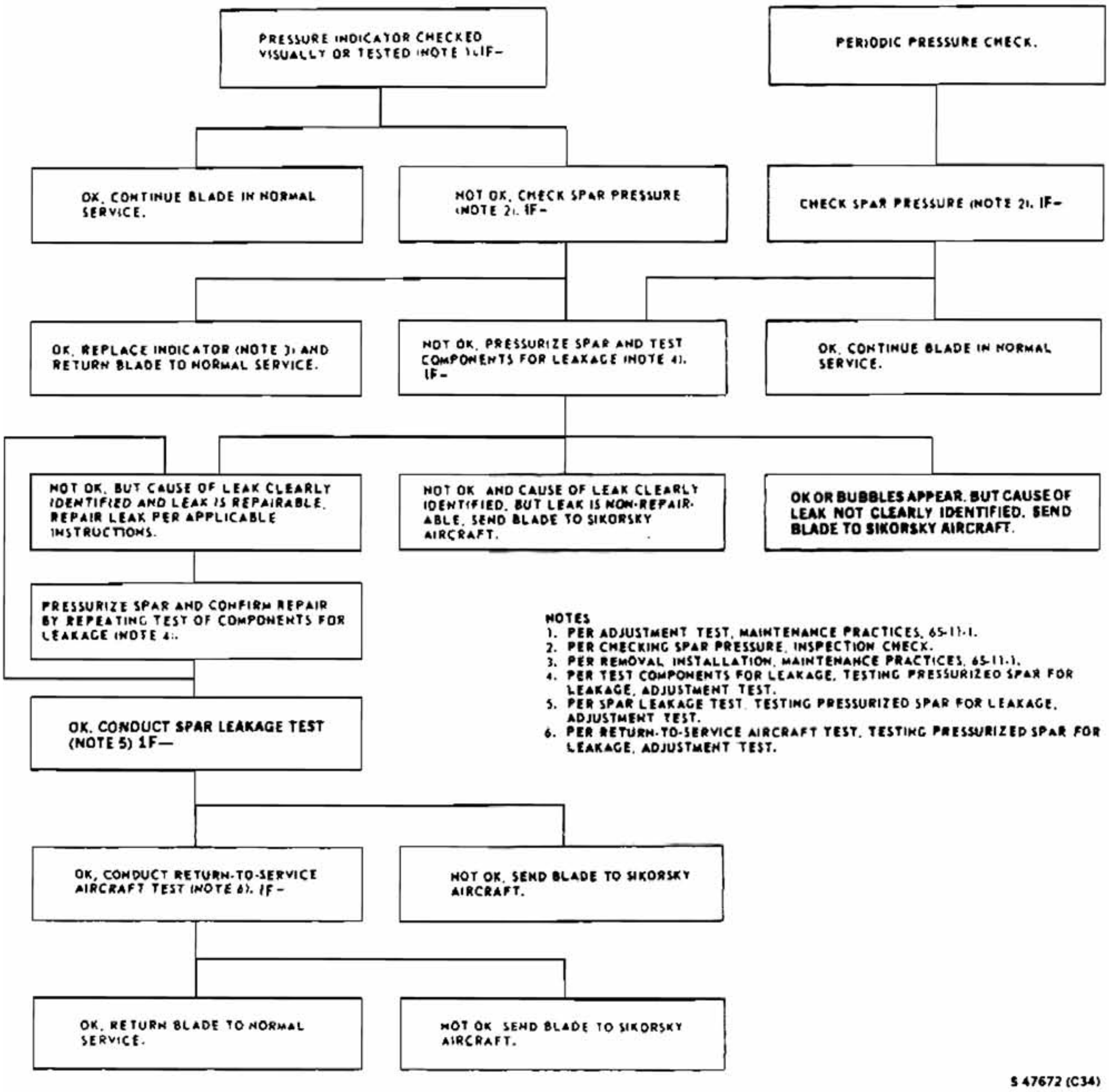
WARNING

ANY BLADE ON WHICH THE PRESSURE INDICATOR SHOWS ANY BLACK OR RED COLOR OR WHOSE PRESSURE TRANSDUCER CAUSES THE COCKPIT BIM SYSTEM WARNING LIGHT TO COME ON MUST BE REMOVED FROM SERVICE UNTIL THE CAUSE OF THE UNSAFE (BLACK OR RED) INDICATION OR WARNING LIGHT COMING ON IS POSITIVELY FOUND AND CORRECTED. IF THE INDICATOR OR TRANSDUCER IS MALFUNCTIONING IT MUST BE REPLACED, BUT ONLY IF SPAR PRESSURE IS WITHIN PERMISSIBLE LIMITS.



Pressurized Spar - Trouble Shooting Chart
Figure 102

PRESSURE INDICATOR - DESCRIPTION AND OPERATION

1. General. (See figure 1.)

The pressure indicator is installed in the back wall of the spar at the root end to show blade serviceability. It has a rigid transparent cover, through which a color indication can be observed. The indicator may contain either of two color combinations, white and black or yellow and red; regardless of color combination, the indicators function exactly alike. The indicator, which is compensated for changes in temperature, compares a reference pressure built into the indicator with the pressure in the blade spar. When pressure in spar is within required limits, the three slots in the glass bulb of the indicator show white or yellow, indicating that the blade is serviceable. If pressure in spar drops below minimum permissible service limits, the indicator shows black or red, an unsafe indication. Amount of black or red that shows depends on pressure in spar. Proper function of indicator internal mechanism is tested by fully depressing test lever (grenade handle) at base of indicator. After testing, indicator is reset automatically when test lever is released.

WARNING: ANY BLADE ON WHICH THE PRESSURE INDICATOR SHOWS ANY BLACK OR RED COLOR OR WHOSE PRESSURE TRANSDUCER CAUSES THE COCKPIT BIM SYSTEM WARNING LIGHT TO COME ON MUST BE REMOVED FROM SERVICE UNTIL THE CAUSE OF THE UNSAFE (BLACK OR RED) INDICATION OR WARNING LIGHT COMING ON IS POSITIVELY FOUND AND CORRECTED. IF THE INDICATOR OR TRANSDUCER IS MALFUNCTIONING IT MUST BE REPLACED, BUT ONLY IF SPAR PRESSURE IS WITHIN PERMISSIBLE LIMITS.

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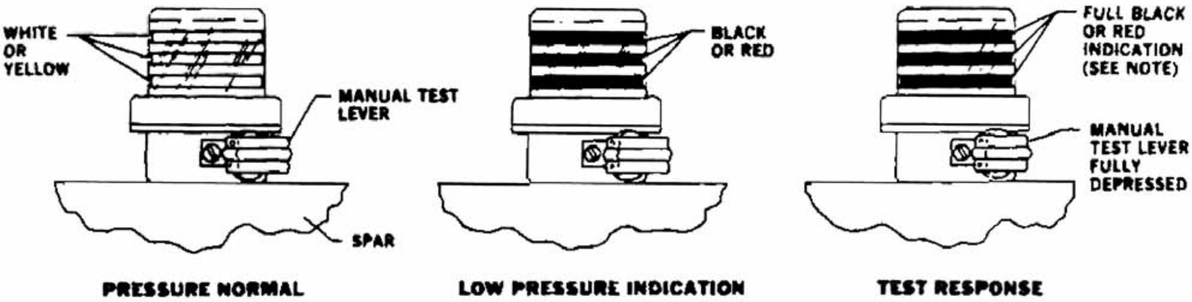
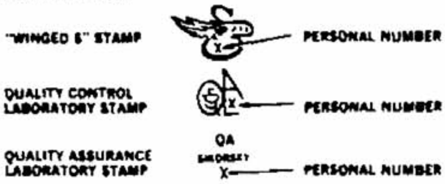


CAUTION

ONLY PRESSURE INDICATORS (S6115-20508-4, S6115-20520-1, OR S6115-20520-3) PROCURED FROM SIKORSKY AIRCRAFT AND IMPRESSION-STAMPED WITH A "WINGED S" STAMP, A QUALITY CONTROL LABORATORY STAMP, OR A QUALITY ASSURANCE LABORATORY STAMP BY SIKORSKY ON THE PRESSURE INDICATOR BASE ARE APPROVED FOR USE.



NOTE: ONLY FULL BLACK OR RED INDICATION IS ACCEPTABLE DURING TEST. INDICATOR MUST RETURN IMMEDIATELY TO NORMAL WHITE OR YELLOW INDICATION FOLLOWING TEST.

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Pressurized Spar Pressure Indicator (BIM)
Figure 1

65-11-1
Page 2

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PRESSURE INDICATOR - MAINTENANCE PRACTICES

1. Removal/Installation Pressure Indicator.

   A. Prepare for Removal.

      (1) Special Tools and Equipment.

         (a) Spanner wrench, Adjustable (AN8514-1) with Pin Arm (AN8514-4).

   B. Remove Pressure Indicator.

      (1) Release pressure in blade spar by removing cap from air valve in root end plate of spar and loosening valve core control nut 2-1/2 turns.

      (2) Remove pressure indicator and packing using adjustable spanner wrench, AN8514-1, with pin arm, AN8514-4, installed. Do not remove bushing in which indicator was installed.

      CAUTION: DO NOT USE SPANNER WRENCH ON SEALED RING NEXT TO GLASS BULB. INSTALL WRENCH ONLY ON BODY OF INDICATOR NEXT TO MANUAL LEVER.

      (3) Immediately install plug in opening in blade, to prevent air from entering blade spar, and install cap over opening in indicator.

      NOTE: Return malfunctioning indicator to Sikorsky Aircraft for repair and for use in failure mode analyses.

   C. Prepare for Installation.

      (1) Special Tools and Equipment.

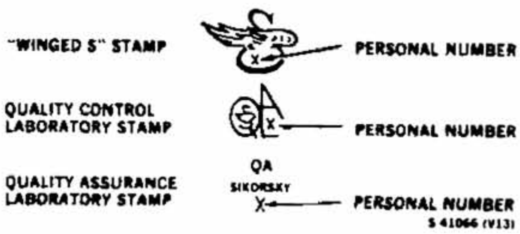
         (a) Spanner wrench, Adjustable (AN8514-1) with Pin Arm (AN8514-4).

      (2) Consumable Materials.

         (a) Leak-Tec No. 372, American Gas & Chemicals, Inc. or a mild liquid detergent.

D. Install Pressure Indicator.

CAUTION: ONLY PRESSURE INDICATORS (S6115-20508-4, S6115-20520-1, OR S6115-20520-3) PROCURED FROM SIKORSKY AIRCRAFT AND IMPRESSION-STAMPED WITH A "WINGED S" STAMP, A QUALITY CONTROL LABORATORY STAMP, OR A QUALITY ASSURANCE LABORATORY STAMP BY SIKORSKY ON THE PRESSURE INDICATOR BASE ARE APPROVED FOR USE.



(1) Remove cap from replacement pressure indicator and remove plug from opening in blade.

(2) Immediately install indicator and new packing. Torque indicator to 108 inch-pounds using adjustable spanner wrench, AN8514-1, with pin arm, AN8514-4, installed.

CAUTION: DO NOT USE SPANNER WRENCH ON SEALED RING NEXT TO GLASS BULB. INSTALL WRENCH ONLY ON BODY OF INDICATOR NEXT TO MANUAL LEVER.

(3) If pressure indicator was replaced as a result of finding low spar pressure:

(a) Check indicator valve and packing for leakage. (Refer to Testing Pressurized Spar for Leakage, Adjustment/Test, 65-11-0.)

(b) Do a spar leakage test. (Refer to Testing Pressurized Spar for Leakage, Adjustment/Test, 65-11-0).

(4) Deleted

(5) Service blade spar to normal pressure. (Refer to Servicing, 65-11-0).

(6) If, when pressure indicator was replaced, spar pressure was within acceptable limits, check indicator packing for leakage.

