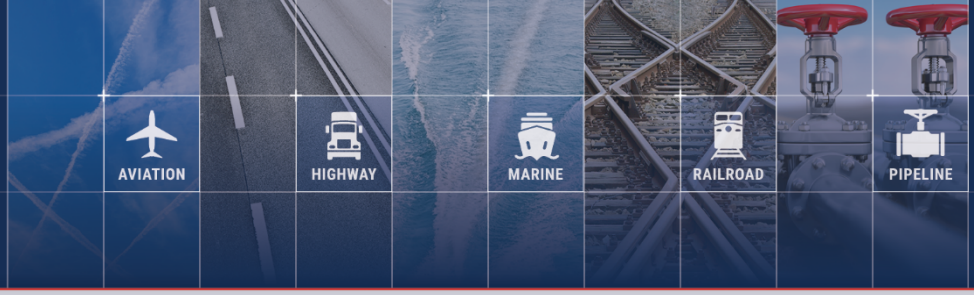

Aviation Investigation Final Report

Location:	Napa, California	**Accident Number:**	LAX03GA145
Date & Time:	April 30, 2003, 19:20 Local	**Registration:**	N341HP
Aircraft:	Eurocopter France AS350B3	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	3 None
Flight Conducted Under:	Public aircraft		

Analysis

The pilot made a forced landing after the helicopter experienced an engine over speed and subsequent engine fire when recovering from a practice autorotation. At 600 feet and 80 knots the pilot under instruction (PUI) entered the practice autorotation after the certified flight instructor (CFI) rolled the collective twist grip to idle to simulate an engine failure. The PUI executed the practice autorotation towards the runway. During the recovery sequence the PUI inadvertently and unknowingly engaged the manual fuel control slide lock on his collective as he adjusted the collective for a power recovery, allowing the CFI to twist the collective grip past the "VOL" (fly) position. The engine and rotor RPM oversped due to excessive fuel flow to the engine, which resulted in a catastrophic failure of the turbine section. The airport tower notified the crew that the helicopter was on fire. The crew made a force landing on the runway, egressed, and fire crews arrived to extinguish the fire. The collective twist grip has two normal operating positions. The "MIN" position sets the engine at idle, while turning the grip counter clockwise to the "VOL" (flight) position stop accelerates the engine to a flight rpm setting. At the "VOL" position the DECU (Digital Engine Control Unit) controls the engine power to maintain rpm as the pilot moves the collective. A slide lock device prevents the twist grip from moving beyond the "VOL" position. The manual fuel control slide lock is only on the right pilot seat collective. The twist grip can be moved beyond the "VOL" position by moving a slide lock lever on the collective twist grip forward and rotating the twist grip beyond the "VOL" position. Once the twist grip is out of the "VOL" detent position the pilot input has priority over the DECU and the pilot is manually metering fuel to the engine; this could allow the pilot to increase the amount of fuel delivered to the engine beyond what the DECU is delivering. The slide lock is spring loaded to its retracted locked position unless moved forward, usually by the pilots thumb, approximately 5 mm. At this point it is then "latched" open allowing the twist grip to be rotated beyond the "VOL" position. Post accident examination and testing of the engine fuel control unit and the manual slide lock mechanism found no preimpact mechanical malfunctions or failures. The helicopter manufacturer is aware of four prior inadvertent manual throttle activations that resulted in engine overspeed conditions and damage to both

the engines and airframe structures. The manufacturer has discontinued installing the twist grip mechanical flight stop device and replaced it with an electrical solenoid type of configuration on all production AS350-B3 helicopters. This new configuration is also available to current owners and operators as a hardware modification.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the pilot under instruction's inadvertent activation of the collective manual fuel slide lock, which led to engine and main rotor overspeeds due to excessive fuel flow during power application. This resulted in failures of the gas generator turbine (N1) blades, power turbine (N2) blades, and created an external engine fire. A factor in the accident was the manufacturer's inadequate design of the twist grip slide lock, which had insufficient safeguards to preclude inadvertent activation.

