



AVIATION



HIGHWAY



MARINE



RAILROAD



PIPELINE

Aviation Investigation Final Report

Location:	Islamorada, Florida	Accident Number:	ERA18LA053
Date & Time:	December 15, 2017, 06:50 Local	Registration:	N911FK
Aircraft:	Sikorsky S76	Aircraft Damage:	Substantial
Defining Event:	Fire/smoke (non-impact)	Injuries:	1 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled - Air Medical (Medical emergency)		

Analysis

The pilot landed the helicopter in an open field to pick up a patient. He reported that he positioned the engine controls to idle, and the main rotor speed (Nr) was less than 60% before he applied the rotor brake to stop the rotors. The rotors stopped, and the paramedic and flight nurse exited the helicopter. After they departed, the pilot noted that the No. 1 engine temperature was fluctuating with an increase in the inlet turbine temperature, so he shut down the No. 1 engine. The flight nurse then noticed dark smoke, sparks, and then flames emanating from the main rotor gearbox cowling area of the helicopter. The pilot was notified of the fire, shut down the No. 2 engine, and discharged both fire bottles, but the fire continued to burn until fire department personnel extinguished it.

The thermal damage observed in the main rotor gearbox compartment appeared centered around the rotor brake. The rotor brake control components did not exhibit evidence of anomalies that would have either led to its uncommanded engagement with rotors turning or sustained engagement after disengagement of the rotor brake. Raised material found on the rotor brake disk surface was consistent with fused material from the rotor brake pads. Both forward and aft brake pucks extended when hydraulic pressure was applied to the brake calipers. The forward pucks of the left and right brake calipers did not automatically retract when hydraulic pressure was removed, but they were manually retracted without difficulty. The rotorcraft flight manual supplement (RFMS) for the accident helicopter mentioned the possibility of a rotor brake fire if pressure has been applied to the rotor brake system that resulted in a rotor brake puck dragging against a brake disk. However, with hydraulic pressure removed, it is unlikely the forward pucks of the left and right brake calipers would have asserted enough force on the rotor brake disk to increase friction between the puck and brake disk to cause these components to heat up enough to result in a fire.

The No. 1 engine did not exhibit evidence of anomalous damage, and its FCU functioned normally on the test bench. There was no evidence of thermal damage to both engines' exteriors. However, the gas generator turbines and thermocouples from the No. 2 engine exhibited thermal damage. Because thermal damage was not observed on the compressor stages, it is unlikely the thermal damage internal to the No.

No. 2 engine was caused by the fire from the main gearbox compartment. Thus, it is likely the internal thermal damage to the No. 2 engine was caused by excess fuel flow into the combustion chamber of the engine.

The No. 2 engine fuel control unit (FCU) functioned normally on the test bench; the FCU governed power turbine speed (Np) when its throttle was set to flight and stopped governing Np when its throttle was set to idle. A check of the rigging between the cockpit engine control levers (ECL) and the FCU throttles revealed no anomalies. Given that the engine FCU bench test was normal, it is likely that, after landing the helicopter, the pilot activated the rotor brake while the No. 2 engine FCU throttle position remained in the flight position and the No. 2 ECL was set to a condition to govern Np. As Nr, and consequently Np, dropped with the application of the rotor brake, the No. 2 engine FCU increased fuel flow to compensate, likely to its maximum rate, which resulted in thermal damage to the engine. The application of the rotor brake increased friction and heat as the additional fuel continued to provide power to the engine; thus, with the rotor brake force applied and with the No. 2 engine attempting to overcome it, the friction increased until a fire ignited near the rotor. The specific origin of the fire could not be determined; however, given the pilot's report that the area around the rotor brake assembly generally can accumulate slung grease and oil, it is possible that these materials, when exposed to the hot rotor brake disk, could have ignited and exacerbated the risk and spread of fire.

A decal on the rotor brake lever cautioned that both engines must be shut down or one engine can be at idle for rotor brake application. The RFMS applicable to helicopters equipped with Arriel 1S1 engines installed indicated that rotor brake application was limited to one or two engines operating at idle or both engines shut down. Although a discrepancy existed between the decal and the RFMS, the Arriel 1S1 engine installation allows both engines to be at idle when applying the rotor brake; thus, the discrepancy was not a factor in this accident.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's activation of the rotor brake while the No. 2 engine was still set to govern the power turbine speed, which resulted in continuous power being applied to the rotor while the rotor brake was engaged and led to excessive friction, heat, and a subsequent fire in the area of the rotor brake.