(a) Apply a suitable test liquid such as Leak-Tec No. 372 or a mild liquid detergent over and around base of indicator. Watch for bubbles to form.

NOTE: To prevent false indications of leakage, make certain that bubbles formed during application of liquid are allowed to settle out.

(b) When check is completed and before test liquid dries, clean area thoroughly with clean, fresh water to remove all traces of liquid, then dry blade.

(7) Test indicator for proper operation. (Refer to 2. Adjustment/Test Pressure Indicator.)

(8) Safety wire indicator to bushing and bushing to bolt in end plate. If bolt is loose or requires replacement, torque with 21 inch-pounds. Safety wire must be sealed by quality control inspector.

NOTE: On helicopters equipped with cockpit BIM system, safety wire pressure indicator to its bushing, pressure transducer to its bushing, pressure indicator bushing to pressure transducer bushing, and pressure transducer bushing to drilled-head bolt that secures bracket to end plate of spar.

(9) If pressure indicator was replaced as a result of finding low spar pressure, do a Return-to-Service Aircraft Test. (Refer to Return-to-Service Aircraft Test, Adjustment/Test, 65-11-0.)

2. Adjustment/Test Pressure Indicator.

A. General.

Test operation of pressure indicator on each rotary wing blade at flight hour intervals referenced in EQUALIZED INSPECTION AND MAINTENANCE PROGRAM, SA 4047-13. The main purpose of this test is to check indicator for proper functioning of internal mechanism. Depressing manual test lever cuts off the spar pressure and vents a portion of the indicator to the atmosphere. If the indicator is operating properly an unsafe indication will appear and, when the test lever is released, the indicator will return to normal.

NOTE: This test must be done by a person who holds a pilot certificate with appropriate rating, a mechanic certificate with airframe rating, or a certificated maintenance entity. Result of test for each indicator must be entered in helicopter maintenance record by person who made test. Entry should include name of person who made test, that person's certificate number, kind of certificate, and signature, and a description and date of test.

B. Test Procedures.

CAUTION: WHEN TESTING PRESSURE INDICATOR, VALVE PLUNGER UNDER MANUAL LEVER MUST BE PUSHED ALL THE WAY DOWN. THIS WILL SHUT OFF ALL SPAR PRESSURE. IT MAY BE NECESSARY TO USE BOTH THUMBS TO DO THIS. ALSO, PRESS ON RIDGED PART OF LEVER, NOT ON SMOOTH TIP. A PARTLY DEPRESSED PLUNGER MAY CAUSE LOSS OF SPAR PRESSURE AND A SLOW INDICATION, OR NO INDICATION AT ALL.

(1) To test pressure indicator, press in and hold manual lever (grenade-type handle). Do not place hand on glass bulb.

CAUTION: DO NOT HOLD INDICATOR AS HEAT OF HAND MAY CHANGE INTERNAL REFERENCE PRESSURE AND RESULT IN ERRONEOUS INDICATOR READING.

(2) If indicator is operating properly, a full-black or a full-red (unsafe) indication must show within 10 to 30 seconds. (See figure 1.) When lever is released, black or red indication must snap back immediately, leaving an all-white or an all-yellow (safe) condition.

NOTE: The 10- to 30-second time limit applies when temperature is -6.7°C or above. At any lower temperture, extend upper limit to the corresponding time listed below.

Temperature		Time
- 7.2°C to -17.8°C	(19°F to 0°F)	35 seconds
-18.3°C to -28.9°C	(- 1°F to -20°F)	40 seconds
-29.4°C to -40.0°C	(-21°F to -40°F)	50 seconds
-40.5°C to -51.1°C	(-41°F to -60°F)	60 seconds

(3) If indicator does not meet these requirements and spar pressure is within permissable limits, replace indicator. If spar pressure is below permissible limit, follow same trouble shooting procedures as for a black or red indication.

Page 204A Deleted

NOTE: Make a blade component record card entry, stating reason for removal, whenever a blade is removed from service.

3. Inspection/Check Pressure Indicator.

A. Inspect Pressure Indicator for Unsafe Indication.

(1) Visually inspect pressure indicator on each rotary wing blade at flight hour intervals specified under UNSCHEDULED MAINTENANCE CHECKS, 5-50-0. Comply with all supplemental information given therein, as applicable.

(2) Object of inspection is to detect any black or red (unsafe) color, no matter how little, that may show through three slots in white mask on inside of glass bulb.

(a) For accurate result, inspector's line of sight should be at 90° angle to center line of indicator.

(b) Black or red color, if any, will appear first at top of each slot.

(c) Black or red color, if any, will appear very gradually, not all at once. It may take several days for unsafe color to expand to more than a very narrow line.

(d) Any visible amount of black or red color is an unsafe indication. Go to Pressurized Spar, Trouble Shooting, 65-11-0.

WARNING: ANY BLADE ON WHICH PRESSURE INDICATOR SHOWS ANY BLACK OR RED COLOR MUST BE REMOVED FROM SERVICE UNTIL CAUSE OF UNSAFE (BLACK OR RED) INDICATION IS POSITIVELY FOUND AND CORRECTED. IF INDICATOR IS MALFUNCTIONING IT MUST BE REPLACED, BUT ONLY IF SPAR PRESSURE IS WITHIN PERMISSIBLE LIMITS.

NOTE: Following additional requirements apply to indicators on any helicopter not equipped with cockpit BIM system (65-64-0) and any helicopter whose cockpit BIM system is inopertive, however temporarily.

(3) Each visual inspection must be done by a person who holds a pilot certificate, a mechanic certificate or an inspection authorization, or a repairman certificate (within specified limitations).

(4) Inspection of each indicator must be made from transmission work platform to be sure that no visible amount of black or red color, however small, is overlooked.

(5) Result of inspection for each indicator must be recorded individually and signed off in helicopter maintenance record by person who made inspection. Entry should include that person's certificate number and a description and date of inspection.

4. Approved Repairs Pressure Indicator.

A. Parts Replacement. Parts replacement consists of replacement of lever.

NOTE: Lever is secured to indicator by a screw. Test indicator after replacing lever. (Refer to Test Procedures.)

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ROTARY WING BLADES - INSPECTION/CHECK

1. General.

A. Damage to any area of blade may cause blade to be out of balance and produce an out-of-track condition. Most types of damage represent structural weakening of blade and could lead to subsequent failure. Certain minor conditions of negligible damage may be continued in service without repair.

B. Inspect rotary wing blades for damage whenever low frequency vibration is detected, or whenever blades have been subjected to rough handling of any kind.

C. Wash blades as soon as possible after exposure to salt spray or salt air.

NOTE: It is not necessary to remove blades from helicopter to wash them.

D. Inspect each main rotor blade spar on bottom at root end for presence of a 4-inch white or yellow circle.

WARNING: A MAIN ROTOR BLADE IDENTIFIED WITH A WHITE OR YELLOW CIRCLE IS SUBJECT TO SPECIAL INSPECTION REQUIREMENTS IN ADDITION TC NORMAL REQUIREMENTS. (REFER TO UNSCHEDULED MAINTENANCE CHECKS, 5-50-0.)

2. Negligible Damage.

A. Conditions not requiring repair:

NOTE: The following descriptions of negligible blade damage not requiring repair were extracted from the S-61L/N STRUCTURAL REPAIR MANUAL, SA 4045-31E. For complete descriptions of damage limitations and related illustrations, refer to the STRUCTURAL REPAIR MANUAL. In the event of any discrepancy between manuals, the STRUCTURAL REPAIR MANUAL takes precedence.

(1) Very smooth dents in spar not exceeding 0.010 inch in depth, except for area of spar inboard of root pocket.

(2) Dents in blade pocket skin, tip cap, root pocket cap, or plate, which do not puncture material.

NOTE: Dents in pocket skin may be quite pronounced without causing skin fracture and are not considered serious unless they cause unusual distortion at trailing edge or are suspected of causing rotary wing blade vibration. If there is any doubt, blades may be tested for balance.

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(3) Deepening of gap between pockets which is caused by shrinkage of foam rubber seal.

(4) Pocket-to-spar bond separations, 3/4 inch or less chordwise and along spar backwall.

(5) Spar area under abrasion strip does not need repair when strip is dented but not punctured, or if strip sustains small punctures and spar is not damaged.

(6) Separations or openings at leading edge of stainless steel abrasion strip on spar or tip cap are permissible as long as corner radii are bonded.

(7) Flaking of excessive adhesive along edges of abrasion strips.

3. Repairable Damage.

A. Limits of damage which may be repaired are outlined in the S-61L/N STRUCTURAL REPAIR MANUAL, SA 4045-31E.

4. Inspection/Check Rotary Wing Blade.

A. Locate pocket-to-spar bonding separations that are not readily visible by tapping lightly along questionable area with a special tapping coin or by trying to insert a piece of stiff paper. Coin tapping procedure should be done by experienced personnel only.

NOTE: A tapping coin may be made from 1/8- to 3/16-inch thick copper, or similar metal, 1-1/2 to 2 inches in diameter, with smooth rounded edges to prevent damage to skin.

CAUTION: DO NOT USE U.S. CURRENCY BECAUSE OF MILLED EDGES ON COINS.

(1) Hold coin loosely between thumb and first finger. Tap lightly along bond line, or areas suspected of having bond separations.

(2) Listen for variations in tapping sounds. A sharp, solid sound indicates a good bond; a dull, dead sound indicates a bond separation.

(3) Tap across suspected area in horizontal, vertical, and diagonal lines.

(4) With grease pencil or felt pen, mark points on skin where sound varies. Continue tapping and marking until outline of bond separation is completed.

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CAUTION: DO NOT USE A METAL FEELER GAGE OR SIMILAR METAL TOOL TO INSPECT FOR BOND SEPARATION.

(5) As a second method of inspection for bond separation, try to insert a piece of stiff paper between pocket skin and spar.

NOTE: For more detailed instructions and limits of allowable blade pocket-to-spar bonding separations, refer to S-61L/N STRUCTURAL REPAIR MANUAL, SA 4045-31E.

B. Inspect pressure indicator for black or red indication. (See 65-11-1, figure 1.) If black or red color is visible, comply with 65-11-0, figure 102.

WARNING: COMPLIANCE WITH FIGURE 102 IS MANDATORY.

C. Test pressure indicator for proper operation. (Refer to Adjustment/ Test, 65-11-1.)

5. Checking Spar Pressure (Using Checking Unit, S1670-15002-2).

A. Prepare for Checking Spar Pressure.

(1) Special Tools and Equipment.

(a) Checking Unit, S1670-15002-2

NOTE: To test the absolute pressure gage that is a part of the checking unit, refer to Adjustment/Test.

(b) Pyrometer, 17-66-00086, Alnor Instrument Co., 7301 N. Caldwell Ave., Niles, Ill. 60648, or equivalent.

NOTE: If Pyrometer is not available, use accurate free-air thermometer capable of being read to one degree.

(2) Consumable Materials.

(a) Leak-Tec No. 372, American Gas & Chemicals, Inc. or a mild liquid detergent.

B. Check Spar Pressure. Check pressure in blade spar at intervals given in EQUALIZED INSPECTION AND MAINTENANCE PROGRAM, SA 4047-13. Also check spar pressure whenever a new, overhauled, or stored blade is being placed in service. This last requirement is not mandatory if spar pressure of blade being placed in service has been checked within last six months and pressure indicator shows no black or red color.

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However, this practice is recommended to obtain maximum service from blade. Check spar pressure as follows:

NOTE: Before checking spar pressure, all portions of blade should be equally exposed to same general sunlight or shade, as the case may be.