Findings

Occurrence #1: FIRE/EXPLOSION
Phase of Operation: LANDING - FLARE/TOUCHDOWN

Findings
1. (C) THROTTLE/POWER CONTROL - INADVERTENT ACTIVATION - COPILOT/SECOND PILOT
2. (F) ACFT/EQUIP,INADEQUATE DESIGN - MANUFACTURER
3. (C) FUEL SYSTEM,FUEL CONTROL - EXCESSIVE FLOW/OUTPUT
4. TURBOSHAFT ENGINE,GAS GENERATOR TURBINE - OVERTEMPERATURE
5. TURBOSHAFT ENGINE,GAS GENERATOR TURBINE - OVERSPEED
6. TURBOSHAFT ENGINE - FIRE

Factual Information

HISTORY OF FLIGHT

On April 30, 2003, about 1920 Pacific daylight time, a single engine Eurocopter AS350B3, N341HP, experienced a combined engine over speed and fire followed by a forced landing at Napa County Airport, California. The California Highway Patrol was operating the helicopter by the under the provisions of 41 CFR Part 91 as an instructional flight. The commercial flight instructor (CFI), the commercial pilot under instruction (PUI), and one passenger were not injured. The helicopter sustained substantial damage. Visual meteorological conditions prevailed, and no flight plan had been filed. The local training flight originated from the Napa County airport around 1740.

The CFI told the National Transportation Safety Board investigator that he and his PUI were on a training flight and had been flying for approximately one hour and forty-four minutes. The crew reviewed the procedure for their first straight-in practice autorotation. At 600 feet and 80 knots the PUI entered the autorotation and the CFI rolled the collective twist grip to the MIN position, simulating a loss of engine power. The PUI executed a practice autorotation towards the runway. To execute a power recovery the CFI rotated the collective twist grip from "MIN" to the "VOL" (voler = fly) position, per the normal procedure. The PUI simultaneously applied collective for a power recovery. The rotor rapidly accelerated in conjunction with an unusual and high-pitched whining sound that originated from the engine compartment. As the pilots executed a forced landing on the runway the tower notified them that the helicopter was on fire. The crew egressed the helicopter, and the airport fire-rescue crew arrived to put the fire out.

Examination of the helicopter revealed thermal damage to the engine and engine compartment. Additionally, structural deformation and breaching of the engine's turbine section occurred.

PERSONNEL INFORMATION

The pilot in command received his commercial helicopter pilot certificate on April 22, 2003, with rotorcraft-helicopter and instrument-helicopter ratings. He received his CFI rotorcraft-helicopter rating on March 3, 2003. He reported in the Pilot/Operator Aircraft Accident Report (NTSB Form 6120.1/2) that he had 3,393 total flight hours with 621 hours in the accident helicopter make/model. He had flown 47 hours within the last 30 days in this make/model. He held a second-class medical certificate issued on January 20, 2003, with no limitations or restrictions.

The PUI held a commercial pilot certificate issued on June 29, 2000, with rotorcraft-helicopter

and instrument-helicopter ratings. He reported in the Pilot/Operator Accident Report that he accumulated 1,000 hours of total flight time and 68 hours in this make/model. He had flown 30 hours within the last 30 days in this make/model. He held a second-class medical certificate issued on June 25, 2002, with no limitation or restrictions.

AIRCRAFT INFORMATION

The single-engine Eurocopter AS350B3 helicopter was new to the California Highway Patrol (CHP) fleet on January 5, 2003. A Turbomeca, Arrius 2B, turboshaft engine powered the helicopter. Examination of the aircraft maintenance logbooks revealed that the last 100-hour inspection was completed April 21, 2003. At the time of that inspection the aircraft had 582 total flight hours.

The Arrius 2B engine consists of a 2-stage centrifugal compressor (gas generator) section, a combustion section, and two turbines. The first turbine drives the gas generator and is referred to as the N1 turbine. N1 data is presented as a percentage of designed turbine speed (RPM). The second turbine is a free turbine (power turbine), which drives the main rotor and tail rotor. The power turbine is referred to as the N2 turbine, and is also presented as a percentage of designed turbine speed. A thermocouple is located between the two turbines and is referred to as T4, measured in degrees C.

WRECKAGE AND IMPACT INFORMATION

The CHP recovered the aircraft to the CHP hanger at Napa County airport. The Safety Board investigator examined the helicopter at that location.

The engine cowling/fairing exhibited effects of extreme thermal damage destroying both left and right fairings aft of the engine firewall. Both fairing panels forward of the engine firewall appeared undamaged with only dark discoloration on the aft sections.

The Arrius 2B engine exhibited evidence of thermal damage. Fuel and drain line insulation was melted and charred. The fuel control Hydromechanical Unit (HMU) was black and charred.

The compressor section and gas generator turbine (N1) seized. The compressor inlet blades exhibited black discoloration with no observable mechanical damage.