Findings	
Personnel issues	Incorrect action selection - Pilot
Personnel issues	Use of equip/system - Pilot

Factual Information

History of Flight

Standing-engine(s) operating	Fire/smoke (non-impact) (Defining event)
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HISTORY OF FLIGHT

On December 15, 2017, about 0650 eastern standard time, a Sikorsky S-76A, N911FK, was substantially damaged when it was involved in an accident near Islamorada, Florida. The pilot, flight nurse, and paramedic were not injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 135 on-demand air ambulance flight.

According to the operator, the flight departed Florida Keys Marathon International Airport (MTH), Marathon, Florida, about 0637 for an air medical trauma patient pickup; the pilot landed at a presurveyed landing zone about 0650 to pick up the patient. The pilot reported that, after landing, he positioned the engine controls to idle and the main rotor speed (Nr) was less than 60% before he applied the rotor brake to stop the rotors. After the rotors stopped, the paramedic and flight nurse exited the helicopter to attend to the patient.

The pilot indicated that after the medical crew departed the helicopter, he noticed that the No. 1 engine temperature was fluctuating with an increase in the inlet turbine temperature, so he shut down the No. 1 engine. The operator reported that, about the same time, the flight nurse noticed dark smoke coming out of the main rotor gearbox cowling area of the helicopter. The flight nurse reported that the smoke was accompanied by sparks, which shortly after turned into flames; she and the paramedic ran toward the helicopter and signaled the pilot about the fire.

The pilot reported that he noticed the flight nurse waving her arms and warning of a fire but did not observe any cockpit indications of a fire; however, he shut down the No. 2 engine and observed flames when he partially exited the helicopter. He discharged both engine fire bottles and then exited the helicopter. He stated that the fire continued to burn until fire department personnel extinguished it.

The pilot additionally reported that the area around the rotor brake assembly generally accumulated a lot of slung grease and oil.

AIRCRAFT INFORMATION

The helicopter was equipped with two Safran Helicopter Engines Arriel 1S1 turboshaft engines (in accordance with supplemental type certificate No. SH568NE) driving a four-blade main rotor system. The No. 1 engine had accumulated about 10,412.5 hours total time since new (TSN) and 383 hours total time since overhaul. The No. 2 engine had accumulated about 5,101 hours TSN and 228.3 hours total time since overhaul. A manually activated rotor brake system was installed in the helicopter.

WRECKAGE AND EXAMINATION INFORMATION

The helicopter remained largely intact as the fire was in the area immediately adjacent to the rotor hub assembly and main transmission compartment; the helicopter sustained thermal damage to the main gearbox compartment and engine inlets. Further postaccident examination of the helicopter revealed heavy soot deposits in the engine's transmission compartment and debris on the floor of the compartment consistent with thermal damage deposits from the surrounding compartment. There was soot on the rotor head assembly to the pitch change links, dampers, and pitch horns. The upper surfaces of the engine cowling exhibited two areas of heavy soot deposits aligned between the Nos. 1 and 2 oil cooler ducts and the main gearbox oil cooler duct. The left and right intake fairing, engine cowling, internal ducting for both engine oil coolers, and rotor brake cowl exhibited thermal damage.

The airframe oil supply lines from the oil tank were intact for both engines. The airframe oil return lines to the oil tanks for both engines were thermally damaged and fractured. The No. 1 engine oil filler cap was removed, and there was no visible evidence of oil near the filler. The No. 2 engine oil filler cap was removed, and there was visible evidence of an oil level near the filler.

No. 1 Engine Examination and Disassembly

The exterior of the No. 1 engine did not exhibit evidence of thermal damage. The compressor turned freely when manually rotated. The transmission input shaft turned freely in the freewheeling direction when manually rotated, and turning the transmission input shaft in the driving direction resulted in rotation of the main rotor head. A check of the rigging between the No. 1 engine control lever (ECL) in the cockpit and the fuel control unit (FCU) for the No. 1 engine revealed no anomalies and indicated an FCU throttle position of about 27° when the ECL was set to idle.

The No. 1 first-stage compressor did not exhibit evidence of foreign object debris (FOD) damage. The free (power) turbine exhibited no evidence of blade shedding. A borescope inspection of the first- and second-stage gas generator turbines revealed no anomalies or damage.