NOTE: If spar pressure is below that given in "Servicing Blade (Minimum)" column of table 301, but above "Checking Blade (Minimum)" pressure, increase spar pressure so it is between "Servicing Blade (Minimum)" and "Servicing Blade (Maximum)" pressures. Any blade with spar pressure found to be below "Checking Blade (Minimum)" limit during normal checking shall be treated as through the pressure indicator had shown a full black or red (unsafe) condition.

CAUTION: DO NOT ATTEMPT TO PRESSURIZE BLADE SPAR IF PRESSURE IS FOUND TO BE BELOW "CHECKING BLADE (MINIMUM)" LIMIT OF TABLE 301.

NOTE: Pressure gage used in checking unit, S1670-15002-2, is an absolute pressure type. This means that gage, when not connected to blade, measures and indicates barometric pressure of the day in inches of mercury, but, when connected to blade, indicates in psi any pressure applied to it above that barometric pressure, up to a maximum of 20 psi(g). Pointer position may vary from day to day because of changes in barometric pressure. Pointer variance is a normal occurrence and should have no influence on use of checking unit. No attempt should be made to zero pointer. The only requirement in checking spar pressure is to make sure that pointer on gage indicates correct blade pressure for existing blade spar temperature as shown in table 301.

(1) Remove cap from air valve in root end plate of blade. Connect coupling of checking unit, S1670-15002-2, to air valve. Check for tight connection. Loosen valve core control nut (outer hex nut) 2-1/2 turns and note gage reading.

NOTE: Before measuring spar pressure, be sure that calibration expiration date on checking unit has not expired.

NOTE: Checking unit should be tested at regular intervals for leakage at each joint in its plumbing.

NOTE: To make sure no pressure is lost from spar, connect coupling of checking unit to air valve before loosening valve core control nut.

(2) Using a Pyrometer, measure and record three temperature readings of upper surface of blade spar. Disregard first reading and use average of second and third readings. If a Pyrometer is not available, strap (tape) an accurate free-air thermometer to upper surface of blade spar. Record free-air temperature to nearest degree after thermometer stabilizes.

(3) Record temperature and pressure in applicable checking document.

(4) If spar pressure is within acceptable limits for temperature recorded in step (2), as shown in table 301, blade can be continued in service.

WARNING: IF SPAR PRESSURE IS BELOW ACCEPTABLE LIMITS, CAUSE OF PRESSURE LOSS MUST BE DETERMINED AND CORRECTED BEFORE RELEASING BLADE FOR FLIGHT. FOLLOW SAME TROUBLE SHOOTING PROCEDURES AS FOR A BLACK OR A RED INDICATION.

NOTE: Make a blade component record card entry, stating reason for removal, whenever a blade is removed from service.

(5) Tighten valve core control nut on air valve with 105 inch-pounds torque. Disconnect checking unit from air valve. Install valve cap and tighten fingertight plug one-quarter turn. Safety wire valve core control nut to air valve body. Safety wire must be sealed by quality control inspector.

NOTE: Make sure air valve body is safety wired to bolt on end plate.

(6) Check air valve for leakage, especially in stem area.

(a) Apply a suitable test liquid such as Leak-Tec No. 372 or a mild liquid detergent. Watch for bubles to form.

NOTE: To prevent false indications of leakage, make certain that bubbles formed during application of liquid are allowed to settle out.

(b) When check is completed and before test liquid dries, clean area thoroughly with clean, fresh water to remove all traces of liquid, then dry blade.

(7) Test pressure indicator for proper operation. (Refer to Maintenance Practices, 65-11-1.)

5A. Checking Spar Pressure (Using Checking and Filling Unit, S1670-15000-25).

A. Prepare for Checking Spar Pressure.

(1) Special Tools and Equipment.

(a) Checking and Filling Unit, S1670-15000-25

NOTE: To test the absolute pressure gage that is a part of the checking and filling unit, refer to Adjustment/Test.

(b) Pyrometer, 17-66-00086, Alnor Instrument Co., 7301 N. Caldwell Ave., Niles, Ill. 60648, or equivalent

NOTE: If Pyrometer is not available, use accurate free-air thermometer capable of being read to one degree.

(2) Consumable Materials.

(a) Nitrogen, Technical, Federal Specification BB-N-411, Type I, Class 1, Grade A or B.

(b) Leak-Tec No. 372, American Gas & Chemicals, Inc. or a mild liquid detergent

B. Check Spar Pressure. Check pressure in blade spar at intervals given in EQUALIZED INSPECTION AND MAINTENANCE PROGRAM, SA 4047-13. Also check spar pressure whenever a new, overhauled, or stored blade is being placed in service. This last requirement is not mandatory if spar pressure of blade being placed in service has been checked within last six months and pressure indicator shows no black or red color. However, this practice is recommended to obtain maximum service from blade. Check spar pressure as follows:

CAUTION: WHEN USING CHECKING AND FILLING UNIT, S1670-15000-25, TO CHECK SPAR PRESSURE, IT IS MANDATORY THAT 20-FOOT HOSE LINE BE PURGED OF AIR BEFORE OPENING VALVE CORE CONTROL NUT ON BLADE AIR VALVE.

NOTE: Before checking spar pressure, all portions of blade should be equally exposed to same general sunlight or shade, as the case may be.

NOTE: If spar pressure is below that given in "Servicing Blade (Minimum)" column of table 301, but above "Checking Blade (Minimum)" pressure, increase spar pressure so it is between "Servicing Blade (Minimum)" and "Servicing Blade (Maximum)" pressures. Any blade with spar pressure found to be below "Checking Blade (Minimum)" limit during normal checking shall be treated as through the pressure indicator had shown a full black or red (unsafe) condition.

CAUTION: DO NOT ATTEMPT TO PRESSURIZE BLADE SPAR IF PRESSURE IS FOUND TO BE BELOW "CHECKING BLADE (MINIMUM)" LIMIT OF TABLE 301.

NOTE: Pressure gage used in checking and filling unit, S1670-15000-25, is an absolute pressure type. This means that gage, when not connected to blade, measures and indicates barometric pressure of the day in inches of mercury, but, when connected to blade, indicates in psi any pressure applied to it above that barometric pressure, up to a maximum of 20 psi(g). Pointer position may vary from day to day because of changes in barometric pressure. Pointer variance is a normal occurrence and should have no influence on use of checking and filling unit. No attempt should be made to zero pointer. The only requirement in checking spar pressure is to make sure that pointer on gage indicates correct blade pressure for existing blade spar temperature as shown in table 301.

(1) Open cover of checking and filling unit. Remove adjustment handle (5, figure 301) from cylinder regulator (6). Remove regulator from bracket (1). Reinstall handle on regulator.

(2) Connect cylinder regulator (6) of checking and filling unit to source of technical nitrogen, Federal Specification BB-N-411, Type I, Class 1, Grade A or B, at fitting (4) on regulator. If necessary, use one of the adapters supplied with checking and filling unit to attach regulator to nitrogen container.

(3) Make certain station regulator (10), cylinder regulator (6), and station valve, adjacent to station regulator, are closed. Turn station regulator shut-off knob (8) and cylinder regulator adjustment handle (5) counterclockwise to close. Turn station valve shut-off knob (12) clockwise to close.

(4) Open valve on nitrogen bottle. Gage will now show supply pressure.

(5) Turn on flow on nitrogen at cylinder regulator (6) and adjust pressure to between 30 and 40 psi, using adjustment handle on cylinder regulator.

(6) Remove cap from air valve in root end of blade. Just before connecting checking and filling unit coupling (9) to air valve, open station valve shut-off knob (12) and station regulator shut-off knob (8) for a few seconds to purge air from lines. Close valves and connect coupling to air valve. Check for tight connection. Loosen valve core control nut (outer hex nut) 2-1/2 turns and note gage reading.

NOTE: The absolute pressure type gage should now indicate existing spar pressure.

NOTE: Before measuring spar pressure, be sure that calibration expiration date on checking and filling unit has not expired.

NOTE: Checking and filling unit should be tested at regular intervals for leakage at each joint in its plumbing.

NOTE: To make sure no pressure is lost from spar, connect coupling of checking and filling unit to air valve before loosening valve core control unit.

(7) Using a Pyrometer, measure and record three temperature readings of upper surface of blade spar. Disregard first reading and use average of second and third readings. If a Pyrometer is not available, strap (tape) an accurate free-air thermometer to upper surface of blade spar. Record free-air temperature to nearest degree after thermometer stabilizes.

(8) Record temperature and pressure in applicable checking document.

(9) If spar pressure is within acceptable limits for temperature recorded in step (8), as shown in table 301, blade can be continued in service.

WARNING: IF SPAR PRESSURE IS BELOW ACCEPTABLE LIMITS, CAUSE OF PRESSURE LOSS MUST BE DETERMINED AND CORRECTED BEFORE RELEASING BLADE FOR FLIGHT. FOLLOW SAME TROUBLE SHOOTING PROCEDURE AS FOR A BLACK OR A RED INDICATION.

NOTE: Make a blade component record card entry, stating reason for removal, whenever a blade is removed from service.

NOTE: Omit steps (10) and (11) if it is not necessary to increase spar pressure.

(10) To increase spar pressure, open station valve by turning station valve shut-off knob (12, figure 301) counterclockwise. Using station regulator shut-off knob (8), gradually increase pressure until gage (2) reaches required pressure that was found in table 301 for measured temperature. Allow spar to fill to this pressure.

(11) Pressure in spar should be checked periodically by turning station valve shut-off knob (12) fully clockwise and noting reading on gage (2) at station regulator (10). When pressure in blade spar has reached specified limit, shut off nitrogen supply at station valve by turning station valve shut-off knob (12) fully clockwise. Check gage at station regulator for a reading within limits specified in table 301 for measured blade spar temperature.

(12) Tighten valve core control nut on air valve with 105 inch-pounds torque. Disconnect checking and filling unit from air valve. Install valve cap and tighten fingertight plus one-quarter turn. Safety wire valve core control nut to air valve body. Safety wire must be sealed by quality control inspector.

NOTE: Make sure air valve body is safety wired to bolt on end plate.

(13) Check air valve for leakage, especially in stem area.

(a) Apply a suitable test liquid such as Leak-Tec No. 372 or a mild liquid detergent. Watch for bubbles to form.

NOTE: To prevent false indications of leakage, make certain that bubbles formed during application of liquid are allowed to settle out.

(b) When check is completed and before test liquid dries, clean area thoroughly with clean, fresh water to remove all traces of liquid, then dry blade.

(14) Shut off nitrogen supply to cylinder regulator (6, figure 301). Open station valve shut-off knob (12) to release pressure in lines. Shut off station regulator (10) and disconnect nitrogen supply from checking and filling unit.

(15) Test pressure indicator for proper operation. (Refer to Maintenance Practices, 65-11-1.)

6. Overspeed Inspection Requirements.

A. Rotary wing head overspeeds between 237 and 263 rpm (117 and 130 percent Nr) require inspection of rotary wing blades.

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CAUTION: IF ROTARY WING OVERSPEEDS MORE THAN 263 RPM (130% Nr), BLADES MUST BE CONDEMNED FOR FLIGHT.

NOTE: For more detailed instructions and limits of allowable blade damage, refer to the S-61L/N STRUCTURAL REPAIR MANUAL, SA 4045-31E.

(1) Inspect rotary wing blades for dents, cracks, and buckled pocket skin.

(2) Inspect bonded joints for separation beyond specified limits.

(3) On standard-spar blades inspect tip block rivets for security and distortion.

NOTE: Any blade with loose or distorted tip block rivets must be returned to contractor for further examination of blade and replacement of rivets. Record reason for removal and inspection discrepancies on historical records.

7. Sudden Stoppage Inspection Requirements.

A. For a definition of sudden stoppage applicable to rotary wing blades and for inspection requirements that must be complied with after sudden stoppage, refer to Inspection/ Check, 65-12-0.