The turbine case section (N2, module 4) was deformed and separated from the burner section with the majority of the attaching bolts sheared or pulled out of their respective holes. The right side of the turbine section exhibited signs of ductile torsional distortion in the clockwise direction. There was an approximately 1-inch tear originating at a bolt hole at the 8 o'clock position in the turbine casing. The left side of the turbine case separated from the burner section at the 4 o'clock position. Ductile distortions and an approximately 2-inch long hole were at the same location. Coin sized metal debris that resembled turbine blade roots was at the exhaust section behind the N2 turbine. The N2 turbine wheel was displaced to the right of

the engine approximately 20 degrees with all turbine blades missing from their respective attach points.

All transmission and flight control actuator components forward of the engine firewall appeared to be undamaged. The engine remained attached to all mounting points. Bolt fragments resembling the bolts used to attach the burner section to the turbine section were on the engine deck area along with coin sized metal chunks that resembled turbine blade roots. The magnetic drain plug, removed from Module 5 (accessory gear box), revealed 3 pieces of 1/2-inch metal debris attached to the plug magnet.

Fuel was in the main fuel inlet line to the fuel control unit and in the fuel filter.

Investigators removed and examined the oil filter, and found no debris.

Investigators turned the engine primary drive shaft by hand in the free wheel direction. They then freed the shaft using a wrench and applied moderate torque to rotate it in the power delivery direction.

The short shaft that leads from the engine drive shaft to the tail rotor long drive shaft was black and charred. The flexible coupling between the two was intact, all bolts were present, and exhibited no observable distortion.

The baggage compartment upper bulkhead showed color distortions and bubbled-cracked paint on the surface.

Inspection of the crew flight deck revealed no damage. All flight controls were present and actuated the appropriate flight control surfaces. The collective twist grip was in the VOL position with the manual fuel control slide lock retracted in the locked position. The emergency fuel shut off lever was in the actuated position.

Investigators removed the VEMD (Vehicle Engine Multifunction Display) from the mishap helicopter and installed it into another helicopter in-order to display the recorded memory from the mishap flight. The recorded data revealed that at 1 hour 44 minutes 58 seconds into the flight #108, N2 sensor A & B failed. At 1 hour 45 minutes 2 seconds, the N1 sensor A & B failed, and at 4 seconds the T4 sensor failed.

FIRE

The helicopter experienced a fire external to the engine. The aircrew landed, shutdown the helicopter, and egressed. The airport fire crew put out the fire, confining the damage to the helicopters engine compartment vicinity.

TESTS AND RESEARCH

Airframe

The flight deck auto/man switch simulates a failure of the Digital Engine Control Unit (DECU) to automatically control the fuel to the engine. A functional test with a multi-meter verified that the switch functioned normally. Examination of the wiring diagram for this system revealed that a broken wire from the switch to the DECU would not initiate a manual fuel control event and that the auto position corresponded to an open circuit.

The VEMD failed sensor readings indicate that the actual N1 speed and T4 temperature exceeded the set limits of the VEMD data collection criteria. The values recorded by the VEMD for N1 was 112.6 % and T4 was 999C.

Engine

The engine was shipped to Turbomeca, Grand Prairie, Texas, for further examination under the supervision of a Safety Board investigator.

Examination established rotational continuity on the compressor section and turbine section. Compressor stages exhibited visual signs of smoke and fire retardant induction. The burner section was intact with no deformation, gouges, or dings, and had a dark gray color on the interior. The igniters and fuel nozzles did not appear unusual or damaged according to the Turbomeca technicians. The gas generator turbine (N1) wheel remained attached to the compressor drive shaft, and the turbine blade root fir trees were present in the wheel. All of the N1 turbine blades fractured at the base of the blades, some exhibiting a rough granular fracture surface and others exhibiting a ground and smeared surface. The free power turbine (N2) wheel was deformed into a slight oval shape. The N2 turbine blades exhibited reddish and dark gray discolorations with many blades having leading edge damage. The turbine containment ring was deformed into an oblong oval shape. The exhaust diffuser appeared to have retained its shape with dark gray and black sooty deposits on the interior.

Technicians removed the Hydro-Mechanical Unit (HMU), which delivers scheduled fuel to the engine, from the main engine structure and bench tested it at Turbomeca under the supervision of a Safety Board investigator. The bench test revealed that the HMU resolver was not responding, which caused incorrect indications of the manual throttle operation position tests. Turbomeca Alert Letter 2303/04/AR2B/21, addresses a concern of the acceleration control shaft sticking which could result in an engine overspeed. The HMU test recorded acceleration control shaft movement within operational parameters. Technicians performed all other fuel flow tests and all results were within operational parameters.

The HMU was sent to Turbomeca Headquarters in France for further evaluation under the supervision of the Bureau D'Enquestes Et D'Analyses (BEA). Examination of the HMU resolver by Turbomeca technicians revealed, "that one wire was detached from the connector pin due to overheating of the solder by external fire" and "five other wires also showed the same aspect, but at different steps."