Disassembly of the No. 1 engine revealed no evidence of cracks or fractures to the external lines removed from the engine or damage noted to the thermocouples, power transmission shaft, or reduction gearbox. All power turbine blades were present and free of damage, and the power turbine rotated freely with no binding. The combustion liner had no damage or debris. The first-stage (axial) compressor exhibited black coloration but did not exhibit anomalous damage. The second-stage (centrifugal) compressor had an even coating of soot. The first- and second-stage nozzle guide vanes exhibited no evidence of anomalous damage. Soot deposits were observed on the first-stage nozzle guide vane surfaces, and the second-stage nozzle guide vane surfaces exhibited bluing. Continuity was confirmed between the accessory drive and the starter-generator pad. The drained oil was tan in color.

The No. 1 FCU was removed and bench tested. The FCU was brought from normal start to flight idle with no anomalies detected.

No. 2 Engine Examination and Disassembly

The exterior of the No. 2 engine did not exhibit evidence of thermal damage. The compressor and the transmission input shaft could not be manually rotated in either the freewheeling or the driving direction. The exterior surfaces of the transmission input shaft exhibited a matted appearance consistent with exposure to fire. A check of the rigging between the No. 2 ECL in the cockpit and the FCU for the No. 2

engine revealed no anomalies and indicated an FCU throttle position of about 27° when the ECL was set to idle.

The No. 2 first-stage compressor did not exhibit evidence of FOD damage. The power turbine exhibited no evidence of blade shedding. A borescope inspection of the first- and second-stage gas generator turbines revealed damage to the turbine blades.

Disassembly of the No. 2 engine revealed that the power transmission shaft and the gas generator could not be manually rotated. All three thermocouples exhibited evidence of thermal damage. The reduction gearbox was removed, and the gearbox and power transmission shaft rotated freely with no evidence of binding, but the power turbine could not be rotated. The reduction gearbox splined nut did not show misalignment. The overspeed sensor and muff coupling showed no anomalous damage. The power turbine was removed and could be manually rotated, during which the turbine bearings made a chattering sound. The turbine inlet stator vanes had a dull, gray coating flaking off their surfaces. The axial compressor could be manually rotated, but its movement was not smooth. Soot deposits were on the axial compressor and centrifugal compressor surfaces. Rub marks were on the interior of the centrifugal compressor cover and the centrifugal compressor blades matching the rub mark location on the cover. The tips were missing on the second-stage gas generator turbine blades, and the second-stage nozzle guide vanes exhibited partial melting. The first-stage gas generator turbine blades exhibited missing surface coating near the blade tip ends. Continuity of drive was confirmed between the accessory drive and the starter-generator pad. The drained oil was tan in color.

The No. 2 FCU was removed and bench tested. The FCU was brought from normal start to flight idle, and the Np rpm, fuel flow, and gas generator speed (Ng) were normal in both the governed and nongoverned range; no anomalies were detected.

Rotor Brake Assembly

Raised material was observed on the rotor brake disk surface and had the appearance of brake pad (puck) material fused to the rotor brake disk surface. Soot deposits were observed on the exterior of the No. 1 tail rotor drive shaft. A hydraulic fluid level could not be seen through the sight gauge for the rotor brake accumulator. Hydraulic pressure was applied to both rotor brake calipers using a manual handheld hydraulic pump. When about 200 pounds per square inch (psi) was applied, the pistons extended, and no leaks were observed.

The left and right brake caliper assemblies were examined further and tested with hydraulic pressure. Tests were performed after bleeding air from the system, then increasing hydraulic pressure to 230 psi. The forward and aft pucks (both left and right brake calipers) extended as pressure was applied. When pressure was reduced, the forward pucks did not automatically retract but were manually retracted without difficulty. A slight hydraulic leak existed at the forward seal subassembly of the right brake caliper but did not affect the action of the brake pucks.

The caliper was disassembled. The O-ring was in good condition, and there was no evidence of damage or irregular tolerances between the piston and bore. The spring and pin were disassembled from the forward and aft puck assemblies and revealed no anomalous damage.

The accumulator and master cylinder were examined and bench tested with the application of hydraulic pressure and revealed no anomalies.

ADDITIONAL INFORMATION

The S-76A++ rotorcraft flight manual (RFM) No. SA 4047-76-1 in the accident helicopter contained revision 5 of rotorcraft flight manual supplement (RFMS) No. 29B that was applicable to helicopters equipped with the Arriel 1S1 engines installed in the accident helicopter. The RFMS contained rotor brake limitations for when the rotor was either stopped or turning. The rotor turning limitation stated, in part, “Rotor brake application limited to one (or two) engine(s) operating at idle or both engines shut down” and “Maximum rotor speed for normal rotor brake application is 65% Nr.”