8. Lightning Strike.

A. The rotary wing blades are the most likely area for a lightning strike to enter the helicopter. This is due to the relatively low radii-of-curvature aerodynamically necessary for the leading edge, trailing edge, and tip cap and because portions of the blade surface form both the upper and outer extremities of the helicopter.

B. A single lightning strike can consist of many individual current strokes that occur in rapid succession. Series of these strokes often become attached to different blades as they rotate through the single ionized lightning channel. In fact, it is quite unlikely that only one blade will sustain damage in a strike through the rotor disk. Further, since the blade sweeps through the lightning channel and since the channel is relatively stationary, strokes can occur anywhere on the blade surface.

C. The rotary wing blade is constructed on an aluminum spar that is bolted to the rotary wing head by means of a steel cuff. The cuff and spar are joined by steel bolts that are press-fitted into the spar. The spar has a D-shaped cross-section and forms the leading edge of the blade's airfoil shape (about 40% chordwise). The trailing edge of the airfoil is formed by aluminum pocket assemblies that are bonded to the spar. The outboard end of the blade supports an aluminum tip cap secured with screws to the spar and final pocket assembly.

D. The tip cap, spar, cuff, and attachment bolts are, therefore, electrically continuous and would pass a lightning current without severe arcing. The individual pocket assemblies, however, while being conductive within themselves, are electrically isolated from the other conductive elements of the blade by structural bonding layers. Lightning would arc across or through these layers to impact the spar in a direct strike to a pocket assembly.

E. The initial lightning attachment, though, can occur anywhere on the upper or lower surface of the blade. When the strike is a direct hit to the spar, it produces a crater partially filled with resolidified aluminum. The size of the crater depends on the severity of the strike; a typical size would be in the vicinity of 0.060-inch diameter by 0.060 inch deep. Tests have shown that the spar is damaged further than the visible crater reveals, due to an underlying region of softened material beneath the impact zone.

F. If a strike does not hit the spar directly, it will travel through either the tip cap, or pocket assembly and adhesive layers, to eventually enter the spar. The currents will cause a small burn hole at the points of surface entry. The strike is then expected to travel through the spar and attachment bolts into the cuff and to exit the blade through the attachment bolts to the rotary wing head.

G. A lightning strike during flight may weaken the bonds that hold some of the individual pocket assemblies to the blade structure, or it may deform pockets themselves. Catastrophic structural failure of the spar, however, is extremely unlikely. Severe lightning damage to blades may be indicated by an abnormal noise and/or vibration changes.

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H. The following inspection should be made after a rotary wing blade lightning strike:

(1) Perform a detailed visual inspection of complete upper and lower surfaces of each blade, paying particular attention to corners, spar-to-pocket joints, and other areas of sharp radius-of-curvature, for holes and burn marks, no matter how small.

I. Return blade for overhaul if <u>any</u> evidence of a strike is found on it. Discard attachment bolts that show arc burns.

J. If any evidence of a strike is found on blade(s) and blade(s) are removed and returned for overhaul, then remove Main Rotor Head and route Head to work shop.

<u>NOTE</u>: To make it easier for the work shop to locate the actual sleeve/spindle when blades are removed, identify, by markings, the rotary wing head sleeve/ spindle(s) which have been connected to the struck rotary wing blade(s).

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TABLE 301

BLADE TEMPERATURE/PRESSURE CHART

BLADE SPAR TEMPERATURE (Notes 1, 4)		PERMISSIBLE BLADE PRESSURE (PSI) (Notes 2, 3)		
C	F	Checking Blade (Minimum)	Servicing Blade (Minimum)	Servicing Blade (Maximum)
70 to 72	158 to 162	12.50	14.25	14.50
67 to 69	153 to 157	12.25	14.00	14.25
64 to 66	148 to 152	12.00	13.75	14.00
61 to 63	143 to 147	11.75	13.50	13.75
59 to 60	138 to 142	11.50	13.25	13.50
56 to 58	133 to 137	11.25	13.00	13.25
53 to 55	128 to 132	11.00	12.75	13.00
50 to 52	123 to 127	10.75	12.50	12.75
48 to 49	118 to 122	10.50	12.25	12.50
42 to 47	108 to 117	10.25	12.00	12.25
39 to 41	103 to 107	10.00	11.75	12.00
36 to 38	98 to 102	9.75	11.50	11.75
34 to 35	93 to 97	9.50	11.25	11.50
31 to 33	88 to 92	9.25	11.00	11.25
28 to 30	83 to 87	9.00	10.75	11.00
25 to 27	78 to 82	8.75	10.50	10.75
23 to 24	73 to 77	8.50	10.25	10.50
20 to 22	68 to 72	8.50	10.00	10.25
17 to 19	63 to 67	8.25	9.75	10.00
14 to 16	58 to 62	8.00	9.50	9.75
12 to 13	53 to 57	7.75	9.25	9.50
9 to 11	48 to 52	7.50	9.00	9.25
6 to 8	43 to 47	7.25	8.75	9.00
3 to 5	38 to 42	7.00	8.50	8.75
1 to 2	33 to 37	6.75	8.25	8.50
-5 to 0	23 to 32	6.50	8.00	8.25
-7 to -6	18 to 22	6.25	7.75	8.00
-10 to -8	13 to 17	6.00	7.50	7.75
-13 to -11	8 to 12	5.75	7.25	7.50
-15 to -14	3 to 7	5.50	7.00	7.25
-18 to -16	-2 to 2	5.25	6.75	7.00
-21 to -19	-7 to -3	5.00	6.50	6.75
-24 to -22	-12 to -8	4.75	6.25	6.50
-27 to -25	-17 to -13	4.50	6.00	6.25
-30 to -28	-22 to -18	4.50	5.75	6.00
-32 to -31	-27 to -23	4.25	5.50	5.75
-35 to -33	-32 to -28	4.00	5.25	5.50
-38 to -36	-37 to -33	3.75	5.00	5.25
-41 to -39	-42 to -38	3.50	4.75	5.00
-46 to -42	-52 to -43	3.25	4.50	4.75

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TABLE 301

BLADE TEMPERATURE/PRESSURE CHART (Cont)

BLADE SPAR TEMPERATURE (Notes 1, 4)		PERMISSIBLE BLADE PRESSURE (PSI) (Notes 2, 3)		
C	F	Checking Blade (Minimum)	Servicing Blade (Minimum)	Servicing Blade (Maximum)
-49 to -47	-57 to -53	3.00	4.25	4.50
-52 to -50	-62 to -58	2.75	4.00	4.25
-55 to -53	-67 to -63	2.50	3.75	4.00

NOTES

1. This table is for measured blade spar temperature with nitrogen in blade spar at a stabilized temperature. If blade is moved to an area of different temperature before servicing or checking spar pressure, allow enough time for temperature of nitrogen in spar to stabilize. For example, if temperature change is from -17.8 to 21.1°C (0 to 70°F), allow five hours for temperature of nitrogen in blade to stabililze. When servicing blade, also allow an equivalent period of time for temperature of equipment and nitrogen tank to stabilize.

2. Servicing pressures listed provide an allowance for normal nonsignificant leakage that can occur between servicing intervals, before blade pressure indicator will start to show red/black.

3. Pressure gage used in checking unit or checking and filling unit is an absolute pressure type. This means that gage, when not connected to blade, measures and indicates barometric pressure of the day in inches of mercury, but, when connected to blade, indicates in psi any pressure applied to it above that barometric pressure, up to a maximum of 20 psi(g). Pointer position may vary from day to day because of changes in barometric pressure. Pointer variance is a normal occurrence and should have no influence on use of checking unit or checking and filling unit. No attempt should be made to zero pointer.

4. Round off measured blade temperature reading to nearest degree.

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ROTARY WING BLADES - ADJUSTMENT/TEST

1 Tracking Blades.

A. General. Rotary wing blades must be adjusted so that all blades rotate in the same plane or track.

B. Theory. Rotary wing blades are manufactured and balanced within extremely close controls and tolerances. However, due to slight variations between the blades, the effective blade angle may be slightly different from blade to blade and, under the same conditions, the blades will fly at a slightly different height. During manufacture or overhaul this difference is compared to a master blade and pretrack numbers are assigned. The pretrack number of each blade is the angular adjustment, expressed in minutes, required to bring the blade into standard track with the master blade. On pretrack rigged rotary wing heads, tracking is accomplished by adjusting the pitch control rods to the pretrack numbers of the blades. (For additional information on tracking concept, refer to Adjustment/Test, 65-12-0.)

C. Track Blades. There are two types of adjustable pitch control rods and they are adjusted differently from each other. For blade tracking procedure, refer to applicable Adjust Pitch Control Rod to Pretrack Number of Blade, Adjustment/Test, Double Lock Nut-Type or Single Lock Nut-Type, 65-12-4. Under certain circumstances, when it has been decided not to use the pretrack feature of the blades, the blades may be tracked using the flag or electronic tracker. Refer to Adjustment/Test, 65-12-0.

2. Testing Pressurized Spar for Leakage.

A. General. These tests normally are a part of the trouble shooting procedure that must be followed if spar pressure is found to be below the permissible limit. (Refer to Trouble Shooting.)

B. Pressurizing Blade Spar for Leakage Test. The instructions in this paragraph apply only when testing components for leakage (paragraph D.) or when performing a spar leakage test (paragraph E.).

CAUTION: DO NOT ALLOW PRESSURE IN SPAR TO EXCEED 25 PSIG.

(1) Pressurize blade spar to 18 psig with technical nitrogen, Federal Specification BB-N-411, Type I, Class 1, Grade A or B, using procedure given in B. Service Blades, SERVICING, steps (1) through (10), but do not safety wire valve core control nut.

C. Prepare for Testing.

(1) Consumable Materials.

(a) Leak-Tek No. 372, Americal Gas & Chemical Co., Ltd. or a mild liquid detergent.

D. Test Components for Leakage. This paragraph contains instructions for testing for leakage at the pressure indicator valve and packing, pressure transducer packing, air valve, root end plate seal, and cuff/spar bolts.

(1) Pressurize blade spar for a leakage test. (Refer to paragraph B.)

(2) Make sure valve core control nut on air valve is tightened with required torque. (Refer to Servicing.)

(3) Support blade on sawhorses, or equivalent, with top side of blade up. Place one sawhorse at tip end of spar. Place second sawhorse at a flat area of cuff.

<u>CAUTION</u>: PLACE PROTECTIVE PADDING BETWEEN BLADE AND EACH SAWHORSE TO PREVENT POSSIBLE DAMAGE TO BLADE.

<u>CAUTION</u>: DO NOT SUPPORT BLADE AT TIP CAP OR AT POCKET AREA AFT OF BLADE SPAR AS DAMAGE TO CAP OR POCKET WILL RESULT.

(4) Position a 300-pound weight, with a protective pad underneath, on spar at pocket number 17 of a standard-spar blade or at pocket number 19 of an extended-spar blade in accordance with paragraph E, step (5).

<u>CAUTION</u>: PLACE PROTECTIVE PADDING UNDER WEIGHT TO PREVENT POSSIBLE DAMAGE TO BLADE.

<u>NOTE</u>: Weight must be distributed on spar over as small an area as practical.

<u>NOTE</u>: Count pockets by starting at outboard end of blade. Tip pocket is number 1. (See figure 1.)

(5) Spread a suitable test liquid, such as Leak-Tek No.372 or a mild liquid detergent, over and around base of pressure indicator and around manual test lever valve under grenade handle, over and around base of transducer or transducer port plug, over and around entire air valve, around entire edge of root end plate, and around each bolt head or nut that secures cuff to

spar. Watch carefully at all of these spots for bubbles to form.

NOTE: To prevent false indications of leakage, make certain that bubbles formed during application of liquid are allowed to settle out.