Collective Twist Grip Slide Lock

The collective twist grip controls engine power. The "MIN" position sets the engine at idle. As the pilot turns the twist grip counter clockwise to the "VOL" or flight position, the engine accelerates to a flight rpm setting. At the "VOL" position the DECU controls the engine power to maintain rpm as the pilot moves the collective, adjusting to power demands. A slide lock device prevents the twist grip from moving beyond the "VOL" position. The manual fuel control slide lock is only on the right pilot seat collective. The twist grip can be moved out of the "VOL" position by either turning it back to "MIN," which causes a "forced idle" condition, or by moving a slide lock lever on the collective twist grip forward approximately 5 mm and rotating the twist grip beyond the "VOL" position. Once the twist grip is out of the "VOL" detent position the pilot has priority over the DECU and is manually metering fuel to the engine. Moving the twist grip beyond the "VOL" position allows the pilot to increase the amount of fuel delivered to the engine beyond what the DECU is delivering.

The slide lock is located at the 2 o'clock position when the twist grip is in the "VOL" position. The slide lock is spring loaded to its retracted locked position unless moved forward, usually by the pilots thumb, approximately one inch. At this point it is then "latched" open allowing the twist grip to be rotated beyond the "VOL" position. The slide lock can be released and retracted by lifting a small lever on the forward end of the twist grip.

The Safety Board investigator attempted, using various hand positions and twist grip configurations, to "force" an inadvertent disengagement of the slide lock. Inadvertent movement of the slide lock was possible, but moving the slide lock forward enough to achieve an unlocked position was not successful.

ADDITIONAL INFORMATION

History of Inadvertent Activation of Manual Throttle in the AS350B3.

Eurocopter technical representatives recorded four inadvertent manual throttle activations resulting in an over speed condition that damaged the airframe and engine since the AS 350 B3 was introduced to the United States. They also have information stating that several other inadvertent manual throttle activation events have occurred that did not lead to helicopter damage. The NTSB has investigated one occurrence of inadvertent manual throttle activation in the AS350B3 helicopter (NTSB case number: ANC00LA132).

Flight instructor Information

Certificate:	Commercial; Flight instructor	**Age:**	47,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	January 20, 2003
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	April 15, 2003
Flight Time:	3394 hours (Total, all aircraft), 622 hours (Total, this make and model), 3283 hours (Pilot In Command, all aircraft), 191 hours (Last 90 days, all aircraft), 48 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft)		

Pilot Information

Certificate:	Commercial; Military	**Age:**	38,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	June 25, 2002
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	January 10, 2002
Flight Time:	1000 hours (Total, all aircraft), 68 hours (Total, this make and model), 700 hours (Pilot In Command, all aircraft), 45 hours (Last 90 days, all aircraft), 30 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Eurocopter France	**Registration:**	N341HP
Model/Series:	AS350B3	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	3407
Landing Gear Type:	Skid	**Seats:**	3
Date/Type of Last Inspection:	April 4, 2003 100 hour	**Certified Max Gross Wt.:**	4961 lbs
Time Since Last Inspection:	30.2 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	613.3 Hrs at time of accident	**Engine Manufacturer:**	Turbomeca
ELT:	Installed, not activated	**Engine Model/Series:**	Arriel 2B
Registered Owner:	California Highway Patrol	**Rated Power:**	847 Horsepower
Operator:		**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KAPC,33 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	18:54 Local	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Few / 5000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	11 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	270°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.02 inches Hg	**Temperature/Dew Point:**	14°C / 9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Napa, CA (KAPC)	**Type of Flight Plan Filed:**	None
Destination:	Napa, CA (KAPC)	**Type of Clearance:**	VFR
Departure Time:	17:40 Local	**Type of Airspace:**	Class D

Airport Information

Airport:	Napa County APC	**Runway Surface Type:**	Concrete
Airport Elevation:	33 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	24	**IFR Approach:**	None
Runway Length/Width:	5007 ft / 150 ft	**VFR Approach/Landing:**	Forced landing

Wreckage and Impact Information

Crew Injuries:	3 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	Both in-flight and on-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 None	**Latitude, Longitude:**	38.213054,-122.280555

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Ken Meyer; Federal Aviation Administration-FSDO; Sacramento, CA Joe Syslo; American Eurocopter Corp; Grand Prairie, TX Mark Nalley; California Highway Patrol; Sacramento, CA Archie Whitten; Turbomeca; Grand Prairie, TX
Original Publish Date:	March 30, 2005
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=56939