A decal on the rotor brake lever of the accident helicopter contained the following caution in red lettering: “NORMAL ROTOR BRAKE STOPS ARE AUTHORIZED ONLY AT 65% NR OR LESS WITH BOTH ENGINES SHUT OFF OR ONE ENGINE AT IDLE.”

The RFM, Part 1, Section III, Emergency Procedures, contained the following statement about the possibility of a rotor brake fire: “The ROTOR BRAKE caution light indicates that pressure has been applied to the rotor brake system. If this pressure results in a rotor brake puck dragging against brake disk, a rotor brake fire might occur.”

According to the Trauma Star Part 135 General Operations Manual, Section S, Helicopter Emergency Medical Services (HEMS), S-26; Ground Operations at Off Airport Landing Sites,

A. Once the aircraft has landed, the pilot will apply the rotor brake and stop the aircraft rotor system. The pilot will then advise the medical crew when it is safe to exit the aircraft. Trained medical crew will supervise the preparation of the patient for loading into the aircraft, including ensuring the patient is adequately secured to the litter, removal of any unsecured sheets or blankets from the litter assembly, etc. Ambulances may bring the patient to the aircraft but will not approach within 30 feet of the aircraft or rotor system.

Pilot Information

Certificate:	Airline transport	Age:	51, Male
Airplane Rating(s):	Multi-engine sea	Seat Occupied:	Right
Other Aircraft Rating(s):	Helicopter	Restraint Used:	5-point
Instrument Rating(s):	Airplane; Helicopter	Second Pilot Present:	No
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 2 Without waivers/limitations	Last FAA Medical Exam:	June 19, 2017
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	October 6, 2017
Flight Time:	5850 hours (Total, all aircraft), 685 hours (Total, this make and model), 3166 hours (Pilot In Command, all aircraft), 43 hours (Last 90 days, all aircraft), 15 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Sikorsky	Registration:	N911FK
Model/Series:	S76 A	Aircraft Category:	Helicopter
Year of Manufacture:	1981	Amateur Built:	
Airworthiness Certificate:	Normal; Transport	Serial Number:	760197
Landing Gear Type:	Retractable - Tricycle	Seats:	8
Date/Type of Last Inspection:	December 1, 2017 Annual	Certified Max Gross Wt.:	10800 lbs
Time Since Last Inspection:	26 Hrs	Engines:	2 Turbo shaft
Airframe Total Time:	11432 Hrs at time of accident	Engine Manufacturer:	TURBOMECA
ELT:	C126 installed, not activated	Engine Model/Series:	ARRIEL 1S1
Registered Owner:	MONROE COUNTY SHERIFFS OFFICE	Rated Power:	725 Horsepower
Operator:	Global Sky Air Charter Corp.	Operating Certificate(s) Held:	On-demand air taxi (135)
Operator Does Business As:	Trauma Star	Operator Designator Code:	GHEA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	MTH,5 ft msl	Distance from Accident Site:	38 Nautical Miles
Observation Time:	06:53 Local	Direction from Accident Site:	80°
Lowest Cloud Condition:	Clear	Visibility	10 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	/	Turbulence Type Forecast/Actual:	None / None
Wind Direction:		Turbulence Severity Forecast/Actual:	N/A / N/A
Altimeter Setting:	30.09 inches Hg	Temperature/Dew Point:	13°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Marathon, FL (MTH)	Type of Flight Plan Filed:	Company VFR
Destination:	Islamorada, FL	Type of Clearance:	None
Departure Time:	06:37 Local	Type of Airspace:	Class G

Wreckage and Impact Information

Crew Injuries:	1 None	Aircraft Damage:	Substantial
Passenger Injuries:		Aircraft Fire:	On-ground
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	1 None	Latitude, Longitude:	24.922222,-80.630554(est)

Administrative Information

Investigator In Charge (IIC):	Mccarter, Lawrence
Additional Participating Persons:	Rick Beckstrom; FAA; Miramar, FL Neil Doh; FAA ; Boston, MA Frederic Aime; BEA Thomas O'Dea; Monroe County Sheriff's Office (Aviation); Marathon, FL Javier Casanova; Sikorsky Aircraft Corporation; Jupiter, FL Bryan Larimore; SAFRAN ; Dallas, Fort Worth, TX Xavier Azema; SAFRAN; Dallas, Fort Worth, TX
Original Publish Date:	February 2, 2021
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=96514

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate, and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties ... and are not conducted for the purpose of determining the rights or liabilities of any person” (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available [here](#).