CAUTION: A SIGNIFICANT LEAK SHOULD BE READILY DETERMINED BY THIS TEST. HOWEVER, A SLOW LEAK MAY BE MORE DIFFICULT TO FIND. SHOULD THERE BE ANY DOUBT THAT THE SOURCE OF A LEAK HAS BEEN FOUND, THE BLADE SHOULD BE FORWARDED TO SIKORSKY AIRCRAFT FOR FURTHER TESTS.

(6) When this part of the test is completed and before test liquid dries, clean area thoroughly with clean, fresh water to remove all traces of liquid, then dry blade.

(7) Remove weight from spar and turn blade so bottom side is up. Reposition weight on spar as in steps (3) and (4).

(8) Repeat procedures in steps (5) and (6).

E. Spar Leakage Test.

(1) Remove pressure indicator and packing. (Refer to Maintenance Practices, 65-11-1.) Plug opening in spar with plug, MS9015-05, and packing, MS28778-5.

(2) Pressurize blade spar for a leakage test. (Refer to paragraph B.)

(3) Make sure valve core control nut on air valve is tightened with required torque and safety wired correctly. (Refer to Servicing.)

(4) Support blade on sawhorses, or equivalent, with top side of blade up. Place one sawhorse at tip end of spar. Place second sawhorse at a flat area of cuff.

CAUTION: PLACE PROTECTIVE PADDING BETWEEN BLADE AND EACH SAWHORSE TO PREVENT POSSIBLE DAMAGE TO BLADE.

CAUTION: DO NOT SUPPORT BLADE AT TIP CAP OR AT POCKET AREA AFT OF BLADE SPAR AS DAMAGE TO CAP OR POCKET WILL RESULT.

(5) Position a 300-pound weight, with a protective pad underneath, on spar at pocket number 17 of a standard-spar blade or at pocket number 19 of an extended-spar blade.

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CAUTION: PLACE PROTECTIVE PADDING UNDER WEIGHT TO PREVENT POSSIBLE DAMAGE TO BLADE.

NOTE: The weight must be distributed on spar over as small an area as possible.

NOTE: Count pockets by starting at outboard end of blade. Tip pocket is number 1. (See figure 1.)

(6) Check and record spar pressure and temperature reading.

(7) Let blade stand for five days with weight on spar. Check and record spar pressure and temperature reading daily, if desired, or at least at end of fifth day. (Refer to Checking Spar Pressure, Inspection/Check.) Correct for temperature variations as follows:

(a) If temperature increases, subtract 0.07 psi for every degree Fahrenheit (or subtract 0.126 psi for every degree Centrigrade) of increase.

(b) If temperature decreases, add 0.07 psi for every degree Fahrenheit (or add 0.126 psi for every degree Centrigrade) of decrease.

Example:

	Pressure (psi)	Temperature °F	°C
Initial reading:	18.0	73.0	22.8
Reading after 24 hours:	17.0	62.0	17.2

Temperature change is 10.0°F (5.6°C) decrease.

10.0 x 0.07 = 0.70 psi (for °F)) correction to
) be added to
reading
5.6 x 0.126 = 0.70 psi (for °C))

Therefore, the actual corrected pressure in the spar is 17.0 + 0.70 = 17.7 psi

(8) If, after five days, corrected spar pressure does not drop below 17.0 psi, turn blade bottom side up and repeat procedures in steps (4) through (7).

(9) If, after these additional five days, corrected spar pressure does not drop below 17.0 psi, blade is

considered to have passed this test. Release pressure in blade spar by removing cap from air valve and loosening valve core control nut 2-1/2 turns. Remove plug and install pressure indicator. (Refer to Maintenance Practices, 65-11-1.) Service blade spar to normal pressure. (Refer to Servicing.)

NOTE: If at any time within 10-day test period, corrected spar pressure drops below 17.0 psi, blade is considered to have failed this test and should be forwarded to Sikorsky Aircraft.

F. Return-to-Service Aircraft Test. The return-to-service aircraft test provides a final check on the integrity of a rotary wing blade spar that has had a loss of spar pressure. This test is made after all other corrective actions have been taken.

NOTE: This return-to-service aircraft test is not required on any blade that, for the first hour of flight after being installed, will positively be on a helicopter that has an operational Cockpit BIM System

(1) Check pressure indicator for unsafe indication. If any black or red shows in indicator, stop test and forward blade to Sikorsky Aircraft.

(2) Check spar pressure to see that it is within limits shown in table 301. (Refer to Checking Spar Pressure, Inspection/Check.) If pressure is within limits, record pressure to nearest 0.1 psi, record temperature within 1°F, and proceed with test. If pressure is not within limits, stop test and forward blade to Sikorsky Aircraft.

(3) Install blade on an operational helicopter. Ground run helicopter with test blade installed for a total of one hour at normal rpm (100% N_r), low collective, neutral cyclic, and neutral directional control.

(a) Divide this one-hour test time into increments of one-half hour runs.

(b) After each increment check pressure indicator. If any black or red shows in indicator, stop test and forward blade to Sikorsky Aircraft.

(c) If pressure indicator reading is satisfactory at end of first half-hour, proceed with next increment of this test.

(d) After second increment (total running time of one hour), measure spar pressure using procedure given under Checking Spar Pressure, Inspection/Check. Correct for temperature variations using procedure in paragraph E., step (7). If corrected spar pressure is less than original pressure measured in step (2) by 0.25 psi or more, forward blade to Sikorsky Aircraft.

(4) After a total of one hour of test time has been accumulated with satisfactory pressure indicator and spar pressure readings throughout, blade may be returned to normal service.

3. Testing Absolute Pressure Gage, S1670-15004-1.

The absolute pressure gage, S1670-15004-1, is used on the Checking and Filling Unit, S1670-15000-25, and on the Checking Unit, S1670-15002-2. This procedure tests only the gage. To test the checking and filling unit, refer to Testing Checking and Filling Unit, S1670-15000-25.

NOTE: It is recommended that the gage be tested every 6 months.

SIKORSKY AIRCRAFT
S-61N MAINTENANCE MANUAL, SA 4045-80

A. Prepare to Test Absolute Pressure Gage, S1670-15004-1.

(1) Special Tools and Equipment.

(a) Precision Aneroid Manometer, 0-100" Hg ABS, ± 1/10 of 1% full-scale accuracy

(b) Nitrogen Regulator, 0-20 psig range

(c) Shutoff Valve (2 each)

(d) Hoses/Tubes and Fittings per figure 501

(2) Consumable Materials.

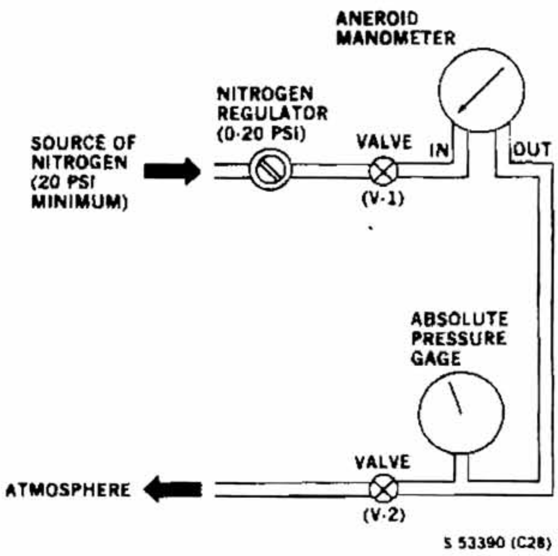
(a) Nitrogen, Technical, Federal Specification BB-N-411, Type I, Class 1, Grade A or B.

B. Test Absolute Pressure Gage, S1670-15004-1.

NOTE: Conduct test at ambient temperature of 70° to 90°F (21° to 32°C).

(1) Assemble test equipment as shown in figure 501.

(2) Set regulator to 20 psig.



Absolute Pressure Gage, S6170-15004-1 - Test Setup
Figure 501

(3) Close valves V-1 and V-2.

(4) Open valve at source of nitrogen.

(5) Open valve V-1 slowly until gage shows GAGE PRESSURE listed in table 501 for TEST NO. 1. Close valve V-1.

NOTE: Bring gage pressure up to required valve slowly. If gage goes over required value, decrease pressure with valve V-2 at least 2 psi below required value or to 0 psi. Close valve V-2. Then bring pressure up to required value again.

(6) Check that reading on manometer is within limits of MANOMETER READING listed in table 501 for TEST NO. 1.

NOTE: When reading manometer, be sure to line up pointer with its mirror image to reduce error due to parallax.

(7) Repeat steps (5) and (6) for each of the remaining tests in table 501.

TABLE 501

ABSOLUTE PRESSURE GAGE VS ANEROID MANOMETER READINGS

TEST NO.	GAGE PRESSURE (PSI)	MANOMETER READING (INCHES Hg ABS)	
		MINIMUM	MAXIMUM
1	1	31.6	32.2
2	5	39.8	40.4
3	10	50.0	50.6
4	15	60.2	60.7
5	19	68.3	68.9

4. Testing Checking and Filling Unit, S1670-15000-25.

This procedure tests the operation of the checking and filling unit, S1670-15000-25, including the absolute pressure gage, S1670-15004-1, which is a part of the checking and filling unit. To test only a gage, refer to Testing Absolute Pressure Gage, S1670-15004-1.

NOTE: It is recommended that the checking and filling unit be tested every 6 months.

SIKORSKY AIRCRAFT
S-61N MAINTENANCE MANUAL, SA 4045-80

A. Prepare to Test Checking and Filling Unit, S1670-15000-25.

(1) Special Tools and Equipment.

(a) Precision Aneroid Manometer, 0-100" Hg ABS, ± 1/10 of 1% full-scale accuracy.

(b) Shutoff Valve

(c) Hoses/Tubes and Fittings per figure 502.

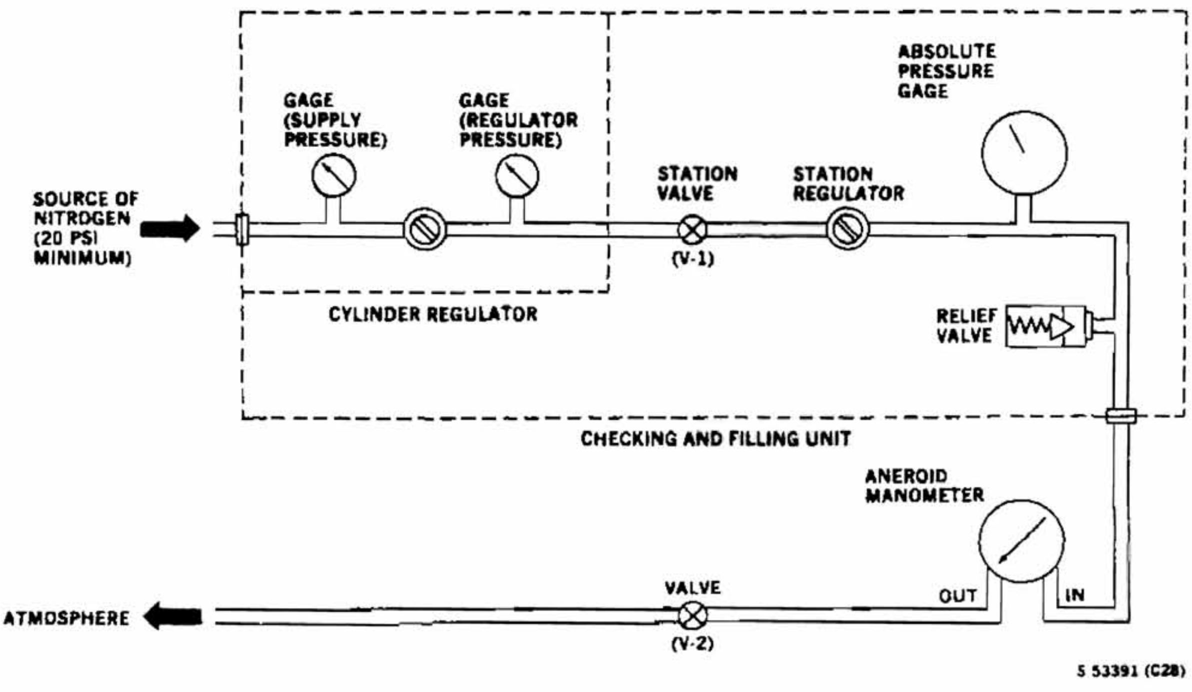
(2) Consumable Materials.

(a) Nitrogen, Technical, Federal Specification BB-N-411, Type I, Class 1, Grade A or B.

B. Test Checking and Filling Unit, S1670-15000-25.

NOTE: Conduct test at ambient temperature of 70° to 90°F (21° to 32°C).

(1) Connect cylinder regulator (6, figure 301) of checking and filling unit to source of nitrogen at fitting (4).



Testing and Filling Unit, S6170-15000-25 - Test Setup
Figure 502

(2) Unscrew chuck (9) from nipple at end of filling line of checking and filling unit. Assemble test equipment as shown in figure 502 and connect it to filling line.

(3) Close station valve (V-1) and valve (V-2).

(4) Open valve at source of nitrogen.

(5) Set cylinder regulator so regulator pressure gage shows 20 psi.

NOTE: Turn cylinder regulator adjustment handle clockwise to open.

(6) Open station valve (V-1). Using station regulator shutoff knob, gradually raise pressure until gage shows 19 psi.

NOTE: Turn station regulator shutoff knob clockwise to open.

(7) Check that manometer has responded to this pressure.

(8) Close station valve (V-1). Check that reading on manometer holds steady.

NOTE: A change in manometer reading at this time, or at any other time that station valve (V-1) is closed with pressure in test setup, indicates a leak into or out of test setup. Find and repair source of leak before continuing test.

(9) Open valve (V-2) and allow pressure to drop to zero. Close valve.

(10) Open station valve (V-1) slowly until gage shows GAGE PRESSURE listed in table 501 for TEST NO. 1. Close station valve.

NOTE: Bring gage pressure up to required value slowly. If gage goes over required value, lower pressure with valve (V-2) at least 2 psi below required value or to 0 psi. Close valve (V-2). Then bring pressure up to required value again.

(11) Check that reading on manometer is within limits of MANOMETER READING listed in table 501 for TEST NO. 1.

NOTE: When reading manometer, be sure to line up pointer with its mirror image to reduce error due to parallax.

(12) Check that reading holds steady. (Refer to note at step (8).)

(13) Repeat steps (10), (11), and (12) for each of the remaining tests in table 501.

APPENDIX B
Sikorsky Safety Advisory SSA-S61-06-002

Sikorsky
A United Technologies Company

Sikorsky Aircraft Corporation
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(203) 386-4000

Sikorsky Safety Advisory

Document Number:	SSA-S61-06-002
Revision (Date):	Original
Date:	October 20, 2006
System:	Rotors
Affected Aircraft:	All S-61 Series Models
Subject:	Main Rotor Blade BIM Indications

1. Introduction

A Blade Inspection Method (BIM®) system unsafe indication (Cockpit BIM® alert or black or red Visual BIM®) may be indicative of a blade crack. Sikorsky S-61L/N Flight Manuals (SA 4045-100 and SA 4045-82) and Maintenance Manuals (SA 4045-101 and SA 4045-80) clearly define the procedures for inspections of Visual BIM® systems, checks of Cockpit BIM® systems, the testing of the pressurized spar for leakage and Return-To-Service tests.

WARNING

FAILURE TO FOLLOW-ESTABLISHED TECHNICAL DIRECTIVES AND PUBLICATIONS DURING THE INSPECTION, MAINTENANCE AND REPAIR OF MAIN ROTOR BLADES EQUIPPED WITH BIM SYSTEMS COULD RESULT IN SPAR DAMAGE REMAINING UNDETECTED. MAIN ROTOR BLADE FAILURE WILL RESULT IN LOSS OF CONTROL OF THE HELICOPTER, EITHER ON THE GROUND OR IN THE AIR, AND SUBSEQUENT LOSS OF LIFE AND PROPERTY.

2. Corrective Action

Operators and maintenance / overhaul personnel are reminded to rigorously observe and adhere to all procedures, cautions and warnings published in the relevant flight and technical manuals when inspecting, maintaining and repairing Main Rotor Blades equipped with BIM® systems.

3. Parts Required

None at this time.

4. Contact Information

For additional information or questions, contact your Sikorsky Commercial Product Support Manager, or call the Customer Service Engineering Desk at 1-800 Winged-S or E-mail: sikorskywcs@sikorsky.com, or Phone: (203)-416-4299.

APPENDIX C
Special Airworthiness Information Bulletin (FAA SAIB) NE-07-30 and Airworthiness Directives (FAA AD) 74-20-07 R5 and 85-18-05 R2

FAA
Aircraft Certification Service

SPECIAL AIRWORTHINESS INFORMATION BULLETIN

http://www.faa.gov/aircraft/safety/alerts/SAIB

SAIB: NE-07-30
Date: *April 19, 2007*

This is information only. Recommendations aren't mandatory.

Introduction

This Special Airworthiness Information Bulletin (SAIB) alerts you, owners, operators, pilots, mechanics, and certificated repair facilities of all **Sikorsky Aircraft Model S-61 helicopters** to restrict from further flight any S-61 main rotor blade that has an indication from the Blade Inspection Method (BIM®) system. This restriction is to continue until the cause of the indication is determined and corrected. We are issuing this SAIB because we have been notified of the determination of a fatigue crack in a blade retrieved from a fatal accident of an S-61 helicopter.

Background

The FAA issued airworthiness directive (AD) 74-20-07 R5 that became effective September 26, 1984. This AD applies to the main rotor Visual BIM® and Cockpit BIM® systems of S-61 helicopters. If the blade is equipped with only the Visual BIM®, the pressure indicators must be checked every 3 hours time-in-service. If a Cockpit BIM® is installed, the electrical circuit must be tested every 3 hours time-in-service. The 3-hour interval allows sufficient time to comply with instructions in the Rotorcraft Flight Manual after an in-flight BIM® indication. This interval was based on the assumption that the spar cracks immediately after the last check or test, which causes leakage of internal pressure.

> Note: FAA AD 85-18-05 R2 applies to Sikorsky S-61 main rotor blades for helicopters used for more than six repeated external lifts per hour. The BIM® inspection intervals are more restrictive for these operations.

AD 74-20-07 R5 requires that each blade with any black or red indication visible in the Visual BIM® blade pressure indicator, or whose transducer of the Cockpit BIM® activates the cockpit warning light is considered to be unsafe. Any such blade is restricted from further flight until the cause of the indication is determined and corrected in accordance with the procedures given in Sikorsky Service Bulletin No. 61B15-6P or later FAA-approved revision (or Maintenance Manuals SA 4045-80 and SA 4045-101).

Sikorsky Aircraft Corporation issued Safety Advisory SSA-S61-06-002, dated October 20, 2006, to emphasize the need to follow flight manual and maintenance manual procedures. The advisory carried the following warning:

WARNING

> Failure to follow established technical directives and publications during inspection, maintenance and repair of main rotor blades equipped with BIM systems could result in spar damage remaining undetected. Main rotor blade failure will result in loss of control of the helicopter, either on the ground or in the air, and subsequent loss of life and property.

Recommendation

We remind all owners and operators of Sikorsky S-61 helicopters that any BIM indication should be viewed as a spar failure of that blade and, as stated in FAA AD 74-20-07 R5AD, that blade should not be flown until the cause of the indication is **determined and corrected.**

For Further Information Contact

FAA Contact; Richard Noll, Aerospace Safety Engineer, FAA Boston Aircraft Certification Office, ANE-150, 12 New England Executive Park, Burlington, MA 01803; (781) 238-7160; email: dick.noll@faa.gov

For Service Letter Information Contact

Sikorsky Aircraft Corporation Contact: Sikorsky Customer Service Engineering Desk at 1-800 Winged-S or E-mail: sikorskywcs@sikorsky.com or Phone: (203) 416-4299.

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RGL Home

Airworthiness Directive

Federal Register Information

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

Amendment 39-4895; AD **74-20-07 R5**

Airworthiness Directives; Sikorsky Models S-61L, S-61N, S-61NM, S-61R, S-61A, and S-61V Helicopters

PDF Copy (If Available):

Preamble Information

AGENCY: Federal Aviation Administration, DOT

DATES: Effective September 26, 1984, as to all persons including those persons to whom part was made immediately effective by priority letter AD 74- 20-07 R4 issued December 30, 1983.

Regulatory Information

74-20-07 R5 SIKORSKY AIRCRAFT: Amendment 39-1971 as amended by Amendments 39- 1989, 39-2152, and 39-2439 is further amended by Amendment 39-4895. Applies to S-61L, S- 61N, S-61NM, and S-61R helicopters certificated in all categories, and S-61A (aircraft S/N's 61083, 61087, 61094, and 61161) and S-61V (aircraft S/N 61271) helicopters certificated in the restricted category.

Compliance is required as indicated (unless already accomplished).

To prevent operation with fatigue cracks in the spar of a main rotor blade, accomplish the following:

(a) Remove from service within the next 10 hours time in service from the effective date of this amended AD:

(1) Any main rotor blade which does not comply with Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions, excluding Section 2, Accomplishment Instructions, Part II, Operation, Pilot Information. For main rotor blades which are in compliance, the service life limits are:

(i) 8,000 hours total time in service for S6117-20101 series blades;

(ii) 9,400 hours total time in service for S6115-20501, S6115-20601, S6188-15001, and 61170-20201 series blades;

(2) Any military main rotor blade installed on a helicopter certificated in the restricted category which is not equipped with a visual blade pressure inspection system equivalent to that specified in Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions. For military blades which are in compliance, the service life limits shall be those specified in the restricted category approval.

(b) Inspect main rotor blades equipped with approved visual blade pressure indicators but not equipped with an in-cockpit blade inspection system, or if equipped, with the system inoperative, in accordance with paragraphs (c) and (d). For helicopters equipped with an operative in-cockpit blade inspection system, inspect the main rotor blades in accordance with paragraphs (e) and (f).

(c) Within the next 3 hours time in service after the effective date of this amended AD, unless already accomplished, inspect the visual blade pressure indicators of the following blades of helicopters not equipped with an in-cockpit blade pressure monitoring system (see Sikorsky Service Bulletin No. 61B15-20D), or equipped with such system inoperative:

S6115-20501 Series
S6115-20601 Series
S6117-20101 Series
S6188-15001 Series
61170-20201 Series
61170-20201-062 (S-61A aircraft S/N's 61083 and 61094)
S6115-20201-2 (S-61A aircraft S/N's 61087 and 61161)
61170-20201-060 (S-61V aircraft S/N 61271),

according to the procedures set forth in Section 2, Part IV, of Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions, and as supplemented by paragraph (d) of this AD.

(1) Conduct visual inspections or checks of blade-mounted pressure indicators from the transmission work platform of the helicopter to ensure that an accurate visual check is conducted.

(2) The visual inspections or checks of blade-mounted pressure indicators shall be conducted by an individual who holds a pilot certificate with appropriate rating or a mechanic certificate with airframe rating or by a certificated maintenance entity. The person performing this inspection or check shall make entries of the results in the aircraft maintenance record including a description and date of the

inspection and the name of the individual performing the inspection along with the certificate number, kind of certificate, and signature.

(3) Each blade with any black or red indication visible in the blade pressure indicator is considered to be unsafe and is restricted from further flight until the cause of the indication is determined and corrected in accordance with the procedures given in Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions.

NOTE: The inspections that are required by paragraph (c) to be performed and recorded may be considered to be "airworthiness checks."

If preventive maintenance action in accordance with Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions, is required as a result of these inspections (airworthiness checks), the subsequent inspections required are considered preventive maintenance that may be performed by persons authorized to perform preventive maintenance under Part 43 of the FAR.

(d) After the initial inspections in accordance with paragraph (c), conduct further inspections in accordance with paragraph (c) prior to the first flight of each day and at intervals not to exceed 3 hours time in service from the last inspection, except for blades identified with yellow or white circles which are limited to inspection intervals of 1 and 2 hours, respectively.

Helicopter time in service for any single flight in excess of the specified inspection interval is not permitted, and if the time in service since the last inspection will exceed the specified interval during the next flight, the visual inspection must be conducted prior to the flight.

Yellow or white circles and attendant speed restrictions of AD 74-25-05 may be removed if the main rotor blade is refurbished by Sikorsky in accordance with FAA-approved procedures of June 16, 1975.

(e) Prior to the first flight of the day and every 8 hours time in service thereafter for helicopters equipped with an operable in-cockpit blade pressure monitoring system (see Sikorsky Service Bulletin No. 61B15-20D), and with main rotor blades with serial numbers of 61M-6350- 6105 or greater, or which have been refurbished by Sikorsky in accordance with FAA-approved procedures of June 16, 1975, inspect the main rotor blade pressure indicators and pressure transducers of the blades specified in paragraph (c) according to the procedures set forth in Section 2, Part IV of Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions.

(1) The visual inspections or checks of blade-mounted pressure indicators are to be conducted from the transmission work platform of the helicopter to ensure that an accurate visual check is conducted.

(2) The required functional tests and visual checks shall be conducted by an individual who holds a pilot certificate with appropriate rating or a mechanic certificate with airframe rating or by a certificated maintenance entity. The person performing these tests and checks shall make entries of the results of the inspections in the aircraft maintenance record including a description and date of the inspection and the name of the individual performing the inspection along with the certificate number, kind of certificate, and signature.

(3) Each blade with any black or red indication visible in the blade pressure indicator or whose transducer activates the cockpit warning light is considered to be unsafe and is restricted from further flight until the cause of the indication is determined and corrected in accordance with procedures given in Sikorsky Service Bulletin No. 61B15-6P, or later FAA- approved revisions.

(f) After the initial inspections in accordance with paragraph (e):

(1) Conduct functional tests in accordance with the procedures of paragraph (e) of all visual blade pressure indicators and in-cockpit blade inspection system transducers every 8 hours time in service.

(2) Check the in-cockpit blade inspection system electrical circuit every 3 hours time in service by use of the system test switch located in the cockpit. An in-flight indication of a failure of the system electrical circuit must be treated in the same manner as an in- cockpit system warning light indication as provided in the Emergency Procedures section of the Rotorcraft Flight Manual.

(g) Alternate inspections, repairs, modifications, or other means of compliance which provide an equivalent level of safety to this AD must be approved by the Manager, Boston Aircraft Certification Office, FAA, New England Region, 12 New England Executive Park, Burlington, Massachusetts 01803. In accordance with FAR Section 21.197, flight is permitted to a base where the requirements of this AD may be accomplished.

(h) For helicopters equipped with an operable in-cockpit blade pressure monitoring system (see Sikorsky Service Bulletin No. 61B15-20D), inspect the main rotor blade pressure indicators and transducers of the blades specified in Paragraph (f) according to the procedures set forth in Section 2, Part IV of Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions, and as supplemented by the inspection intervals specified in paragraph (g).

(1) The required visual checks may be performed by the pilot.

(2) Each blade whose transducer activates the cockpit warning light is considered to be unsafe and is restricted from further flight until the cause of the indication is determined and corrected in accordance with procedures given in Sikorsky Service Bulletin No. 61B15-6P, or later FAA-approved revisions.

(i) Alternate inspections, repairs, modifications, or other means of compliance which provide an equivalent level of safety to this AD must be approved by the Manager, Boston Aircraft Certification Branch, FAA, New England Region, 12 New England Executive Park, Burlington, Massachusetts 01803. In accordance with FAR 21.197, flight is permitted to a base where the requirements of this AD may be accomplished.

The manufacturer's specifications and procedures (Sikorsky Service Bulletin No. 61B15- 6P Revision No. 16, 12/3/81 including Revision No. 12, 6/2/77 and Revision No. 15, 4/21/80; Sikorsky Service Bulletin No. 61B15-20 Revision No. 4, 11/9/77) identified in this directive are incorporated herein and made a part hereof pursuant to 5 U.S.C. 552(a)(1). All persons affected by this directive who have not already received these documents from the manufacturer may obtain copies upon request to United Technologies Corporation, Sikorsky Aircraft Division, North Main

Street, Stratford, Connecticut, 06601, Attn: S-61 Commercial Product Support Dept. These documents also may be examined in the Rules Docket at the Office of the Regional Counsel, Southwest Region, Federal Aviation Administration, Room 156, Building 3B, 4400
Blue Mound Road, Fort Worth, Texas 76106.

This supersedes Amendment 39-283 (31 FR 11714), AD 66-22-5, as amended by Amendment 39-809 (34 FR 12563), Amendment 39-828 (34 FR 13969), Amendment 39-981 (35 FR 6858) and Amendment 39-1178 (36 FR 5674).

Amendment 39-1971 became effective October 4, 1974.

Amendment 39-1989 became effective October 24, 1974.

Amendment 39-2152 became effective April 16, 1975.

Amendment 39-2439 became effective December 23, 1975.

This Amendment 39-4895 becomes effective September 26, 1984, as to all persons including those persons to whom part was made immediately effective by priority letter AD 74- 20-07 R4 issued December 30, 1983, which contained part of this amendment.

Airworthiness Directive

Federal Register Information

Header Information

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

Amendment 39-6098; AD **85-18-05 R2**

Airworthiness Directives; SIKORSKY AIRCRAFT Model S-61L, S-61N, S-61NM, and S-61R, S-61A, S-61V Series Helicopters

PDF Copy (If Available):

Preamble Information

AGENCY: Federal Aviation Administration, DOT

DATES: Effective February 8, 1989.

Regulatory Information

85-18-05 R2 SIKORSKY AIRCRAFT: Amendment 39-5129 as amended by Amendment 39-5525 is further amended by Amendment 39-6098.

Applicability: Model S-61L, S-61N, S-61NM, and S-61R series helicopters, certificated in all categories, and S-61A (S/N's 61083, 61087, 61094, and 61161) and S-61V (S/N 61271) helicopters, certificated in the restricted category, which are engaged in more than six external cargo lifts per flight hour under Part 133, Class B, Rotorcraft external load combination operations.

Compliance: Required as indicated (unless already accomplished).

To prevent operation with a main rotor spar crack and possible loss of the helicopter, accomplish the following:

(a) Within the next 25 hours time in service after the effective date of this AD, unless already accomplished, remove main rotor blades from the rotorcraft that are not approved for use in Part 133 (Class B, Rotorcraft-external load combination operations), and replace with approved blades. The approved main rotor blades are as follows:

(1) The following blades are approved for Model S-61L, transport category helicopters operating up to a combined vehicle and cargo gross weight of 22,000 lbs., provided the main rotor blades have been altered and maintained in accordance with Service Bulletin (SB) 61B15-6, Rev. P, or later FAA-approved revisions, excluding Section 2, Part II:
(i) P/N's S6115-20501-041 and -042.
(ii) P/N's S6115-20601-042, -047, and -048.
(iii) P/N's 61170-20201-055, -056, -058, -059, -060, -061, -062, -065, and -067.
(iv) P/N's S6117-20101-041, -046, -050, -051, -054, -055, -056, -057, and 058.

(2) The following blades are approved for Model S-61N, transport category helicopters operating up to a combined vehicle and cargo gross weight of 22,000 lbs., or Model S-61NM, transport category helicopters operating up to a combined vehicle and cargo gross weight of 20,500 lbs., provided the main rotor blades have been altered and maintained in accordance with SB No. 61B15-6, Rev. P, or later FAA-approved revisions, excluding Section 2, Part II:
(i) P/N's S6115-20501-041, and -042.
(ii) P/N's S6115-20601-041, -042, -045, -046, -047, and -048.
(iii) P/N's S6188-15001-041 and -045.
(iv) P/N's 61170-20201-054, -055, -056, 058, -059, 060, -061, -062, -065, -067.
(v) P/N's S6117-20101-041, -046, -050, -051, -054, -055, -056, -057, and -058.

(3) P/N's 61170-20201-062 blades are approved for the Model S-61A (S/N's 61083 and 61094), restricted category helicopters, operating up to a combined vehicle and cargo gross weight of 22,000 lbs.

(4) P/N's S6115-20201-2 and -3 blades are approved for the Model S-61A (S/N's 61087 and 61161), restricted category helicopter, operating up to a combined vehicle and cargo gross weight of 19,000 lbs.

(5) P/N 61170-20201-060 blades are approved for the Model S-61V (S/N 61271), restricted category helicopter, operating up to a combined vehicle and cargo gross weight of 19,100 lbs.

(6) The following blades are approved for Model S-61R transport category helicopters operating up to a combined aircraft and cargo gross weight of 19,500 pounds:
(i) P/N's S6115-20501-041 and -042.
(ii) P/N's S6115-20601-042, and -045 through -048.
(iii) P/N's S6117-20101-041, -050, -051, -054, -056, -057, and -058.
(iv) P/N's 61170-20201-055, -056, -058 through -062, -064, -065, and -067.

(b) Within the next 1 1/2 hours time in service after the effective date of this AD, unless already accomplished, inspect main rotor blades equipped with approved visual blade pressure indicators (VBIM) but not equipped with an in-cockpit blade inspection system (CBIM) in accordance with paragraph (c). After the initial inspection, conduct further inspections in accordance with paragraph (c) prior to the first flight of each day and conduct subsequent visual inspections of the VBIM indicators in accordance with Section 2, Part IV, paragraph la of Sikorsky Service Bulletin No. 61B15-6, Revision P, or later FAA-approved revisions, at intervals not to exceed 1 1/2 hours time in service from the last inspection.

(c) Inspect the VBIM indicators of the main rotor blades in accordance with procedures set forth in Section 2, Part IV, of Sikorsky SB No. 61B15-6 Rev. P, or later FAA-approved revisions.

(1) Conduct visual inspection of blade-mounted VBIM indicators from the transmission work platform of the helicopter or equivalent to ensure that an accurate visual check is conducted.

(2) The visual inspection of blade-mounted VBIM indicators shall be conducted by either an individual who holds a pilot certificate with appropriate rating, or a mechanic certificate with airframe rating, or by an appropriately certificated maintenance entity. The person performing this inspection or check shall make entries of the results in the aircraft maintenance record including a description and date of the inspection and the name of the individual performing the inspection along with the certificate number, kind of certificate, and signature.

(d) For helicopters equipped with in-cockpit CBIM (reference Sikorsky SB No. 61B15-20D).

(1) Prior to the first flight of the day, after the effective date of this AD, unless already accomplished, and every 8 hours time in service thereafter.

(i) Visually inspect the main rotor blade VBIM pressure indicators in accordance with paragraph (c).

(ii) Test the VBIM pressure indicators and the in-cockpit CBIM transducers in accordance with the procedures set forth in Section 2, Part IV, of Sikorsky SB No. 61B15-6, Rev. P, or later FAA-approved revisions.

(2) Check the in-cockpit blade inspection system electrical circuit and CBIM warning light in flight by activating the (cockpit) BIM test switch located on the left overhead quarter panel at least once each (1) hour time in service during flight operations in accordance with the Rotorcraft Flight Manual (RFM).

(i) If the (cockpit) BIM warning light illuminates, continue operations in a normal manner.

(ii) If the (cockpit) BIM warning light does not illuminate, immediately check the BIM circuit breaker and reset if tripped.

(A) Repeat check of (cockpit) BIM test switch to verify if warning light illuminates. Continue with normal operations if BIM warning light functions properly.

(B) If the (cockpit) BIM warning light fails to illuminate, discontinue external load operations and land as soon as practical. Investigate and correct malfunction prior to further flight.

(3) If the (cockpit) BIM warning light illuminates during flight, discontinue external load operations and follow the appropriate emergency flight procedures in Part I, Section III, of the SA 4045-30 (S-61L) SA4045-100 (S-61L), or SA4045-82 (S-61N) RFM's.

NOTE: For Model S-61 helicopters not engaged in Part 133 external load operations, AD 74-20-07, Rev. 5, main rotor blade inspection requirements are applicable.

(e) Each blade with any black or red indication visible in the blade VBIM pressure indicator (or whose transducer activates the cockpit BIM warning light) is restricted from further flight until the cause of the indication is determined and corrected in accordance with procedures given in Sikorsky SB 61B15-6, Rev. P, or later FAA-approved revisions.

(f) Alternate inspections, repairs, modifications, or other means of compliance which provide an equivalent level of safety may be approved by the Manager, Boston Aircraft Certification Office, FAA, New England Region, 12 New England Executive Park, Burlington, Massachusetts 01803.

(g) Rotorcraft may be flown in accordance with the provisions of FAR Sections 21.197 and 21.199 to a base where the AD can be accomplished, except when a VBIM or CBIM indication exists.

The manufacturer's specifications and procedures identified and described in this directive are incorporated herein and made a part hereof pursuant to 5 U.S.C. 552 (a) (1). All persons affected by this directive who have not already received these documents from the manufacturer may obtain copies upon request to Sikorsky Aircraft, Division of United Technologies, North Main Street, Stratford, Connecticut 06601, Attn: S-61 Commercial Product Support Department. These documents also may be examined at the Office of the Regional Counsel, Southwest Region, FAA, Bldg. 3B, 4400 Blue Mound Road, Fort Worth, Texas 76106.

This amendment revises Amendment 39-5129 (50 FR 38506; September 23, 1985), AD 85-18-05, as amended by Amendment 39-5525 (52 FR 8582; March 19, 1987), AD 85-18-05 R1 which was effective on April 13, 1987.

This amendment (39-6098, AD **85-18-05 R2**) becomes effective February 8, 1989.

Footer Information

Comments

APPENDIX D
Sikorsky Service Bulletin no. 61B15-6Q. Troubleshooting chart for a pressurized spar

SERVICE BULLETIN

No. 61B15-6 O

BIM® MAIN ROTOR BLADES (S6115-20501, S6115-20601, S6117-20101, S6188-15001 AND 61170-20201 SERIES)

2. ACCOMPLISHMENT INSTRUCTIONS (CONTINUED)

PART III - (CONTINUED)

B. TROUBLESHOOTING

WARNING ANY BLADE ON WHICH THE PRESSURE INDICATOR SHOWS ANY BLACK OR RED COLOR (UNSAFE), OR WHOSE TRANSDUCER CAUSES THE COCKPIT BIM SYSTEM WARNING LIGHT TO GO ON, IS RESTRICTED FROM FURTHER FLIGHT UNTIL THE CAUSE OF THE BLACK OR RED INDICATION OR WARNING LIGHT GOING ON IS POSITIVELY FOUND AND CORRECTED. FOR TROUBLESHOOTING THE TRANSDUCER, COMPLY WITH THE MAINTENANCE MANUAL, CHAPTER 65. IF THE COCKPIT BIM SYSTEM WARNING LIGHY INDICATION IS POSITIVELY IDENTIFIED AS AN ELECTRICAL MALFUNCTION, AND THE PRESSURE INDICATORS MEET THE SPECIFIED REQUIREMENTS OF PART III, PARAGRAPH N., SCHEDULED FLIGHTS MAY BE CONTINUED, PROVIDED: COCKPIT BIM SYSTEM WARNING LIGHT CIRCUIT BREAKER IS PULLED OUT AND TAGGED WITH A NOTE THAT SYSTEM IS INOPERATIVE; THE CONDITION NOTED IN FLIGHT LOG; VISUAL BIM INSPECTION REQUIREMENTS OF PART IV ARE CONTINUED. AS SOON AS POSSIBLE THE COCKPIT BIM SYSTEM ELECTRICAL MALFUNCTION MUST BE CORRECTED.

CAUTION WHEN AN OPERATOR HAS REPAIRED A BLADE THAT HAD AN UNSAFE INDICATION ON ITS PRESSURE INDICATOR, THAT BLADE MUST NOT BE REPAIRED FOR A SECOND UNSAFE INDICATION IF THE SECOND UNSAFE INDICATION OCCURS WITHIN 30 FLIGHT HOURS OF THE FIRST.

July 22/66 65-44

Revision No. 15 - April 21/80 Page 13

APPENDIX E
Safety Information Notice (EASA SIN) No. 2007-13

EASA Safety Information Notice

No.: 2007 – 13

Issued: 22 May 2007

Subject: **Sikorsky Aircraft Model S-61 Series helicopters Blade Inspection Method (BIM®) system.**

Ref. Publications: FAA Special Airworthiness Information Bulletin (SAIB) NE-07-30, dated April 19, 2007. This SAIB refers to 2 existing FAA Airworthiness Directives (ADs), 74-20-07 R5 and 85-18-05 R2. Both ADs are considered by EASA to be applicable under EC Regulation 1702/2003, Article 2, sub 3(a)(iii) to all S-61 helicopters registered in EU Member States.

Introduction: This Safety Information Notice (SIN) refers to FAA SAIB NE-07-30 (attached to this document as pages 2 and 3) and alerts owners, operators, pilots, mechanics, and certificated repair facilities of all **Sikorsky Aircraft S-61 Series helicopters** to restrict from further flight any S-61 main rotor blade that has an indication from the Blade Inspection Method (BIM®) system.

Applicability: All Sikorsky Aircraft S-61 Series helicopters.

Recommendation: EASA fully endorses the FAA recommendations.

This Safety Information Notice is for information only. No AD action by NAAs is required.

Contact: For further information contact the Section Airworthiness Directives, Certification Directorate, EASA.
E-mail: ADs@easa.europa.eu

FAA
Aircraft Certification Service

SPECIAL AIRWORTHINESS INFORMATION BULLETIN

http://www.faa.gov/aircraft/safety/alerts/SAIB

SAIB: NE-07-30
Date: April 19, 2007

This is information only. Recommendations aren't mandatory.

Introduction

This Special Airworthiness Information Bulletin (SAIB) alerts you, owners, operators, pilots, mechanics, and certificated repair facilities of all **Sikorsky Aircraft Model S-61 helicopters** to restrict from further flight any S-61 main rotor blade that has an indication from the Blade Inspection Method (BIM®) system. This restriction is to continue until the cause of the indication is determined and corrected. We are issuing this SAIB because we have been notified of the determination of a fatigue crack in a blade retrieved from a fatal accident of an S-61 helicopter.

Background

The FAA issued airworthiness directive (AD) 74-20-07 R5 that became effective September 26, 1984. This AD applies to the main rotor Visual BIM® and Cockpit BIM® systems of S-61 helicopters. If the blade is equipped with only the Visual BIM®, the pressure indicators must be checked every 3 hours time-in-service. If a Cockpit BIM® is installed, the electrical circuit must be tested every 3 hours time-in-service. The 3-hour interval allows sufficient time to comply with instructions in the Rotorcraft Flight Manual after an in-flight BIM® indication. This interval was based on the assumption that the spar cracks immediately after the last check or test, which causes leakage of internal pressure.

> Note: FAA AD 85-18-05 R2 applies to Sikorsky S-61 main rotor blades for helicopters used for more than six repeated external lifts per hour. The BIM® inspection intervals are more restrictive for these operations.

AD 74-20-07 R5 requires that each blade with any black or red indication visible in the Visual BIM® blade pressure indicator, or whose transducer of the Cockpit BIM® activates the cockpit warning light is considered to be unsafe. Any such blade is restricted from further flight until the cause of the indication is determined and corrected in accordance with the procedures given in Sikorsky Service Bulletin No. 61B15-6P or later FAA-approved revision (or Maintenance Manuals SA 4045-80 and SA 4045-101).

Sikorsky Aircraft Corporation issued Safety Advisory SSA-S61-06-002, dated October 20, 2006, to emphasize the need to follow flight manual and maintenance manual procedures. The advisory carried the following warning:

WARNING

> Failure to follow established technical directives and publications during inspection, maintenance and repair of main rotor blades equipped with BIM systems could result in spar damage remaining undetected. Main rotor blade failure will result in loss of control of the helicopter, either on the ground or in the air, and subsequent loss of life and property.

Recommendation

We remind all owners and operators of Sikorsky S-61 helicopters that any BIM indication should be viewed as a spar failure of that blade and, as stated in FAA AD 74-20-07 R5AD, that blade should not be flown until the cause of the indication is **determined and corrected.**

For Further Information Contact

FAA Contact; Richard Noll, Aerospace Safety Engineer, FAA Boston Aircraft Certification Office, ANE-150, 12 New England Executive Park, Burlington, MA 01803; (781) 238-7160; email: dick.noll@faa.gov

For Service Letter Information Contact

Sikorsky Aircraft Corporation Contact: Sikorsky Customer Service Engineering Desk at 1-800 Winged-S or E-mail: sikorskywcs@sikorsky.com or Phone: (203) 416-4299.

APPENDIX F

Specific Additional Instruction to AMM no. AHS – 0540 «MAIN ROTOR BLADE, BIM WARNING TROUBLE SHOOTING»

(original in yellow)

Astec Helicopter Services Manual Revision

CHC

Manual affected: HELICOPTER TYPE: S61N MM: SA 4045-80		No: AHS - 0540
		Date: 06.07.2002
		Page: 1 of 1
Prepared by: Per Arne Braaten	*Revised by:*	*Approved by:* F. Bjørnsen
Insert this page facing:	**Chapter: 65-11-0**	**Page: 101**

SUBJECT: **MAIN ROTOR BLADE, BIM WARNING TROUBLE SHOOTING.**

REASON: Repetetive BIM warning on the same blade

NOTE: This document originates from the previously issued HS Manual Revision no. 294B. And are from this Date an approved AHS Revision.

EFFECTIVITY: S-61N

REFERENCE: CHC Astec Engineering Dept.

DESCRIPTION: For a specific blade's first BIM warning (post installation on actual A/C), if blade pressure is above Blade Checking Minimum, check for leakage at CBIM, VBIM transducers or schrader valve, if leak is not found, fill blade to Servicing Maximum.

Enter into HIL, Filled Spar pressure and spar temperature, and order a recheck of Blade pressure after 30 flight hours or 10 Days, whichever occurs first and 100 flight Hours, or 30 Days.

NOTE: **It is absolutly vital that the Temperature used to choose the correct filling pressure is in fact the actual stabilized Spar temperature. The Spar Temperature must be checked both before and upon completion of servicing.**

If after 30 hrs (10 days), pressure has dropped below Servicing Minimum, replace blade and route to workshop for further investigation.

If after 30 hours (10 Days) blade pressure is still above Servicing Minimum, **do not refill.** Enter pressure and spar temperature into HIL, and allow blade to stay in service until next recheck of Blade pressure after 100 flight hours or 30 Days, whichever occurs first.

If after 100 hours (30 days), pressure has dropped below Servicing Minimum, replace blade and route to work shop for further investigation, otherwise refill to Servicing Maximum and sign out the entered HIL item.

NOTE: **If BIM Warning occurs anytime before 2nd recheck, actual blade SHALL be replacemed .**